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GVC PARTICIPATION AND ECONOMIC TRANSFORMATION: LESSONS FROM THREE SECTORS

Marie-Agnes Jouanjean, Julien Gourdon and Jane Korinek, OECD

Integration into Global value chains (GVCs) provides opportunities for economic growth and development. However, the nature and extent of these opportunities differ across countries and sectors, and participation in GVCs can support processes of economic transformation in a variety of ways depending on the type of GVC. This paper explores some of the linkages between GVC participation and economic transformation at the sectoral level, with a view to assisting countries in assessing the various policy options for maximising their comparative advantages and their benefits from GVC participation. Three aspects of the relationship between GVC participation – defined as the use of foreign intermediates and integration into international production networks – and economic transformation are explored: i) sectoral differences in upgrading dynamics; ii) the role of services; and iii) resilience to external shocks. A range of qualitative and empirical approaches are used to explore and test the robustness of the relationship for three sectors presenting different characteristics in terms of their trade dynamics and links with economic transformation: mining and quarrying; motor vehicles, trailers and semi-trailers; and transport and storage services.

JEL codes: F14; F60; F63.

Key words: Global Value Chain; Sectoral Analysis; Economic Transformation; Developing Countries; Upgrading; Services; Resilience, Multi-Regional Input Output, Network Analysis.

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Highlights

- GVC participation supports processes of economic transformation in heterogeneous ways, varying by the international structure of sectoral GVC linkages (vertical sectors characterised by few sellers and buyers throughout the value chain, and horizontal sectors characterised by many sellers and buyers). These differences require policy makers to approach sectors in different ways in considering measures to enhance the benefits from GVC participation.

- The results in this paper point to a path in the transformation process related to GVC engagement: Countries with a higher degree of integration into GVCs in the 90s, with a higher use of foreign intermediates in their exports, have increased the share of domestic value added in their exports over time. Countries which were poorly integrated in the 1990s have increased their integration in GVCs by increasing their use of foreign value added.

- The link between GVC integration and economic transformation is not immediate and requires time to mature and as such, policies need to be adapted to the stages of GVC integration. Rather than forcing upgrading processes through measures that seek to increase the share of domestic value added in exports within GVCs, policies that enhance sectoral competitiveness and allow for the exploitation of natural comparative advantages are key. For all sectors, an important element of the transformation path is "learning by importing", underscoring the importance of reducing import tariffs and other barriers to imports.

- Longer run economic transformation opportunities from GVC integration are not always in the form of a direct upgrading of production in the integrated sectors. For some, transformation may come in the form of opportunities related to upgrading in support and upstream sectors, such as the services for Mining and Quarrying sectors. Support services are often highly regulated, reducing levels of competition and efficiency. Analysis in this paper supports a move toward more open domestic policies to enhance competitiveness in those sectors.

- Services are the glue that bind GVCs together, in particular support services such as transport and storage, along with wholesale and retail trade. Regulations reducing competition in transport and storage, in particular maritime logistics services, are detrimental for the efficiency of the sector and for GVC integration – in the transport and storage sector, but also in other sectors.

- Vertically organised sectors are more likely to act as a springboard for economic transformation compared to horizontal sectors. However, vertically organised structures are more sensitive to shocks in key markets, underscoring the importance of policies aimed at building resilience to shocks. These can include enabling diversification into sectors presenting different risk profiles, for example in the context of policy strategies related to FDIs.

- Better understanding of the structure and characteristics of sectors is necessary when defining GVC integration strategies and policies, including to manage expectations in terms of economic transformation. Greater sectoral understanding can also help inform the need for, and design of buffers to prevent the contagion of potential shocks throughout domestic and international value chains. These can include enabling diversification into sectors presenting different risk profiles, for example in the context of policy strategies related to FDIs and more broadly the creation of an enabling environment supporting the sustainable transformation of all sectors.

OVERVIEW

Integration into GVCs provides opportunities for economic growth and development. However, the nature and extent of the opportunities that GVCs can offer differ across countries and sectors. In particular, GVC participation can support processes of economic transformation in a variety of ways according to the type of GVC. Therefore, maximising and sustaining the benefits, and making policy choices that are in line with country capabilities and comparative advantages, all require careful consideration of the heterogeneity of GVCs and their role in processes of economic transformation.

This paper explores some of the linkages between GVC participation and economic transformation at the sectoral level, with a view to assisting countries in their consideration of the various policy choices for maximising their comparative advantages and benefits from GVC participation. Evidence in this paper provides a new perspective on the importance of understanding the GVC structure of various sectors to enable policies to be better targeted to support economic transformation. In other words, when considering policy measures to enhance the benefits from GVC participation, policy makers have to consider the specific structure of the sectors in their economy.

This overview presents the main definitions and approaches used in the paper, highlights the main results from the analysis by sector, and then puts these sectoral findings in perspective by presenting key research and policy findings from analysis across sectors.

Key definitions and approaches

The paper uses a broad concept of GVCs, described as the use of foreign goods and services (that is foreign value added, FVA) in the production of exports. In the aggregate, GVC integration can allow countries to focus their resources on tasks in which they have a comparative advantage without having to build a whole value chain. This is done through importing intermediates from other countries, to which countries add value and then sell on domestic markets or re-export. The paper also defines economic transformation as the movement of labour and other productive resources from lower- to higher-productivity activities, within/between firms and sectors. Accordingly, when discussing GVC upgrading, what matters is not necessarily domestic value added (DVA) as a share of exports (i.e. the share of DVA in exports) but rather the way a country uses foreign inputs and GVC participation to expand the level of its economic activity (i.e. the total amount of DVA in aggregate), enhance sectoral competitiveness and allow for the exploitation of comparative advantages.

Three aspects of economic transformation relating to GVC integration are tested on three sectors presenting different GVC characteristics. The three aspects linking the use of foreign intermediates and integration into international production networks with economic transformation are i) sectoral differences in upgrading dynamics; ii) the role of services; and iii) resilience to external shocks.

The three sectors analysed are: mining and quarrying (M&Q)[1]; motor vehicles, trailers and semi-trailers (MV&T)[2]; and transport and storage (T&S) services[3]. Each presents different patterns of innovation,

1. ISIC Rev.3 : Category C – Including divisions 10 - Mining of coal and lignite; extraction of peat; 11 - Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying ; 12 - Mining of uranium and thorium ores; 13 - Mining of metal ores; 14 - Other mining and quarrying.

influencing their trade dynamics, their GVC structure and their link with economic transformation. In particular, learning and innovation have sector-specific characteristics resulting in heterogeneous upgrading dynamics among sectors.

A range of qualitative and empirical approaches are used to explore and test the robustness of the relationship between GVC participation and economic transformation at the sectoral level. First a literature review and an analysis of TiVA indicators over the period 1995-2011 are used to describe the structure and dynamics of each sector as well as their position in the GVC landscape from a trade in value added perspective. Then, the paper uses network analysis (centrality) using TiVA and other data sources: first, to identify the relative position of sectors as buyers and sellers of value added and the importance of services in trade in value added; second, to look at the impact of external shocks on the structure of the GVC at the sector level; third, to explore the relationship between the use of foreign intermediates, the sophistication of exports and the centrality of a sector; and fourth, to examine the importance of the regulatory environment in T&S services for GVC integration, with a focus on maritime services.

Box 1. Using network analysis to explore GVCs in sectors – creation of a backward and forward centrality

Network analysis provides a different way to view the organisation of GVCs, as measured by flows of domestic value added across countries. Network analysis indicators are built upon a mathematical approach based on computing the eigenvector of a matrix connecting countries to countries (by sector or not) or sectors to sectors. This metric can for instance shed light on how central a given country is to the GVC of a given product This allows for a more refined analysis of the relative positions and relationships between and within sectors and countries in terms of their relative importance (centrality) in international trade and thereby inform about their sensitivity to shocks. The same approach is also used to infer countries' capacities in economic complexity analysis.

The indicators are compiled using the ICIO, and network analysis is used to examine trade in value added in both goods and services. Two indicators are computed, the **backward centrality** or '***buying for export'* centrality;** and the **forward centrality** or '***selling for export'* centrality**. These respectively provide information about the centrality of a sector or a country in a network as a buyer and a seller of value added. Different types of centrality can then be calculated according to the "node" of interest in the network. For this paper the two "nodes" of interest are the sector or the country-sector. Accordingly, sectors (or countries) that have a more central position play a more important role in the aggregate output of the economy (or the sector) and GVC.

The centrality of sectors looks at the importance of a sector, at an aggregated level, as a buyer of value added from other sectors for its exports (backward centrality), or as a seller of value added for the exports of other sectors (forward centrality).

For the **country-sector level,** the **backward centrality** or ´***buying for export***´ **centrality** captures the importance of a country as a buyer of value added in intermediates of a particular product for the production of its exports. It captures both the number of interactions and the size of those interactions. The backward centrality measure accounts for the number of countries from which intermediate products of interest are purchased. For example, a country will be a central buyer of MV&T value added if it has a relatively large number of suppliers, and purchases relatively large volumes of MV&T value added as intermediates for the production of its exports.

The **forward centrality** or '***selling for export***´ **centrality**: captures the importance of a country as a seller of value added in intermediates (from all industries) for the production of a specific sector of interest, for instance MV&T. Again, the concept is the importance, or centrality, of a country as a seller of value added in intermediates (from all sectors – from agro-food intermediates, to services to manufacturing parts) for the production of exports of a certain sector of interest. For example, this metric captures the importance of a country as a seller of intermediates to other countries producing MV&T for export.

2. ISIC Rev.3 code 34, including the following breakdown: 341 - Manufacture of motor vehicles; 342 - Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers; 343 - Manufacture of parts and accessories for motor vehicles and their engines.

3. ISIC Rev3. Division 60 - Land transport; transport via pipelines; 61 - Water transport; 62 - Air transport; 63 - Supporting and auxiliary transport activities; activities of travel agencies.

Sector overview: GVC integration, characteristics and economic transformation of M&Q, MV&T and T&S sectors

The mining and quarrying sector

Growth from mineral resources is generally lower than expected and can be highly volatile, partly because of what is referred to as the "resource curse". Economic activity in extractive industries is primarily determined by geology and not by the business climate or macro-economic fundamentals. Some countries do not have the capacity to exploit their natural resources domestically and seek investment from large, multinational firms. Development of the sector also generally takes time. Mining requires very large, long-term investments which entail substantial risks. Only large firms with secure access to financing can undertake such operations.

In most countries, sub-soil resources belong to the State or to its citizens, therefore firms that aim to extract and develop sub-soil resources for profit require government authorisation that often takes the form of a concession or a licensing agreement. However, the mining sector often provides limited employment in the countries where extraction occurs. Some minerals exporters have tried to increase the value added of their natural resources and create jobs in downstream processing industries and increase linkages with other sectors of the economy by using export restrictions and local content and procurement policies (LCPs). OECD and other research suggests such policies often do not achieve the desired objectives.[4]

Visualisation tools representing the most important flow of exported value added per country in 1995 and 2011 shows a growing polarisation around Germany and the Peoples' Republic of China (hereafter China), two important manufacturing hubs which increasingly became the most important recipients of value added from the M&Q sector from a large number of exporters. Also evident is the increasing importance of the "rest of the world" group, suggesting a growth in a number of M&Q sectors in developing countries where coverage in TiVA is more limited.

In terms of input mix, high income countries, on average, use more services, both foreign and domestic, to produce their minerals exports and use more foreign goods compared with middle income countries. However, the composition of the value added exported over time is biased by a composition effect of the sector, which mixes oil and gas exports with minerals. Not only do those two product areas present different trends over time, but mineral exporters in the dataset are also largely high income countries. Oil & gas and the mineral sector present a very different composition of value added in exports. Oil and gas exports are comprised almost exclusively of DVA in non-service sectors – about 90% – whilst for mining it is less than 70%. This results from higher rents from petroleum compared to minerals. The intrinsic value of the natural resource is often estimated at around 50% of the value added produced in the oil & gas sector compared with less than 20% for mining. Second, services appear to contribute substantially more to value creation in mining compared with oil & gas. That said, with services inputs representing close to 20% of value added exported in mining, this is still less than for the manufacturing sector, with 30-35% of value added made up of services on average. This nevertheless confirms the conventional wisdom that mining can potentially create deeper linkages with other sectors than oil & gas, in particular with services.

The analysis of the evolution of the share of DVA between 1995 and 2001 points to the fact that the M&Q sector – in particular in countries which are knows as mining exporters – seems to confirm the posited finding of the existence of different trends in evolution of DVA share over time, either decreasing or increasing, according to the maturity of participation in the GVC. The large standard deviation on the small sample size nevertheless suggests the need for caution, as well as the heterogeneity of the sector and the diverging trends among types of industries within the sector over the period which might also bias the results.

4. Korinek, J. and J. Kim (2010), Export Restrictions on Strategic Raw Materials and their Impact on Trade and Global Supply, *Trade Policy Working Papers*, No. 95, OECD Publishing, Paris.

The motor vehicles, trailers and semi-trailers sector

The automotive industry is a particularly interesting case study for economic transformation strategies because of its potential in terms of technology spillovers, its use of relatively low-skilled labour in assembly activities and its potential for employment creation. The unbundling of the automotive or motor-vehicle industry was initiated decades ago, making it one of the most documented GVC sectors. However, the sector is also subject to important levels of policy intervention around the world. Those policy interventions considerably influenced the geography of automotive GVCs and the regional rather than global organisation of the industry. Those policy interventions are considered in the literature as part of the reason why finished vehicle trade is less likely to occur between regions and why final assembly usually occurs in the region, if not country, of final consumption. Whilst it is important to note the strong influence of policies on the organisation of the sector, analysing the effect of these policies is beyond the scope of this paper.

Nevertheless, the automobile industry is an interesting case study for two reasons. First, many developing countries currently participate in global auto industry supply chains; some as suppliers of less technologically advanced inputs and as assemblers, and others more central such as China or South Africa, benefiting from their geography, size and skill advantages. Second, it is also a useful case study for analysis of the impact of a shock in the GVC, as both the effect of the global economic crisis and of the 2011 earthquake and tsunami in Japan and floods in Thailand have been well documented.

The analysis over time shows that the total value added exported in the "Motor vehicles, trailers and semi-trailers" sector tripled between 1995 and 2011. Whilst gross exports increased in value, the share of DVA as well as the share of services in those exports did not significantly change. Flows of trade in value added experienced a strong polarisation around three "factories" to which satellite countries sold MV&T products, Europe (in particular Germany), North America and South-East Asia. The sector presents very different features compared to the M&Q sector, with the share of DVA in exports representing on average just over 40% of exported value added.

The evolution of the share of DVA presents much clearer pattern in this sector than in the M&Q sector. Countries that were already well integrated in GVCs in 1995 with a lower DVA share of gross exports seem to have been more likely to increase their DVA share over the period. This is further evidence supporting the importance of FVA as a first step in GVC integration, followed subsequently by an upgrading process and an increasing DVA share, and therefore of the nonlinear relationship between DVA share and processes of economic transformation.

The transport and storage services sector

Connectivity - and in particular the efficiency of T&S services - are critical for GVC participation. Greater efficiency implies making these processes work faster, more reliably, and at lower cost, and this is critical in enabling developing countries to participate in GVCs in other sectors. Additionally, investments in infrastructure and trade facilitation can foster better connectivity within a region, enabling the development of regional transport hubs which provide a base for integration into both regional and global production networks.

The analysis of the T&S sector is in two parts. The first part looks at various indicators based on trade in value added, in particular centrality indicators. The second part uses the centrality indicator to investigate the effect of regulations on GVC participation, both in the T&S sector as well as in other sectors.

The main results from the analysis of trade in value added flows of the T&S sector highlight that, on average, exports of value added in T&S increased threefold over the period 1995 to 2011, with the impact of the global economic crisis visible in the decrease in trade in 2009. Exports of value added in the sector experienced a jump between 2005 and 2008 for the lower middle income countries (LMICs) identified in the TiVA database and the shock of the crisis presented a longer tail for this group of countries. The increase in value added exported by upper middle income countries is much smoother over the same period, with the trend only affected by the crisis in 2009. The pattern for high income countries is more flat, as they were already well integrated, but the crisis also has a longer tail for these countries than for the upper middle income countries.

Most countries, for which disaggregated data is available in the TiVA database, seem to have experienced a decrease in DVA share in the sector over time. This can result from innovation and the increasing digitalisation of services which are important inputs in the T&S sector such as banking and insurance activities, making these services easier to disaggregate and trade. Therefore, rather than information about stages of economic transformation, the evolution of the FVA content in the T&S sector might highlight trends in the creation of GVCs in services as technological progress enabled new trade in tasks in services. However, a further explanation for the declining DVA share may lie in the increase in oil prices over the period studied.

By virtue of its inherent connection to the movement of people and goods, including across borders, T&S services better lend themselves to international fragmentation than other service sectors. Although the T&S sector is used in the movement of all exports, it has lower forward participation than other sectors.[5] This is to be expected as forward linkages represent the importance of trade logistics costs in final demand. As a logistic service, the cost of T&S in the final good influences the competitiveness of exports and the objective of exporters is therefore to minimise their proportion in exports. However, when looking at the share of total value added in exports, results show that T&S services, while not the most important services inputs, are the most traded valued added service in value and are central to the functioning of GVCs.

GVC trade in the T&S sector mainly occurs among developed economies, which accounted for 70% of purchases and 61% of sales of value added in the sector in 2011. By contrast, T&S trade among developing economies represented less than 5% of total value added traded. However, sales by developing economies to developed economies represented over 20% of all flows. Part of this simply results from the difference in trade flows between these groups of countries. However, in theory, shippers should be able to use services from anywhere in the world and the provision of those services should not necessarily match trade flows. It is therefore worth looking at the determinants of engagement in the exports of T&S value added. Those findings are further explored using the centrality measures, able take into account both the frequency and the value of flows.

Analysis across sectors

The importance of sectors and countries as sellers and buyers of value added: evolution of the centrality of sectors and countries over the period 1995-2011.

The three sectors occupy very different positions as buyers and sellers of value added for export. But most notable across all three sectors, is the increasing importance of services as sellers of value added for export.

The position of sectors as sellers of value added for export (forward centrality) reflects the importance of services in GVCs. M&Q is in fourth position in 2011 with an important change in position compared to 1995, partially explained by the increase in commodity prices over the period. T&S follows M&Q in fifth position as a seller of value added for exports in 2011. Finally, MV&T is at the very end of the ranking as a seller of value added to other sectors, consistent with its position close to final demand.

The position of sectors as buyers of value added for export (backward centrality) highlights that the most connected sector among the 34 sectors in TiVA is *Computer, Electronic and optical equipment* followed by MV&T. T&S ranks fifth and M&Q is positioned around the median.

These results, whilst still consistent with traditional TiVA indicators, provide a new perspective on the importance of these sectors, in the economy and for other sectors, as a result of not only the size of the transaction as captured by traditional indicators, but also their frequency, with the centrality indicators also capturing the number of interactions. This is particularly the case for M&Q and T&S, which are both

5. It should be noted that supply-use tables (SUT) use purchaser prices and therefore do not record the T&S cost from the factory to buyer (industry for intermediate or consumer for final good), and could thus miss a significant contribution in forward integration. However in TiVA with the transformation from supply use tables to input output tables (IOT) in basic prices, this has been corrected by extracting the transport margin from sectors and reallocating it as an input of the T&S sector into other sectors.

horizontal sectors. As expected, M&Q and T&S sectors both have relatively high positions as a seller of value added for export. But more surprising is their relatively high position as a buyer of value added for export. The T&S sector even takes the fifth position both as a buyer and a seller of value added for export.

The analysis of the two centrality indicators –backward and forward centrality – developed in this paper confirmed previous GVC analysis in highlighting the importance of services as a seller (provider) of value added for export. Services have increased in importance in supporting GVC. In particular, two service sectors have a high centrality position both as buyers and seller of value added for export and appear as the sectors tying GVC nodes together: Wholesale and retail trade, repairs and T&S. However, the centrality of both those sectors decreased relative to the others over the period analysed, an evolution which could, among other things, reflect the declining cost of those sectors relative to others, a factor that by itself supports GVC integration processes. In particular, unpacking the consumption of intermediates for the three sectors analysed sheds further light on the importance of trade support services.

Examining the structure of value addition in minerals suggests potential growth sectors for minerals exporters: the M&Q sector can be contrasted with the other two sectors studied in that backward linkages are fewer and less deep. There are simply less opportunities for integration in GVCs for minerals exporters compared to other sectors. Apart from the mining activity itself, only two other sectors represent over 5% of the total intermediates used for production: wholesale and retail trade and repairs, and T&S; overall, services are prevalent with eight of the ten main contributing sectors being services. This suggests that minerals exporters wishing to increase the value addition in their export sectors should facilitate the emergence of such services.

The evolution of centrality and the position of developing countries in the value chain

Observation of the centrality indicator over time permits examination of assumptions about trends in GVC integration and the impact of a shock in the reorganisation of the value chain.

Overall, analysis of the concentration of centrality over time reflects the production structure of the sector and the degree of evolution of GVC integration. Analysis over time of the three sectors highlights the heterogeneity behind aggregated data. At the aggregate level, the concentration of the centrality of countries as sellers of value added for the production of export represents a decrease from 1995 to 2008. In itself, this observation is a distinctive feature of the development of GVCs, with the decrease in concentration of forward centrality capturing the increase in country participation in trade in intermediates.

Of the three sectors analysed, only MV&T shows significant movement in terms of centrality over the 1995-2011 period. Trade in value added analysis highlights the increasing use of FVA in the production of exports and in particular the use of services for all three sectors. Whilst on average all sectors increased their reliance on intermediate inputs originating from countries all around the world, the MV&T sector, as a vertical sector, lent itself more readily to trade in tasks via GVCs. However, the sector presents at first a concentration of centrality, highlighting the emergence of hubs or "regional factories" as the first step toward the internationalisation of production processes. The M&Q and T&S sectors – both "horizontal" in nature, the M&Q sector because the supply of natural resources is primarily determined by geology, in many countries in the world, without relationship to specific comparative advantages; and T&S because of its nature as a trade logistic service – appear to follow similar trends both as buyers and sellers of value added for export,

For the three sectors, the global economic crisis also seems to have had a contraction effect. A similar trend can be observed for all three sectors, with a particularly important change in trend for the MV&T sector and more minimal impact in the M&Q sector, where the crisis resulted in an increased centrality of some countries compared to others, both as buyers and sellers of value added for export. For the MV&T sector, while the relative increase in concentration is not large compared to the evolution over the period, it is nevertheless an important change in trend. This suggests that the impact of the crisis was higher for some buyers compared to others in the sector. For the M&Q sector, demand and prices dipped at the outset of the crisis in 2008 but the sector recovered more quickly than others. The impact of the crisis is still visible, however, with a slight delay between the effect on the concentration of the forward and backward centrality indicators, suggesting that a first shockwave of the crisis was a break on the supply side. Such supply shocks

can come from either the exporting country side (unable to export) or from the demand side (for instance, from a decline in trade finance or a sudden decrease in demand).

The evolution of the position of countries as buyers of value added in intermediates for the production of M&Q, MV&T or T&S for exports, or as sellers of value added of M&Q, MV&T or T&S as intermediate for the production of exports is also studied.

For the MV&T sector, with the exception of Germany, the composition and importance of countries in the sector, and in particular their movement over the period 1995 to 2011, highlights the relative decline in centrality of some of the historical actors and the rise, as buyers of value added of MV&T for the production of exports, of emerging economies: China, Mexico, Russian Federation, Korea and Thailand. There is a strong regional bias in the change of centrality and the pace of post-crisis recovery, with Europe recovering more slowly than North America. The result highlights once again the important regional dynamic of GVCs with the impact of shocks spreading mostly through regional links and resulting in a shift of importance of regions in the sector.

For the M&Q sector, in terms of backward centrality, movements within the sector are driven by China which has become the most important buyer of value added for the production of exports of intermediates from the sector, followed by increased centrality of emerging economies. OECD countries maintain their position as strong buyers of value added from the sector although their relative shares dropped over the period. Looking at seller of value added to the sector for the production of exports, the decrease in concentration might have been influenced by various phenomena, including the entry of numerous actors. .

For the T&S sector, changes in backward centrality between 1995 and 2011 mostly result from the large increase in the centrality of Asian countries, with a dramatic increase by China, but also large increases in relative terms for India, Korea, Vie Nam, and to some extent Thailand. Because of the hub and spoke nature of the service, the evolution of regional hubs is important. Latin American countries have, on average, increased their importance as buyers from the sector, but decreased their importance as sellers of intermediates to the sector. In Asia, most of the change happened on the selling side, with clear advances by India and China. India also increased its engagement as a buyer of value added for export, as did Thailand.

The relationship between FVA and sophistication in the M&Q and MV&T sectors

Preliminary analysis is also undertaken on the use of FVA as a pathway toward increased sophistication of exports, and therefore economic transformation. As such, and controlling for country specific factors, the DVA share in products exported should be negatively related to complexity of exported products.

The analysis shows that in both the M&Q and MV&T sectors, and controlling for other factors, lower DVA share is associated with exports of a more sophisticated bundle of products. That is, countries exporting more complex products to more diverse countries use more FVA for the production of their exports.

For the M&Q sector, this relationship does not present any differentiation by income group. This result points to an underlying implication for policymaking: as product sophistication rises, the share of DVA naturally falls, at any level of development. The policy implications for keeping markets open, lowering trade barriers and ensuring trade logistics are efficient are therefore correlated with countries that move toward more sophisticated exports, whatever their initial level of development. However, the relationship, has not been stable over the period examined. The significance of the relationship in the M&Q sector increases if 2008 is excluded from the analysis. This result suggests that the crisis had an immediate disruptive impact on the transformation relationship.

The level of complexity of the bundle of products in the MV&T sector is much higher than for the M&Q sector. Preliminary analysis of the distribution of the weighted product complexity over DVA share of exports for 1995 and 2011 does not seem to present any correlation. However, further analysis testing the correlation on various time periods show the existence of a strong and significant relationship between the level of DVA and the complexity of the bundle of exported product before 2008. The lack of correlation after that period points to a disruption associated with the crisis, with a larger impact on the structure of the sector compared to

the M&Q sector. This difference can relate to the different structures of the two sectors, but may also have been influenced by the way the crisis was handled by policy makers.

Finally, both the centrality as a buyer and a seller of value added seems to be positively related to export complexity, with the relationship somewhat stronger for sellers of value added for export. Whilst the regressions conducted for the analysis say nothing about causality, they nonetheless support the notion that exporters of higher complexity bundles of products have on average a higher centrality but therefore also a higher sensitivity to shocks as sellers of value added for export.

Overall, the results provide evidence to support the use of FVA as a means to progress economic transformation. However, they also highlight that the relationship was disrupted, to varying degrees, by the economic crisis in 2008.

The impact of Maritime transport services on GVC participation

Restrictions in the T&S sector have been associated with a decrease in competition in the sector, and therefore in the quality and efficiency of services supplied, resulting in lower GVC engagement. The paper uses centrality measures to provide a new way of looking at these effects. It looks more specifically at the maritime transport sector, which is particularly relevant for GVC integration as close to 80% of international trade is still transported by sea. The high volumes of trade occurring by sea means that ports are crucial nodes in global supply networks and their regulation can significantly affect a country's integration in GVCs and the T&S value chain. Similarly, with the majority of international containerised cargo transported by regular liner shipping services, regulations imposed on these operations are also likely to play a significant role. To gain insights into these two areas, two indicators of port and ship liner regulation and their impact in T&S GVC centrality are explored.

Maritime regulations, measured as a tariff equivalent (ad valorem equivalent), appear to be highly significant for T&S centrality. Similarly, there is a strong relationship between the number of available services and the number of shipping lines operating direct services with centrality indicators in the T&S value chain. Large and rich countries are also more central in the T&S value chain. But above all, the correlation is strongly significant with all types of centrality measures for indexes capturing maritime connectivity and de facto regulation in maritime transport. Efficient maritime connectivity significantly improves centrality positions in the T&S GVC, and conversely de facto restrictions on foreign maritime transport impede achievement of a more central position.

The importance of T&S services in supporting other GVCs is further examined by looking more specifically at the two other sectors analysed in this paper, the M&Q and MV&T sectors. The empirical approach tests the impact of restrictions in freight maritime transport services and bilateral maritime connectivity on bilateral trade in value added, by the T&S, MV&T and M&Q sectors.

This analysis confirms that GVC integration is particularly sensitive to maritime connectivity and more specifically to restrictions in foreign freight maritime transport services. Moreover, connectivity and restrictions not only affect integration into the T&S value chain, but also GVC integration overall. The effect is very different according to sectors and country groups, with a divide in terms of impacts between developed and developing economies. Focusing on the T&S value chain, restrictions in maritime services in developed economies are especially constraining for the integration of T&S value added originating from developing countries in their exports. The corollary also holds with restrictions in developing countries affecting integration of T&S value added from developed economies. This could indicate also a potential gap between maritime transport regulation between developed and developing economies, suggesting this as an area for future work. Maritime connectivity is positively correlated with the use of foreign T&S value added in exports except when trade partners are both developed economies. The coefficient of the correlation is also much higher when it involves two developing economies.

Those results underline the importance of trade facilitation in developing regions for which digitalisation and adoption of information systems to facilitate data sharing has been recognised as a key factor for shippers, forwarders and brokers as well as transport operators (OECD, 2014). Such digitalisation strategies are currently restricted to large international port such as Hamburg, Rotterdam or Singapore since such systems

require access to ICT infrastructure and the implementation of various regulations, including on cybersecurity, which can be challenging for some developing economies. Yet, digitalisation offers important opportunities for reducing unnecessary trade costs, in particular in trade logistics and can be a step towards implementing the WTO Trade Facilitation Agreement.

Conclusion to the overview

Overall, evidence gathered in this paper confirms various traditional but also less traditional policy intuitions or findings from the GVC literature. All sectors benefit from the use of foreign intermediates, including through "learning by importing processes", underscoring the importance of reducing import tariffs and other barriers to imports. However, the results in this paper point to a path in the transformation process related to GVC engagement. In particular, the analysis supports the idea that the link between GVC integration and economic transformation is not immediate and requires time to mature. Countries with a higher degree of integration into GVCs in the 90s, who had a higher use of foreign intermediates in their exports, have increased the share of DVA in their exports over time. Countries, which were poorly integrated in the 90s, have increased their integration in GVCs by increasing their use of foreign value added.

As such, policies should be adapted to the stages of GVC integration. Rather than forcing upgrading processes through measures that seek to increase the share of domestic value added in exports within GVCs, policies that enhance sectoral competitiveness and allow for the exploitation of natural comparative advantages are key. In particular, policies aimed at increasing DVA share in exports are likely to be counterproductive if they create a disconnect with the level of production capabilities in the country. It should not be forgotten that, whilst GVCs increase opportunities in terms of the gains from trade, comparative advantage still matters and policies aimed at increasing the DVA share in exports are generally ultimately detrimental for competitiveness and further GVC integration.

Moreover, GVC participation supports processes of economic transformation in heterogeneous ways, varying by the international structure of sectoral GVC linkages (vertical sectors characterised by few sellers and buyers throughout the value chain, and horizontal sectors characterised by many sellers and buyers). These differences require policy makers to approach sectors in different ways in considering measures to enhance the benefits from GVC participation.

Vertically organised sectors are more likely to act as a springboard for economic transformation compared to horizontal sectors. However, vertically organised structures are more sensitive to shocks in key markets, underscoring the importance of policies aimed at building resilience to shocks. This underscores the need for policy makers to better understand and take into consideration the structure and characteristics of sectors when defining GVC integration strategies and policies, not only to manage expectations in terms of economic transformation but also consider sensitivity to shocks and potential set-backs from strategies narrowly relying on a few champion sectors. Greater sectoral understanding can help inform the need for, and design of buffers to prevent the contagion of potential shocks throughout domestic and international value chains. These can include enabling diversification into sectors presenting different risk profiles, for example in the context of policy strategies related to FDIs and more broadly the creation of an enabling environment supporting the sustainable transformation of all sectors.

Finally, market openness for services is important for GVC integration and economic transformation. Services play an important role, even in natural resource-based sectors, in supporting economic transformation. In particular, the analysis suggests that learning by importing opportunities also exist with regard to this sector, likely around the support services for the sector.

The analysis also supports the notion that services are the glue that bind GVCs together. Of particular importance are support services such as transport and storage, along with wholesale and retail trade. However, support services are often highly regulated. The analysis in this paper supports a move toward more open domestic policies to enhance competitiveness in those sectors as a means to support the transformative role that GVCs can have on sectors. Moreover, the scope of the impact of poor market openness in the sector goes far beyond the sector itself. Regulations reducing competition in transport and storage, in particular maritime

logistic services, are detrimental for both the efficiency of the sector itself, and also for other sectors limiting the potential for GVC integration overall.

Once again, consideration of development stages and gaps is important for the prioritisation of policies and investments. The impact of maritime connectivity and services restrictions differ between developed and developing economies. Maritime services restrictions are particularly problematic for the integration of T&S sectors between developed and developing economies. However, maritime connectivity (a measure that captures the market conditions and service level depending on the mix of hard infrastructure provisions and regulations) is particularly important in the development of GVCs among developing economies. This could indicate a potential area where progress could reap significant gains in terms of GVC integration and particularly underscores the importance of pursuing regional and global integration as important tools for promoting economic transformation in developing countries.

Overall, the results of this study suggest that longer run economic transformation opportunities from GVC integration are not always in the form of a direct upgrading of production in the integrated sectors. For some, transformation may be in the form of opportunities related to upgrading in support and upstream sectors. The analysis provides evidence that, as product sophistication rises, the share of DVA will naturally fall, and this for countries at any level of development. Keeping markets open, lowering trade barriers and ensuring trade logistics are efficient would therefore support the move toward more sophisticated exports, whatever the initial level of development.

1. Introduction

The end of the 20th century witnessed a change in the nature of trade, increasingly moving from trade in final goods to trade in intermediates and tasks. It is no longer necessary to build a whole value chain to participate and benefit from trade; global value chains (GVCs) now provide new opportunities for developing countries to integrate into the global economy (OECD, 2013). Indeed, the expansion of GVCs has already resulted in a redistribution of global economic activity towards developing countries (Baldwin, 2012), which are now more widely engaged in GVCs (OECD, 2015a).

Moreover, theoretical and empirical analysis at the aggregate level has documented the link between GVC integration, productivity, job creation and economic development.[6] Many developing countries have thus been looking at the possibility of integrating into GVCs as a way to increase their economic growth. However, participation in GVCs and the importance of GVC linkages differ markedly across countries and sectors, giving rise to questions about the nature and extent of the opportunities GVCs offer for developing countries. Maximising and sustaining benefits, and policy choices and implementation, in line with country capabilities and comparative advantages, all require careful consideration of the heterogeneity of GVCs and their role in processes of economic transformation.

This paper uses a broader conception of GVCs and seeks to describe the use of foreign goods and services - foreign value added (FVA) - in the production of exports. Such a definition encompasses very different types of governance of international production networks, from highly integrated value chains to more traditional supply chain models, which influences production strategies and reactions to external pressures. Acknowledging this heterogeneity, this paper adopts a sector scale to explore various intertwined mechanisms identified in the literature as processes linking the use of foreign intermediates and international production network integration with economic transformation. To do so, it uses a range of empirical approaches, testing the robustness of those mechanisms at the sector level under various settings. In particular three areas are investigated throughout the paper.

The first is to explore whether there are differences among sectors in the relationship between GVC integration and economic transformation. To do so, the paper focuses on opportunities offered by the use of foreign intermediates for the production of exports in three sectors important for developing countries. In the aggregate, previous studies suggest that GVC integration can allow countries to focus their resources on tasks in which they have a comparative advantage by importing intermediates from other countries to which they add value and then re-export without having to build a whole value chain. Accordingly, what matters is not necessarily the share of domestic value added in exports but rather how a country has used foreign inputs and GVC participation to expand the level of its economic activity. Moreover, GVC integration over time can be a way to increase productivity at the firm and sector level (OECD 2013a) – that is, it can also change the nature of the economic activity that takes place. The relative importance of the two processes will depend on the level of capabilities, employment and capital endowments of countries seeking to integrate, and profit from GVCs.

Second, the paper investigates the role of services as input in GVCs, in particular in supporting upgrading processes at both the firm and sector level. Recent analyses (Hoekman and Shepherd, 2015) have emphasised a servicification process, highlighting that services are present in production processes and value chains in many ways. Services can be inputs into manufacturing, value creating activities by themselves, or bundled with goods following the servicification of manufacturing (see Miroudot (2016)). Trade in value added analysis sheds light on the importance of services as an intermediate: after accounting for their role as inputs, as well as support activities linking and coordinating activities across countries, services account for a much larger share of exports than previously captured under gross trade data.

6. OECD analyses have also explored various dimensions at a more granular level, looking at issues such as rules of origin, non-tariff measures, in Latin America (OECD, 2015b) and SMEs, employment, and productivity implications in Southeast Asia (OECD, 2015c).

Third, the paper also explores the issue of resilience. Interest in the resilience of GVCs is gaining traction in the light of the global economic crisis and growing natural disaster shocks, including in the context of climate change, that are impacting production systems. The relationship between GVC integration and resilience is complex. One the one hand, spreading risk by diversifying and dispersing the supplier or seller base is a way to increase resilience to shocks. However, implementing such a strategy is a challenge due to asymmetries of information and high entry costs. Moreover, while the growing interconnectedness of economies is a source of resilience, it can also have the opposite effect, with the intensification of specialisation among partners (firms, countries) and a decrease in substitutability between products and suppliers which can amplify contagion through the system.

To shed light on the three areas of interest - sectoral differences in upgrading; the role of services; and resilience to shocks - the paper takes a closer look at three sectors with different GVC characteristics: mining and quarrying (M&Q);[7] motor vehicles, trailers and semi-trailers (MV&T);[8] and transport and storage (T&S) services.[9,10] Each sector occupies a distinct position in the GVC spectrum and their analysis highlights different factors that countries should take into account, about the ways in which various sectors can support economic transformation, the importance of services and resilience.

Because of its complexity and codifiable nature, the production of manufacturing products such as motor-vehicles more readily lends itself to international fragmentation and vertical integration of international production. In this sense, the higher reliance on imported intermediate inputs and thus higher foreign value added content that characterises manufacturing sectors may provide greater scope for integration by developing countries. In practice, the nature of this engagement is often in the less technologically intensive segments of the value chain (e.g. assembly), raising issues of the extent of domestic value added countries are able to generate through their participation in the GVC and the potential to increase this through upgrading. In addition, the sector was and is often still characterised by interventionist policies by governments which have created a path dependency in the international structure of the sector. In terms of economic transformation, manufacturing sectors such as MV&T are associated with upgrading and diversification of economic activities. However, the vertical nature of those value chains, organised around a few powerful hubs, potentially makes them more sensitive to shocks and to the reorganisation of production processes, in particular for satellite providers.

By contrast, natural resource-based sectors are upstream in the value chain and appear generally to offer more scope for engagement by developing countries than more downstream segments. Since the intrinsic value of the extracted minerals is included in the value added calculated for the sector, exports of M&Q tend to have low foreign value added content. The sector is nevertheless integrated into GVCs both as an importer of value added, in particular services, and as a supplier of primary inputs to a vast array of sectors. FDI plays a major role in extractives given the heavy capital and technology requirements which in turn create demand for ancillary services. The sector also has important forward linkages, meaning that it often represents a large share of the value added exported by other countries. However, the capabilities used in the M&Q sectors are very different from those required for the next steps in the value chain; in some cases, there can be large capabilities gaps between two steps in a value chain, as passing from one step to the other can require significantly more sophisticated level of processing and very different mix of intermediate inputs. Therefore,

7. ISIC Rev.3: Category C – Including divisions 10 - Mining of coal and lignite; extraction of peat; 11 - Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying; 12 - Mining of uranium and thorium ores; 13 - Mining of metal ores; 14 - Other mining and quarrying.

8. ISIC Rev.3 code 34, including the following breakdown: 341 - Manufacture of motor vehicles; 342 - Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers; 343 - Manufacture of parts and accessories for motor vehicles and their engines.

9. ISIC Rev3. Division 60 - Land transport; transport via pipelines; 61 - Water transport; 62 - Air transport; 63 - Supporting and auxiliary transport activities; activities of travel agencies.

10. This paper is part of a series of papers looking more specifically at sector specific dynamics in GVCs (see OECD (2015e) for an analysis of GVCs in Food and Agriculture).

suppliers of natural-resources, particularly in poorly diversified economies, often face challenges in pursuing upgrading strategies in the downstream sector as a path toward economic transformation.

Finally, the transport and storage (T&S) sector, as a trade logistic service, presents yet another role in GVCs. Generally speaking, services sector engagement in GVCs tends to occur both upstream, such as in R&D, and downstream, for example wholesale and retail trade.[11] While other services directly impact the productivity of firms, the T&S sector participates directly in shaping trade costs (Hoekman and Shepherd, 2015). Reducing trade costs has always been essential for trade integration; the increased efficiency of trade logistic services has been one of the engines of the internationalisation of production networks. Evidence shows that addressing both the quality of infrastructure and regulatory barriers is essential to ensure efficiency of trade logistics services. Restrictions on trade in services, and in particular in transport services, have been shown to negatively impact the export performance of goods. Whilst the relationship between efficient logistic services, in particular T&S services, with trade and GVC integration is clearly established (Shepherd, 2011), the nature of their interaction with other sectors remains to be fully analysed. The analysis will particularly focus on the influence of regulation in maritime services in GVC integration both for the T&S sector and for other sectors.

The remainder of this paper is structured as follows. The next section introduces the approach adopted and presents pathways from GVC integration to economic transformation. Section 3 discusses the characteristics of the three sectors under consideration (T&S, M&Q and MV&T), beginning with the sector specific context drawing on a literature review, then looking at their global engagement in GVCs. Sections 4 and 5 use various tools and methodologies to explore, at the sector level, the areas linking GVC integration and economic transformation (upgrading, services and resilience). First, social network analysis is used for a mapping exercise identifying how sectors and countries position themselves within global production networks and how these positions have evolved over time, including exploring the relationship between the past use of foreign value added and subsequent evolutions in domestic value added. Second, the relationship between export sophistication and GVC integration in the M&Q and MV&T sectors is used to shed light on the potential transformation of the type of economic activity due to GVC engagement. Finally, the importance of logistic services regulation on the centrality of countries in GVCs is highlighted, with analysis focusing particularly on maritime transport services. The paper concludes with observations and policy recommendations.

2. What is the link between GVC integration and economic transformation?

This section unpacks the concepts behind the three areas tested in the paper. It first discusses the complex relationship between GVC integration, upgrading and economic transformation as well as the role of services. It then further explores the determinants of the heterogeneity of upgrading dynamics between sectors as well as the concept of resilience in GVCs, and how this might vary according to the structure of sectoral GVCs and a country's position in the value chain.

2.1 The complex relationship between GVC integration, upgrading, economic transformation and the role of services

GVC integration can bolster economic transformation through two main processes. First, the internationalisation of production networks has changed the traditional approach to paths of economic transformation. Trade in tasks and more broadly the imports of intermediates can act as a catalyst for the process of economic transformation by hastening the reallocation of resources to higher productivity tasks and sectors – a process that would have been much more difficult and lengthy should the complete value chain

11. This partly reflects the way GVCs are defined. For example marketing, branding, and distribution services also feature prominently at the end of value-chains, when goods are delivered to their final consumers. But as these activities are not typically recorded as crossing borders, they are often not considered as part of the value-chain, even if the activities are provided by resident foreign affiliates.

have had to be developed domestically. Studies have pointed to the development of GVCs having the effect of increasing production and export diversification in emerging economies as these countries have been able to avoid the large investments from R&D to branding associated with exports of a final product. In addition, trade in intermediate goods is determined to a lesser extent by market size or "home bias" than trade in final goods (Miroudot et al., 2009). Second, GVC integration can support economic transformation through upgrading processes driven by learning by exporting and importing, including of services, FDI, and transfers of technologies and know-how.

2.1.1 The changing nature of economic transformation

Traditionally, and in a world of trade in final goods, the structural transformation of an economy was seen as the movement of productive resources and in particular labour, from agriculture to manufacturing and then services (Chenery, 1979; Syrquin, 1989, among others). The concept has been recently revisited by various authors, and is now more often referred to as economic transformation. The process of economic transformation is defined as a continuous process of productivity growth within sectors, as well as the movement of labour and other productive resources from lower- to higher-productivity firms and sectors. (McMillan and Rodrik; 2011; De Vries et al., 2013; McMillan et al, 2015). At the firm level, innovation (technologies, management practices, production processes, etc.) as well as higher quality or cheaper inputs, or increased skills, can increase efficiency and productivity. At the sector level, productivity can, on average, increase through this process but also through the reallocation of resources from lower productivity firms to higher productivity firms: productivity at firm-level is unchanged but the average sector productivity increases through a reallocation effect. Therefore, understanding pathways of economic transformation involves understanding determinants of productivity at the task, firm and sector level, including how resources shift to higher-value uses, and diversification of a country's productive capabilities, including its exports.

The extent of the effectiveness of these mechanisms for increasing productivity for economic development is a focus of the literature looking at GVC integration in developing countries (OECD, 2015). However, an increase in productivity does not necessarily equal economic transformation. To result in economic transformation, a rise in productivity should be accompanied by a movement of labour from low productivity activities to higher productivity activities (task, firm or sector level). In other words, for successful economic transformation, productivity increases should also result in job creation in the economy, and should support the reallocation of labour towards these new, more productive activities. This is particularly important in the case of African economies which are experiencing jobless growth (see for instance Ajakaiye (2016) for Nigeria), or even early de-industrialisation with job creation and movement of labour concentrating in low productivity services (McMillan and Rodrik, 2011, McMillan et al., 2014).[12] While of particular importance to the process of economic transformation, the issue of employment is not covered by the scope of analysis in this paper. Nevertheless, while more analysis should be done at a sector level, analyses find that internationalised firms tend to hire more workers and pay higher wages in developing economies (see for example Shepherd and Stone, 2013).

Early trends towards the servicification of developing economies raised concerns in terms of prospects of economic development. Traditionally, and according to evidence from past development trajectories, services were not considered as a driver of increased productivity. Only the manufacturing sector was argued to lead to productivity convergence patterns between countries (Rodrik, 2013). However, the evolution of the role of services in GVCs and the increasing importance of services in manufacturing but also in food and agriculture value chains (Greenville et al, 2017), underscores the need to re-examine the role that services play in economic transformation and in particular that increased productivity in intermediate services supports firm and sector efficiency gains, whether in agriculture, manufacturing or the service sector itself.

The literature analysing processes of 'servicification' (Kommerskollegium, 2010) of production highlights the growing role of services in supporting economic activity. More efficient business services, or indeed transport and storage services, can be seen as essential to the functioning of GVCs. There exists a

12. Jobless growth can be a sign of increased productivity and higher wages, but this has not been the case in Africa.

significant, if not large, link between services and manufacturing performance: a 10% improvement in services productivity is associated with an increase in productivity of 0.3% in manufacturing and 0.2% in exports (Hoekman and Shepherd, 2015). However, except for trade finance services, little is known about the extent to which developing countries' integration in GVCs is affected by the lack of access to core GVC services.[13]

2.1.2 Processes of upgrading and GVC integration

Upgrading is the mechanism behind economic transformation. Humphrey and Schmitz (2000), define four levels of upgrading: process, product, functional and intersectoral upgrading (Box 2).

Box 2. Four types of upgrading

According to Humphrey and Schmitz (2000), process and product upgrading respectively refer to making products more efficiently and improving product quality or increasing value for consumers. This upgrading can result from better organisation of the production process or from the use of improved technology at the firm level. Functional upgrading relates to the move of a firm into a new, higher value-added function or level in the value chain, to a more skilled or more human-capital-rich activity, within the same sector. It requires the acquisition of new capabilities, for instance in functions with a higher degree of technological or management sophistication. Finally, intersectoral upgrading is the move into a new sector, enabled by the acquisition by the firm of capabilities in its current activity that it uses to enter a new value chain or a new industry producing higher value-added products or services.

In the GVC literature, the process of upgrading is often associated with the objective of increasing the domestic value added (DVA) share of exports. Yet, in the same way that increases in productivity do not fully explain the process of economic transformation, the link between upgrading and economic development is more complex. In other words, policy makers should take into account the nature of their economy and of its comparative advantages before adopting policies with the primary objective of increasing the share of domestic value added in their country's exports. The main reason is the difference in pace and dynamics of various economic phenomena supporting economic transformation and their pass-through to the rest of the economy. Policy makers need to be mindful of the pathways through which upgrading takes place, and in particular, the role that the use of foreign inputs plays in that pathway.

First, "learning by importing" means that the use of higher quality and more sophisticated imports of intermediates and technologies through GVCs increases the quality and efficiency of firms (product and process upgrading) and increases access to know-how and skills, which can then spill over to the rest of the economy. The textile and garment industry in Mauritius and Bangladesh are famous examples of such processes (see Tang, 2015; Mottaleb and Sonobe, 2011). Therefore, increasing FVA share, or decreasing DVA share, can be the source of increased productivity and upgrading. OECD (2015) further highlights that what matters is not the DVA share but rather, at least at first, the total increase in the DVA value. This involves increases in the scale of production, as well as the quantity of jobs created, which – together with spillovers throughout the economy – support processes of economic transformation.

Preliminary evidence in manufacturing indeed shows that the correlation between the share of DVA and the level of capacity in the country is likely to be non-linear (Lopez-Gonzalez and Holmes, 2011). The rationale is that whilst GVC integration can be a rapid phenomenon, building capacities is a process over the longer term. A country can therefore use GVC integration at time *t* to build capacities for the next period (*t+1*) during which upgrading as well as potential spillovers to domestic suppliers and other sectors will occur. As a consequence, the first period is characterised by an increase in imports of intermediates allowing specialisation, resulting in a decrease in the share of DVA but nonetheless in an increase in the total value of exports of DVA. Then, only during the second period does the share of DVA increases. This change in dynamics corresponds to an economy shifting from an assembler position characterised by imports of intermediates, to a position as an exporter of intermediates (Baldwin, 2012; Lopez-Gonzalez and Holmes, 2011). However, the relationship needs further empirical testing (Baldwin, 2012), in particular as policies are

13. Such services vary according to sector, however, performance of the transport and storage services affect all goods sectors, both from the import and the export side.

likely to have a non-negligible influence on the outcomes observed. It is also unclear whether such a pathway is valid for non-manufacturing sectors.

Evidence from patterns of export diversification is another way of observing this dynamic. Export diversification is often used as a proxy for economic transformation with the idea that countries export different products at different stages of development, and that the evolution from one stage to the other is non-linear. Exploring export diversification patterns along the economic development path, Cadot et al. (2011) provide evidence of a hump-shaped relationship between export diversification and level of income. Increased trade flows start with exports of new items (increase in exports at the extensive margin) which are then marketed at increasingly large initial scales (increases at the intensive margin), a period which is followed by a re-concentration of exports into fewer products. Accordingly, lower income countries are positioned at the very beginning of the diversification process and the increase in their trade is occurring at the extensive margin, with exports of new products. These are usually ubiquitous products, meaning that they are exported by many other countries as they are easy to develop and to reproduce in low technology and skills environments.

Part of the explanation for this hump shape is the different pace between the appearance of new sectors and the disappearance of old ones, both of which are influenced by domestic policies. The shift from trade in final goods to trade in intermediates increases the possibilities for diversifying exports. Countries rapidly diversify their economies by performing new tasks in GVCs and, over time, slowly specialise in those tasks for which they have developed stronger capacities. In a world of trade in final goods, the transition might only have taken place when a country reached a higher income level as the country would have had to shift to whole value chains. Trade in intermediates enable this threshold to be reached at lower levels of income. This potentially explains the growth of emerging economies in intermediate products markets (Beltramello et al., 2012) as they developed and were then able to fully exploit task capacities.

However, sector specific characteristics, in particular upgrading patterns, influence these dynamics. These sectoral differences are discussed in the next section.

2.2 Sector analysis of GVCs: Heterogeneity of upgrading patterns and resilience to shocks

2.2.1 Opportunities and dynamics of upgrading are very different between sectors

The sectors analysed in this paper present different patterns of innovation, influencing their position and dynamic in trade, their GVC structure and link with economic transformation. In particular, learning and innovation have sector-specific characteristics resulting in heterogeneous upgrading dynamics among sectors. Those patterns are briefly described below. They are then further explored in the following sections describing the three sectors in more detail.

Sectoral differences in upgrading processes have been analysed long before the GVC era (Pietrobelli and Rabellotti, 2004). Pavitt (1984) described sectoral learning patterns as depending on the sources of technology, users' requirements, and the innovation framework. Accordingly, he describes four categories of industrial firms.

- *Supplier-dominated* characterises firms which rely on sources of innovation external to the firm (e.g. traditional manufacturing such as textiles and agriculture).
- *Scale-intensive* industries: sources of innovation are both internal and external to the firm (e.g. firms producing basic materials and consumer durables).
- *Specialised suppliers* are characterised by firms producing technology that supports production processes in other firms (e.g. specialised machinery and high-tech instruments).
- *Science-based industries* encompass high-tech firms which rely on R&D from both in-house sources and university research (e.g. pharmaceuticals and electronics).

Mining and quarrying can be described as a supplier-dominated sector, where sources of innovation are external to the firm and mainly carried out by the suppliers of machinery and inputs (Pietrobelli and

Rabellotti, 2004). Natural resources sectors, in particular agriculture and mining, are considered to be supplier-dominated models of innovation. Mining firms are seen to be particularly lagging other sectors in transformational innovation: they spend 90% less on technology and innovation compared with petroleum, on a ratio of revenue basis (Ernst and Young, 2015). In addition, much of the innovation that is implemented is influenced by the strong cyclical nature of commodity prices. Most innovation takes place during times of low commodity prices, and involves cost-cutting, so aims for efficiency gains and is of the process upgrading type. During times of high commodity prices, costs in the industry tend to balloon without concomitant increases in innovation (Humphreys, 2015).

By contrast, the automobile industry, as a complex product systems industry, is characterised as a scale-intensive sector. It is led by large headquarter firms and the sources of innovation may be both internal and external to the firm. Complex products are the result of a design broken down into several modules, making them particularly suitable for fragmentation and vertical integration of international production. The modules evolve over time to follow the strategy of the leading firm which controls the design. Accordingly, a first tier supplier able to comply with the high capabilities standards (quality, technology etc.) is contracted by the leading firm or often owned by them. The partnership created is an incentive for upgrading (Humphrey, 1995). However, local firms in the developing economy are often second or third tier suppliers, stuck in the provision of lower value added activities associated with fewer opportunities for upgrading, leading to caution about the potential of such sectors for economic transformation. Nevertheless, the automobile industry has been successful in integrating regional value chains in many countries, suggesting that policies can support different trajectories in the sector (see Section 3.3 for an overview of the automobile industry).

This firm classification is not usually applied to services. That said, because of its characteristics and reliance on hard infrastructure (storage facilities, ports, roads) and technologies (digitalisation, containerisation, transport efficiency), as well as on the transport equipment industry, it seems reasonable to characterise the transport and storage sector as more likely to be supplier-dominated. However, Community Innovation Survey (CIS), which surveys firms every two years to monitor the progress of innovation activity in Europe, found that the proportion of innovative enterprises is generally lower in services than in industry and notes that the share of firms reporting innovation in transport and storage is noticeably lower that the average of the sample.

2.2.2 Resilience in GVCs

Trade integration is a way to reduce risk, increase resilience and help smooth of the impact of local shocks. This has been particularly explored in agriculture and food safety (see Maur and Shepherd, 2015; Engel and Jouanjean, 2014). While theory suggests that spreading risks by diversifying the supplier or seller base can decrease the impact of a shock, this is thrown into question by a series of market failures resulting from bounded rationalities, asymmetries of information and high entry costs. Moreover, the internationalisation of production processes has also increased vulnerability to shocks, from natural disasters to economic crises, as local risks become global risks and vice-versa (OECD, 2013a).

The effect of shocks, and in particular of disasters, on value chains has been documented in relation to climate change and disaster risk management (Hallegatte, 2014) as well as in the analysis of the 2008 global economic crisis. The impacts of a shock on value chains are bi-directional, affecting both backward and forward linkages, resulting in a contagion effect along the chain. On the forward side, suppliers impacted by the shock can no longer supply goods to their buyers, blocking production processes further up. Backward linkages arise when a buyer reduces or completely disrupts its purchases of intermediates following a shock, such as following a disaster; a loss of trade finance; or a change in final demand resulting, for example, from a sudden and significant reduction in purchasing power. Value chains are also known for the "bullwhip"

effect,[14] whereby even small changes in final demand cause large changes in demand upstream in the value chain because of the amplifying effect resulting from coordination failure.

The impact of the shock in the short and longer run is likely to depend on the specific GVC characteristics of the sector and its relationship to other sectors, as well as the importance and the position of the country as a buyer and a seller of value added. This is explored in a series of papers including Acemoglu et al. (2012) and Carvalho (2014), which show that the structure of the production network matters in determining the level of propagation throughout the economy and the aggregate outcome of a microeconomic shock. The former shows that the usual "diversification argument" according to which idiosyncratic shocks would not generate significant aggregate fluctuations doesn't hold in the presence of input-output linkages. Not only might the propagation of the shock through intersectoral linkages lead to aggregate fluctuations, but the structure of the network influences the propagation. In other words, the sectoral structure of the economy matters for aggregate fluctuations. In particular, a microeconomic shock can only have a sizable effect if there are significant asymmetries in the role of different sectors as suppliers to others, directly or indirectly. This is further developed by Carvalho (2014) who emphasises that better understanding the structure of production networks can allow policy-makers to better understand risks and therefore to better manage adverse shocks.

For instance, the extent of the shock might depend on the level of sophistication of the value chain or of one specific task in the chain, acting as a form of vulnerability bottleneck. This is captured by the concept of degree of redundancy (or back-up) in the system (OECD, 2013; Elmqvist et al., 2003; Korhonen and Seager, 2008). Redundancy refers to the idea that other components of the system can substitute for the defective ones. The increased sophistication of tasks and goods reduces redundancies, therefore substitutability, increasing the impact of a shock. After a shock, firms might decide to revise their production strategy to reduce risks across all aspects of their supply chains according to vulnerability bottlenecks; that is, from choice of suppliers of intermediates to the transportation and logistical systems connecting operations, production systems, etc., with the objective of decreasing vulnerability of GVCs and reorienting production and sourcing strategies towards more risk diversification (Dasaklis and Pappis, 2013; Lemma et al., 2015). This change of strategy might impact the structure of the GVCs. Various surveys have highlighted the increasing awareness of firms about risks, as well as the higher frequency of shocks. For instance, services such as the banking system remain concerned about flooding of their data systems, other firms fear disruption of movement of goods, not only in the short run but also as it may impact the firm's reputation and lead to re-shoring or localisation to balance cost savings and risk dispersion in GVCs (CDP, 2014).

Whilst decisions are mainly taken according to supply chain management needs at the firm level, the OECD (2013) highlights the potential role of policies in managing GVC disruption, starting with better public-private co-operation to increase knowledge about the position of the country in the GVC and its vulnerability to domestic as well as international shocks, backward and forward. Recent examples of both types of shocks, natural and economic, and their impact on GVCs have been documented in particular in the automobile industry. They are investigated further below.

This paper draws from these finding to explore the relationship between sectors at the aggregate level, and between countries within sectors. The methodology explores the characteristics of those relationships and their evolution over time, in particular following the 2008 economic crises, by computing and testing an indicator which then provides information about the degree of resilience of the value chain (See Box 3 and Annex C for more details about the methodology).

14. OECD (2013, p 261) "The bullwhip effect is the result of rational behaviour on the part of economic agents confronted with distorted information. The causes are related to lack of co-ordination and communication in the chain, differences in delays for information and material flows, the size of order batching, etc."

Box 3. Methodology and indicators used in the analysis of sectors

The three sectors covered in this paper have specific features in terms of their role in economic transformation, as well as very different positions in GVCs. This allows the paper to highlight the complexity of policy advice for GVCs at more granular levels, it could nonetheless render analysis overly complex. Therefore, whilst the paper acknowledges the heterogeneous characteristics of the three sectors and situates them in the debate over economic transformation and GVC integration, it focuses on the additional information GVC analysis can provide based on TiVA tools.

This paper uses traditional GVC indicators available in TiVA to which it adds new indicators based on the OECD ICIO as well as other databases. Because of their different nature, good or services, the analysis of the M&Q and MV&T sectors can rely on various indicators based on traditional international trade data, and in particular UN-COMTRADE trade data, including data produced by the Economic Complexity Observatory. As a service, it is not possible to use such database for the T&S sector, therefore other databases complement the analysis.

A set of additional indicators is based on social network analysis. They are built upon a mathematical approach based on the computing of the eigenvector of a matrix connecting countries (by sector or not) or sectors. This allows for a more refined analysis of the relative positions and relationships between and within sectors and countries in terms of their relative importance (centrality) in international trade, as well as their sensitivity to shocks and their capacity levels (Annex C).

The first type of indicator is compiled using the OECD ICIO, and uses social network analysis to examine trade in value added in both goods and services. This allows the computing of two indicators, of the backward centrality and the forward centrality of countries or sectors. They respectively provide information about the centrality of a sector or a country in a network as a buyer and a seller of value added. Accordingly, sectors (or countries) that take a more central position play a more important role on the aggregate output of the economy (or the sector) and GVC.

The second type is the Product Complexity Indicator made available by the Economic Complexity Observatory (ECO). The Product Complexity Indicator (PCI) is based on the Economic Complexity Indicator (ECI), which uses international trade data. The use of such data allows for comprehensive and standardised cross-country information; however, it has two caveats. First, it only accounts for exports and not for production and, relying on data from customs offices, it only captures trade in goods and not services. As a consequence, the PCI is only used for the analysis of the M&Q and the MV&T sectors.

Other databases are therefore used to complement the analysis of the T&S, and are presented in the dedicated section. To capture trade costs related to transport and storage the following database are used: Logistics Performance Index (World Bank LPI) and Trade Facilitation Indicators (OECD TFI), the Service Trade Restrictiveness index (OECD STRI), and the Maritime component of T&S the Liner Shipment Connectivity Index (UNCTAD LSCI) and the Ad-valorem equivalent of protection in the maritime transport (CEPII AVE).

3. Sector overview: GVC integration, characteristics and economic transformation of M&Q, MV&T and T&S sectors

3.1 The mining and quarrying sector

3.1.1 Mineral resources: production is determined by geology rather than the business climate and offers few linkages

Growth from mineral resources is generally lower than expected and can be highly volatile, partly because of what is referred to as the "resource curse".15 In some cases, mineral exporting economies are less diversified. This is not only due to the large share of raw materials in their export basket but also to a "crowding out" of other sectors, which characterises the resource curse. Resources-rich countries tend to experience high exchange rates when prices for their commodities are high, making it more difficult to export other products or services. Minerals sectors also compete with other sectors for scarce resources ranging from skilled labour to capital, impeding the development of alternative sectors.

Economic activity in extractive industries is primarily determined by geology and not by the business climate or macro-economic fundamentals. Some countries do not have the capacity to exploit their natural resources domestically and seek investment from large, multi-national firms. As a result, mineral resources bring a level of investment that some host countries are unable to absorb and even regulate.[16] As resource rich

15. Literature on the resource curse is abundant. Useful overviews include Escaping the Resource Curse by Humphreys, Sachs and Stiglitz (Colombia University Press, 2007) or the WTO's World Trade Report 2010: Trade in Natural Resources.

16. OECD, Local content Policies in Minerals-exporting Countries, Part 1, [TAD/TC/WP(2016)3/PART1/REV1].

geographic areas can cut across national boundaries, there could be particular value in regional approaches to enhance capacity development.

Development of the sector over time is also likely to be slower. Mining requires very large, long-term investments which entail substantial risks. Only large firms with secure access to financing can undertake such operations. Thus, a small number of multi-national firms compete on a large scale and account for the vast majority of mining operations.

In most countries, sub-soil resources belong to the State or to its citizens, therefore firms that aim to extract and develop sub-soil resources for profit require government authorisation that often takes the form of a concession or a licensing agreement. As a non-renewable common property resource, many governments have put policies in place that seek to ensure domestic economies are compensated for the exploitation of the resource. Most minerals-exporting countries, for example, charge royalties for the extraction of their minerals. Many also aim to capture some of the gains from extraction of their non-renewable resources through job creation in and around the extractive firm, increased business opportunities and capacity building that, it is hoped, will generate broader economic development.

However, the mining sector often provides little employment in the countries where extraction occurs. Some minerals exporters have tried to increase the value added of their natural resources and create jobs in downstream processing industries by using export restrictions. The rationale is that restricting exports of minerals will help to foster a downstream processing industry, thereby creating more jobs domestically. Other countries use such restrictions to generate revenue; to control illegal exports or the export of illegally mined products; to enhance environmental protection; or to offset exchange rate impacts caused by commodity exports. These are all legitimate policy goals however OECD and other research suggests that export restrictions often do not achieve their desired objectives, in part because the inputs needed to create a successful downstream processing industry are quite different from those needed for mining.[17]

In an attempt to derive more benefits from their resource endowments, and increase linkages with other parts of the economy, some minerals-rich countries have put in place local content and procurement policies (LCPs), especially where a capital-intensive mining sector has developed with few linkages to other parts of the economy. The benefits sought are potentially diverse and include employment generation, supply chain development and technological and knowledge spillovers. Measures that aim to increase local content and procurement in the extractive industries are common, including in OECD countries.[18]

3.1.2 What TiVA indicators tell us about mining and quarrying (M&Q) structure and evolution from 1995 to 2011

The M&Q sector[19] holds an upstream position in the value chain,[20] that is, about 90% of DVA embedded in the sector's gross exports takes the form of intermediate products. The sector experienced a large increase in exports of value added between 1995 and 2011, with an important drop in 2009 due to the global economic crisis. This increase largely reflects the increase in commodity prices but also the entry of new exporting firms in the sector. Figures A1 and A2 in Annex A present a visualisation of the flows of exports of value added by the M&Q sector, representing only the connection between an exporter and its most important export market,

17. Korinek, J. and J. Kim (2010), Export Restrictions on Strategic Raw Materials and their Impact on Trade and Global Supply, *Trade Policy Working Papers*, No. 95, OECD Publishing, Paris.

18. OECD, Local content Policies in Minerals-exporting Countries, Part 1, [TAD/TC/WP(2016)3/PART1/REV1].

19. In the TiVA database, mining and quarrying includes metallic and non-metallic mining as well as oil and gas extraction. Since these are very different sectors in terms of their role in global GVCs, some of this analysis examines only minerals exporters and not oil and gas exporters; this is clearly indicated where it is the case. This methodology is of course suboptimal as it does not make use of the entire TiVA dataset, in particular data for countries that export both minerals and oil and gas. However, splitting the sectors is a major undertaking and outside the scope of this paper. This said, work is underway for a subsequent analysis.

20. Investment flows are excluded from trade in value added analysis.

in 1995 and 2011. The visualisation highlights an increased polarisation around Germany and China, two important manufacturing poles which increasingly became the most important recipients of value added from the M&Q sector from a large number of exporters. China in particular increased its imports in value added substantially from suppliers within and outside its region, creating an intricate web of suppliers and buyers between 1995 and 2011. Interestingly, the US is mostly connected to its region of North America, in particular with Canada – it is both Canada's largest supplier and buyer of value added. This reflects the domestic and regional availability of natural resources, along with the substantial transport costs required to export unprocessed or lightly processed M&Q commodities, limiting the sourcing from other regions. Looking at all flows, shows that additional exports of value added came from the "Rest of the World" (ROW) aggregate, suggesting growth in a number of M&Q sectors in developing countries whose coverage in TiVA is more limited: this means it is not possible to explore changes occurring among this group of countries between 1995 and 2011.

The increasing number of countries exporting value added in M&Q, means that a larger base of countries producing raw materials can better ensure security of supply, pointing to a potential increase in global resilience in the sector. However, the sector is very heterogeneous and even with the entry of new suppliers; some highly specialised commodities might still have narrow markets. One reason for new entrants in the sector has been the sharp rise in commodity prices over the period examined. Although commodity prices have always evolved in a cyclical fashion, the boom over the period examined was particularly marked, with the value of some metals rising 5 or even 10 times during the period. In addition to higher prices, the motivation for new entrants in the sector comes from both expanding demand from traditional sectors (e.g. copper and steel in the construction industry, particularly in China) making the exploitation of more marginal deposits profitable, and from the development of new mineral sectors promoted by the expansion of new technologies in electronics and new environmental goods such as wind turbines and hybrid vehicles that rely more heavily on new materials. Since the lead times between exploration for minerals and actual production are measured in decades rather than years, further changes in exporters of M&Q products can be expected. Additionally, new entrants in the sector may be replacing some current exporting countries to the extent that their existing deposits approach the end of their lifespan.

Figure 1 presents the average evolution of the composition of gross exports, the shares of DVA and FVA content as well as the contribution of services in total exports for LMICs and UMICs included in the TiVA database from 1995 to 2011 (Figures A3 in Annex A present the same information for HICs).[21] The vast majority of value added is domestic and relates to the value added factors used in the sector itself (including the intrinsic value of extracted minerals which is captured in the value of labour, capital and taxes paid in the TiVA database).

High-income countries on average use more services, both foreign and domestic, to produce their minerals exports, and use more foreign goods compared with middle-income countries. Assuming similar economic environments between country groups, this would suggest that, on average, higher incomes M&Q exporters present higher levels of outsourcing compared to other groups of countries[22]. However, this could also result from the need for firms in developing economies to vertically integrate a range of services not available on the local market. Over the time period examined, the DVA share increased in middle income countries but decreased in high income countries. However, a closer look at the evolution of values highlights that shares hide an overall increase in the use of FVA, an effect hidden by the effect of the increase in commodity prices over the period, which inflated the DVA in value and share, biasing the significance of the analysis in shares. This could also be the result of policies aiming at increasing DVA in exports. Finally, it could also a composition effect, as mineral exporters in the dataset are largely high income countries.

21. The TiVA database has data for only one low income country, Cambodia, which is not a resource rich country. It was therefore not considered relevant to present results for this income group.

22. Outsourcing is understood as the reliance of a firm on external service providers instead of producing the service within the firm.

Perhaps most salient is the difference in the composition of value added in exports when comparing oil & gas exporters with minerals exporters (Figure A.4 and A.5, Annex A). Oil and gas exports are comprised almost exclusively of DVA in non-service sectors --about 90%--whilst for mining it is less than 70%. There are various reasons for this. First, rents from petroleum represent a substantially higher order of magnitude compared to minerals. The GTAP model identifies the share of value added by source, including from the intrinsic value of natural resources.[23] In the model, the intrinsic value of the natural resource is set at around 50% of the value added produced in the oil & gas sector compared with less than 20% for mining. Second, services appear to contribute substantially more to value creation in mining compared with oil & gas.

Figure 1. DVA and FVA in Exports, Mining and Quarrying per income group

Figure 1a: Lower Middle Income Countries

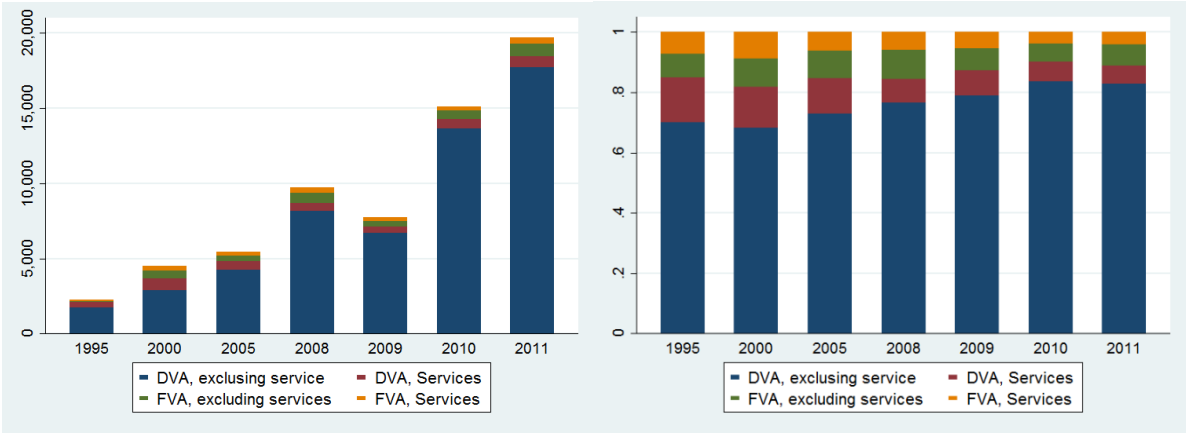
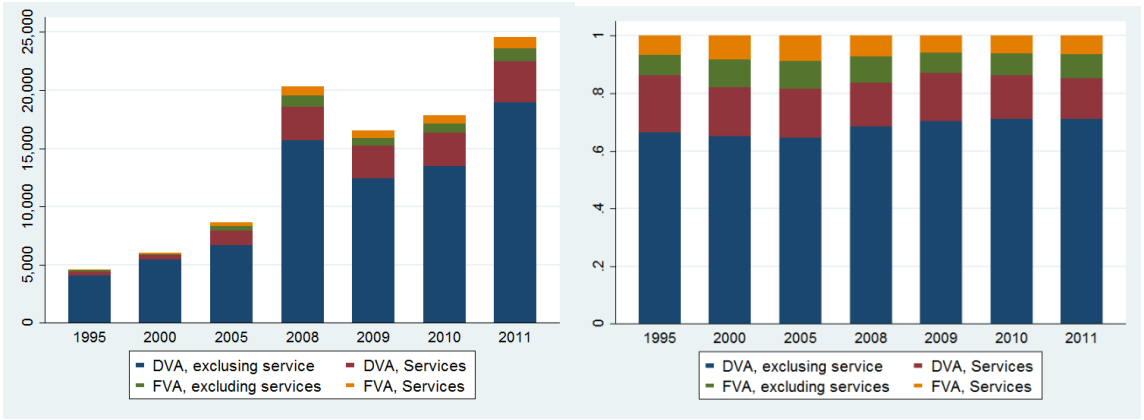


Figure 1b: Upper Middle Income Countries



Source: OECD-WTO TiVA ICIO 1995-2015.

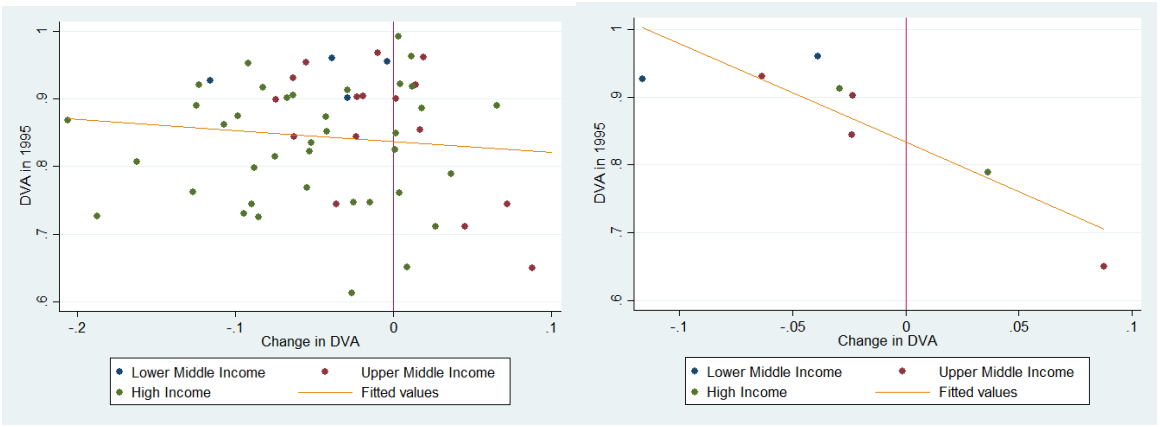
The role of services in the value addition of mining exports, although substantially higher than for oil and gas, remains nevertheless lower than in manufacturing. Close to 20% of the value added in mining can be attributed to services inputs, compared with manufacturing sectors, for which 30-35% of value added is made up of services on average (OECD, 2013). Looking more specifically at the types of intermediates used to produce mining exports, the data suggest that the share of inputs other than the value of the extracted raw material, i.e., services, and factors of production such as labour and capital, have collectively increased relative to the value of the extracted raw materials and that minerals exporters have increased their non-mineral value addition embedded in their minerals exports. This confirms the conventional wisdom that

23. While those figures are averages, imputed for use in modelling, they are nevertheless based on empirical observations.

mining can potentially create deeper linkages with other sectors than oil & gas, in particular with services (this is further explored in section 4.2).

Exploring changes in domestic value added shares over time provides a means to shed light on the impact of integration in GVCs on the share of goods and services produced domestically in value added (Figure 2). The assumptions in the first section of the paper suggests that at early stages of GVC integration, a country first increases the amount of foreign value added used in the production of its exports, resulting in a reduction of the DVA share. Then spillovers from learning by importing result in a second stage during which the DVA share re-increases. If this holds, it would be expected that countries with a high level of integration would tend to increase their share of DVA (positive result on the horizontal axis in Figure 2) while this share would decrease in countries situated at earlier stages of economic development (negative result on the horizontal axis in Figure 2).

Figure 1. Change in DVA share 1995-2011 compare to the DVA share in 1995 – M&Q sector all TiVA countries and only mining exporters



Source: OECD-WTO TiVA ICIO 1995-2015.

Results seem to confirm the theory outlined above, although the large standard deviation around the fitted line suggests the need for caution. Countries presenting a higher share of DVA in 1995 for M&Q have had a tendency to decrease their DVA share over time (positioned on the upper left side of the figure), whilst countries which already had lower shares of DVA in gross exports compared to the rest of the sample, increased it (positioned on the lower right side of the figure).

The heterogeneity of the sector and the diverging trends among types of industries within the sector over the period might have biased the results. The increase in commodity prices over the period might also have artificially increased DVA shares. This is confirmed when clustering the analysis on mining or oil & gas rich countries. Both group of countries present a very different trend. The oil and gas rich countries not only presented larger DVA share in exports than other countries in 1995 on average, but in addition, DVA share increased over the period for most countries except Argentina and to a lesser extent Mexico. Whilst it is not possible to test this assumption in this paper, the decrease in DVA share for those two countries is likely to result from changes in policies. Despite few observations, we can observe that large mining exporters present a very different picture with a much more acute trend and a u-shaped evolution of DVA shares over time when observing changes in absolute terms, indicative of transformation process related to GVC engagement. That is, countries with a higher degree of integration into GVCs in the 90s through a higher use of foreign intermediates for their exports have increased their DVA share, whilst others countries which were poorly integrated in the 90s have increased their integration in GVCs by increasing their use of foreign value added (see Figure 2).

3.2 Motor vehicles, trailers and semi-trailers

3.2.1 Manufacturing and automobile industry: regionally fragmented sector with heterogeneous policy strategies among participating countries

Manufacturing sectors, particularly those with a high technology content such as the electronic equipment and motor vehicles sectors, have long been the focus of GVC analysis. Characterised by complex and coordination-intensive products relying on economies of scale, they have been forerunners of the wave of international fragmentation and optimisation of production processes through GVCs, triggered by the lowering of communication and co-ordination costs around the early 1990s (Sturgeon et al., 2008; Baldwin, 2012). In particular, the unbundling of the automotive or motor-vehicle industry was initiated decades ago, making it one of the most documented GVC sectors.

The automotive industry is a particularly interesting case study for economic transformation strategies because of its potential in terms of technology spillovers, its use of relatively low-skilled labour in assembly activities and potential for employment creation. However, the sector is also subject to important levels of policy intervention around the world. Whilst the following focuses on developing economies, developed economies also engage in considerable policy intervention in the sector. Those policy interventions considerably influence the geography of automotive GVCs and the regional rather than global organisation of the industry. They also explain why finished vehicle trade is less likely to occur between regions and why final assembly usually occurs in the region, if not country, of final consumption (see Van Biesebroeck and Sturgeon, 2010).

As one of the first sectors to unbundle, analysis of the automotive industry can help in understanding the dynamics in other sectors, such as the electronics industry. In the 1970s, for instance, the main source of value added in cars build in Asia came from advanced economies where the knowledge was created. Some Asian countries were subsequently able to increase the domestic content of their products (Baldwin, 2012). However, the automotive industry presents differences compared to other manufacturing sectors (Van Biesebroeck and Sturgeon, 2010). In terms of upgrading patterns, the internationalisation of developing country firms did not arise from a movement from the production of simple labour-intensive components to capital- and technology-intensive components. Instead, local assembly was often the first step, followed by the subsequent development of a parts sector, an example of how GVCs have created new pathways to economic development. This makes the sector particularly relevant for analysis of the evolution of domestic value added over time as a way to identify different stages of integration in GVCs.

However, the automotive sector has also traditionally been targeted as a strategic industry by development planners. Many of the early policy interventions in this sector relied on infant industry protection through import substitution with the aim of building entire domestic automotive supply chains. Some of the resulting indigenous automotive industries subsequently seized opportunities offered by innovations in production processes and further reductions in transport and coordination costs, as well as the lowering of barriers to trade and investment. Some of the traditional, major car producers became the central nodes of international production networks while others, including some newcomers to the sector, specialised in the production of intermediates. (Pack and Saggi, 1997; Baldwin, 2012). Many developing countries currently participate in global auto industry supply chains: some as suppliers of less technologically advanced inputs and assemblers, and others, such as China or South Africa, benefiting from their geographical, size and skill advantages to become more significant players.

Despite this increasing trade in intermediates, the automotive industry remains characterised by a constraining trade and investment environment. Many countries continue to pursue import substitution and restrict investment but with very heterogeneous outcomes. Malaysia and Thailand are two contrasting examples. Both implemented import substitution policies with mixed results before making different policy choices. On the one hand, Thailand created a favourable environment for FDI, reduced barriers to imports of intermediate inputs and encouraged links between foreign investors and domestic component suppliers. On the other hand, Malaysia aimed to maximise domestic content by erecting barriers to imports and remaining relatively closed to FDI. Compared to Malaysia, Thailand's car industry is now strongly integrated in the automobile industry GVC, employs more workers and is deemed more modern (Baldwin, 2012; Wad, 2009;

Natsuda and Thoburn, 2013). Many governments still perceive the auto industry as strategically important and in many countries target the industry with state aid, investment attraction and innovation programmes.

Such policies have had a tremendous impact on the architecture of the modern automotive industry which has been extensively documented in GVC literature. (Sturgeon and Florida, 2004; Van Biesebroeck and Sturgeon, 2010; De Baker and Miroudot, 2012). The motor vehicle value chain is largely organised through a hierarchical structure, with the large manufacturers on top of a pyramid and providing design, branding, and final assembly. The first-tier suppliers produce complete subsystems, which often still require high levels of capabilities and a global presence. These first-tier suppliers then cooperate with a large network of lower tier suppliers and subcontractors. Geography, transport costs as well the political sensitivity of the sector[24] and pressure for local production has resulted in a motor vehicle industry organised regionally and consisting of a large number of suppliers, both local (lower tier suppliers) and global with a local presence (top tier suppliers).

Whilst it is important to highlight the strong influence of policies on the organisation of the sector, this paper does not intend to analyse their effect, but rather to explore, using the OECD TiVA data, the evolution of domestic and foreign content, innovation and upgrading and the role of services.

The automobile industry is also often a case study for analysis of the impact of a shock in the GVC, with the examples of the 2011 earthquake and tsunami in Japan and the floods in Thailand (OECD, 2012; OECD 2013a; Carvalho, 2014). The earthquake and tsunami in Japan damaged production facilities and public equipment, interrupting activities, impacting not only the domestic economy, but also the rest of the world given the central role of Japan as an important producer of higher value intermediates used in automotive GVCs around the world. Honda and Nissan plants in the United Kingdom, for instance, were forced to cut back production. Indeed, the concentration of suppliers was one of the most important reasons for the ripple effect throughout the value chain (OECD, 2013). In a highly disaggregated supply chain, assemblers discovered that following a "two-supplier rule" for key parts was not enough if this rule was not applied consistently throughout the value chain, creating weak links through which the shock could be disseminated.

It is unfortunately not possible to document the impact of this 2011 shock using TiVA as data are not yet available for subsequent years. However, the economic crisis, whilst having a less direct effect than a disaster shock, allows for a comparison of the impact of the shock on the automotive sector compared to the other sectors analysed, both of which have very different GVC structures. The automotive industry was one of the most severely impacted sectors, along with housing and finance, which prompted large-scale government intervention around the world. Van Biesebroeck and Sturgeon (2010) highlight that the credit shortage directly hit an already sluggish sector, with a large impact on assembly and parts plants, but that the effect was largely contained within countries and production regions. Second, they document changes in strategies by lead multinational companies before and after the crisis in a series of countries. This paper provides further evidence of those findings by looking at the impact of the crisis on indicators based on trade in value added.

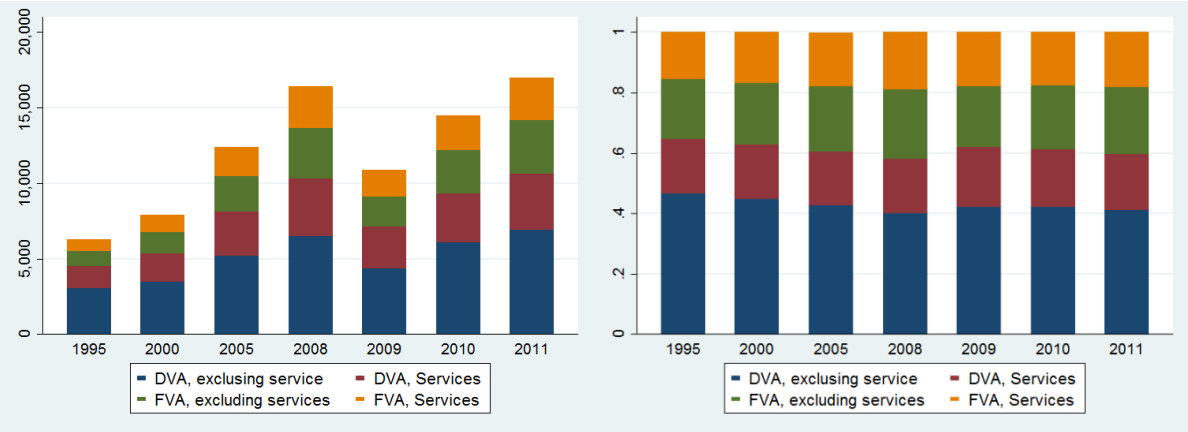
3.2.2 What TiVA indicators tell us about the structure and evolution of the Motor vehicles, trailers and semi-trailers sector (MV&T) from 1995 to 2011

The total value added exported in the "Motor vehicles, trailers and semi-trailers" tripled between 1995 and 2011 (Figure 3). Whilst gross exports increased in value, the share of DVA as well as the share of services in those exports did not significantly change. The trend towards the internationalisation of production in the MV&T sector is clearly visible in Figures A.9 and A.10 in Annex A, which present the most important export flows of value added of the sector per country. This clearly highlights the evolution and strong polarisation around three "factories" to which satellite countries sell MV&T products. In 1995, none of the countries for which data is available in TiVA had China as their most important export market in value added terms. The picture is very different in 2011: the United-States remains the largest buyer of MV&T in value added terms

24. Final assembly stages and vehicles for final demand are still heavily protected in many countries around the world.

from China, but China becomes the most important buyer of value added in the sector for Germany; Hong-Kong, China; Korea; Malaysia; and Singapore. Germany becomes the most important importer of value added in MV&T for an even larger number of countries, taking a central position in Europe, with France diminishing in importance as a destination.

Figure 2. DVA and FVA in exports, in value and share – Motor vehicles, trailers and semi-trailers



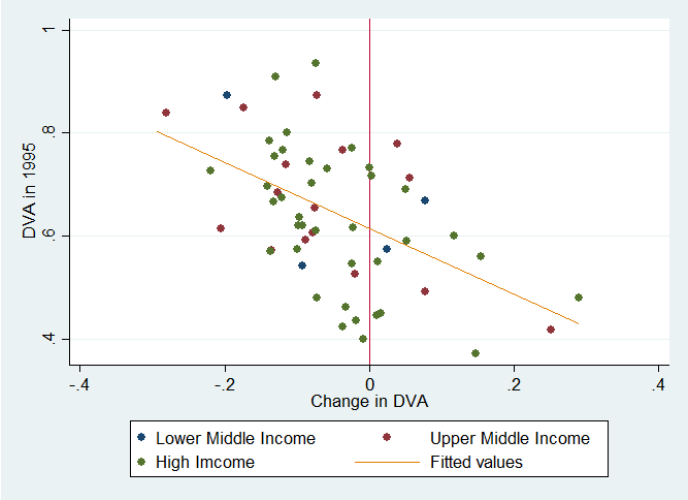
Source: OECD-WTO TiVA ICIO 1995-2015.

The sector presents very different features compared to the M&Q sector. The share of domestic value added in exports represents on average little more than 40% of exported value added. The value and proportions by income groups nevertheless present important differences in dynamics, highlighting different positions in the value chain. High income countries are the most important exporters of value added from the sector on average, followed by upper middle income countries. The dynamic in both country groups seems similar on average, but growth in value added exports after the crisis seems to have recovered more rapidly in upper middle income countries. The average trend for lower middle income countries is very different and, keeping in mind that it represents a much smaller group of countries, highlights a rapid increase in disruption of value added exports by the crisis. Nevertheless, the proportion of FVA and DVA is very similar to that for the other country groups.

Exports in the MV&T sectors are rather evenly distributed between final demand and intermediates and about 60% of DVA is in exports of final goods. A slight increase in the importance of exports in intermediates is observable that could be attributed to the rise of GVCs and trade in intermediates in the sector since 1995.

The evolution of the share of DVA presents much clearer pattern in this sector than in the M&Q sector (Figure 4). Countries that were already well integrated in GVCs in 1995 with a lower DVA share of gross exports seem to have been more likely to increase it over the period. This is further evidence supporting the idea of the importance of FVA as a first step into GVC integration followed then by an upgrading process and increase DVA share, therefore the nonlinear relationship between DVA share and processes of economic transformation and a hump-shape of patterns of export diversification (Cadot et al, 2011). After using GVC integration and foreign intermediates to increase export diversification, economies re-direct their resources on more technology intensive products characterised by higher shares of DVA in exports. (This assumption is tested further in Section 5).

Figure 3. Change in DVA share 1995-2011 compare to the DVA share in 1995 – MV&T sector



Source: OECD-WTO TiVA ICIO 1995-2015.

3.3 Transport and storage

3.3.1 The glue that binds GVCs together

Transport and storage services (T&S) are at the core of trade. Simply put, without transport and storage services, there is no movement and trade in tangible goods. Lower trade logistics costs, and in particular transport costs, have been drivers of unbundling. Every additional day required to get products through the border can reduce trade flows by as much as 4% (OECD, 2014a). Behind the border trade costs are also still an important impediment to trade. While good quality infrastructure matters, efficient trade logistics services are also key, but these services are often constrained by domestic regulations. Indeed, the elimination of barriers that protect transport and communication services may even be quantitatively more important than the elimination of import duties (Jouanjean et al., 2016, for an overview of the academic literature; WEF, 2012).

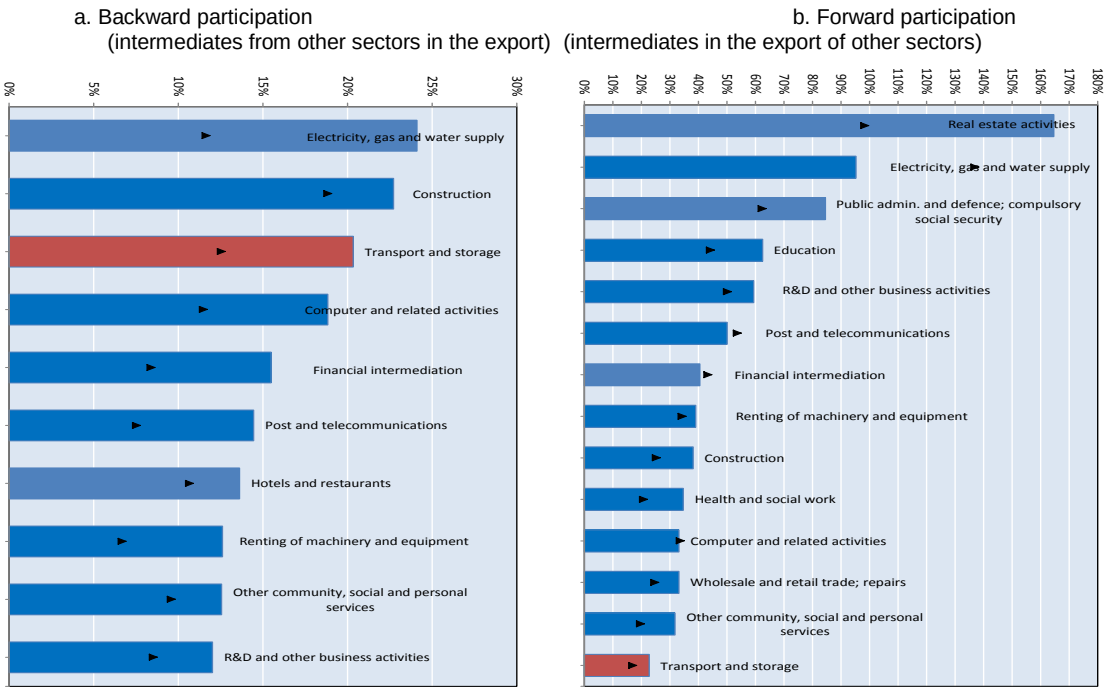
Trade costs remain high in developing countries, a number of which are landlocked or islands and therefore heavily dependent on efficient transport and storage operations to link with world markets, domestically as well as in their neighbouring and gateway countries. (Borchert et al., 2012; Shepherd, 2011). T&S sector has a particular position in the value chain as it is associated with any movement of goods as well as being, itself, a consumer of inputs. The sector also plays a pivotal role as a conduit for the development of domestic and global value chains (Engel and Jouanjean, 2015 and Jouanjean et al, 2015). Shipping quickly, cost effectively and reliably is central to the just-in-time modes of production which characterise many GVCs. The leading role that logistics services play in the development of GVCs has led Aid for Trade initiatives to place more emphasis on reducing trade costs in developing countries to promote inclusive and sustainable growth.

T&S is further investigated by focusing specifically on maritime transport, as most international trade continues to be transported by sea. In developing countries, around 90% of the volume of goods exchanged with the world is transported by sea (UNCTAD 2016). Port services therefore play an important role in the final prices of many products. Competition in maritime ports and transport services is critical for countries with significant volumes of maritime-based trade. Therefore, the analysis in subsequent sections focuses on how attributes of liner shipping 'connectivity' (number of connections of transhipment, container size etc.) relate to the centrality of a country in the T&S sector, but also to the integration of T&S with other sectors. The determinants of liner shipping connectivity, in particular the regulatory environment in maritime transport, are also explored.

3.3.2 What TiVA indicators tell us about the structure and evolution of the Transport and Storage (T&S) sector from 1995 to 2011

Trade in value added in transport and storage is strongly correlated with trade flows as it is, by itself, the means to move goods between countries.[25] Because it is about the movement of people and goods, including across borders, transport and storage services lend themselves readily to international fragmentation, and are observed to have a higher reliance on imported intermediate inputs and thus higher foreign value added content in exports (see Figure 5a). However, although T&S sector is used in the movement of all exports, it has lower forward participation than other sectors.[26] This is to be expected as forward linkages represent the importance of trade logistics costs in final demand. As a logistic service, the importance of T&S in the final good influences levels of competitiveness of exports and the objective of exporters is therefore to minimise their proportion in exports.

Figure 4. GVC participation by services sector (2011) and level in 1995 (black arrows)



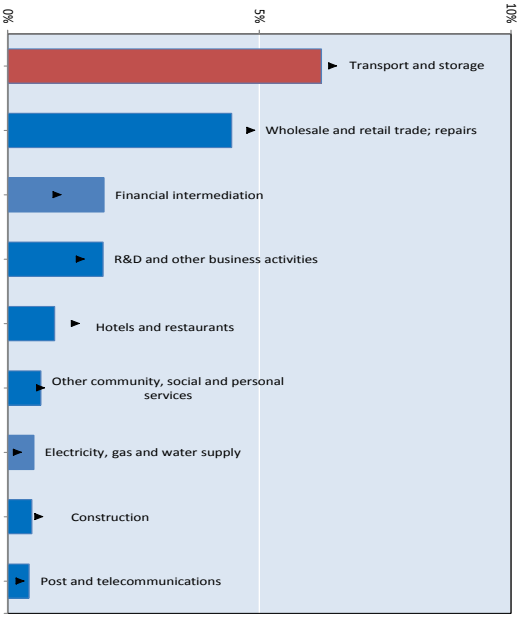
Source: Own calculations using OECD-WTO TiVA ICIO 2015.

25. For T&S, the forward link being measured reflects the T&S component in goods trade, while backward linkages capture the FVA in the supply of T&S services themselves. Therefore the value of T&S across countries is a proxy for the movement of goods, but does not say anything about the gross value, nor the value added, embedded in the flow. In other words, it does not highlight the value dimension of the goods being transported and stored and does not provide information about the importance of the creation of value added between countries.

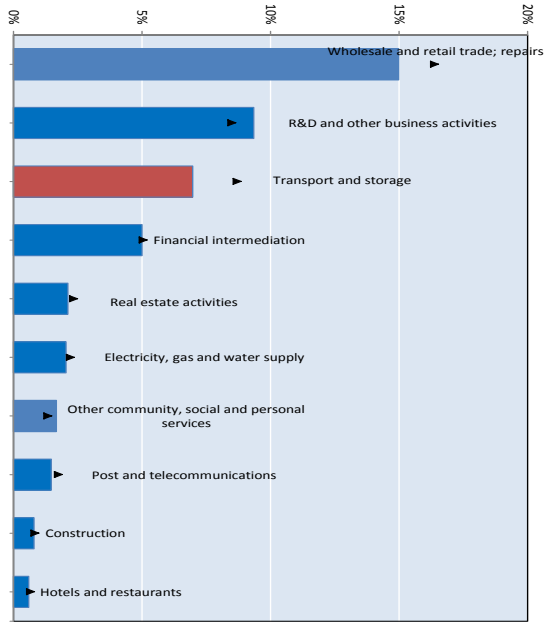
26. One should note that supply-use tables (SUT) use purchaser prices and therefore does not record the T&S cost from the factory to buyer (industry for intermediate or consumer for final good), and could then miss a significant contribution in the forward integration. However in TiVA with the transformation from supply use tables to input output tables (IOT) in basic prices, this has been corrected by extracting the transport margin from sectors to reallocate it as an input of the T&S sector into other sectors.

Figure 5. Purchasing and selling services sector shares of GVC trade (2011)

a. Value added in exports by destination sector (share of total value added in exports traded)



b. Value added in exports by originating sector (share of total value added in exports traded)



Note: The right panel (a) shows the foreign value added in exports by buying sector (backward linkage) divided by the sum of traded value added in exports. The left panel (b) shows the foreign value added in exports by selling sector (forward linkage) divided by the sum of traded value added in exports. The denominator is therefore the same in both expressions.

Source: Own calculations using OECD-WTO TiVA ICIO 2015.

However, the ranking changes when looking at the share of total value added in exports traded (Figure 6). In 2011, over a third of foreign value added purchased by service exports was purchased by the transport and storage export sector (Figure 6a). The same year, transport and storage represented roughly 15% of value chain sales (Figure 6b). Comparison between Figure 5 and Figure 6 shows that T&S services, while not the most important services in terms of inputs to produce exports, are the most traded valued added service, central to the functioning of GVCs. [27]

The flows of transport and storage value added are concentrated around two major industrial producers, China and Germany (Annex Figures A.15 and A.16); that said, transport hubs (e.g. Singapore) or homes of important international freight companies (Denmark) are also important.

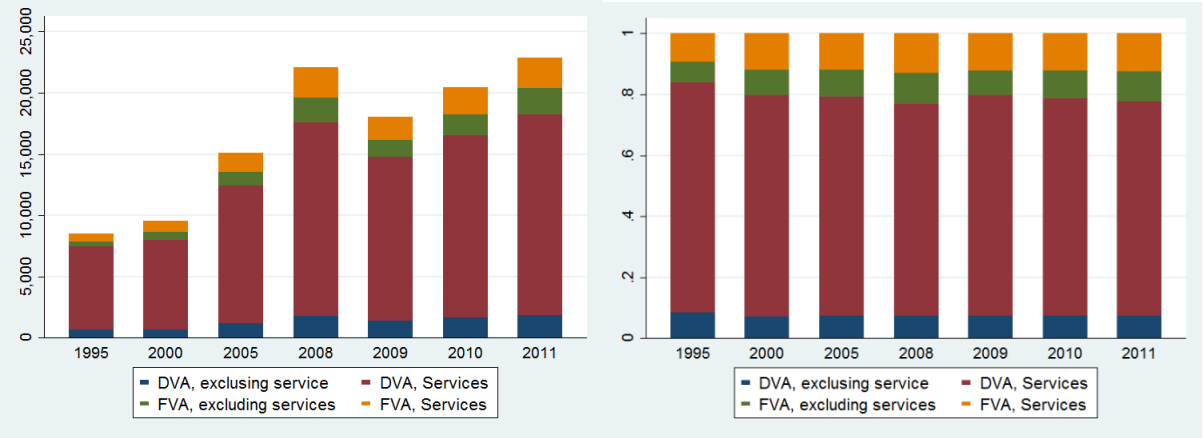
On average, the exports of value added in T&S increased threefold over the period 1995 to 2011 with the visible impact of the crisis in the decrease in trade in 2009. Despite being one of the most integrated service sectors, compared to manufacturing sectors, exports from the T&S sector have high proportions of DVA, even more so than for mining and quarrying, representing more than 80% of exports in value added in 1995 with a light decrease over the period. The T&S sector is the service with the largest consumption of value added both in value and in share.

By income group, exports of value added in the sector experienced a jump between 2005 and 2008 for the lower middle income countries identified in the TiVA database, similar to that observed in the automobile industry (Figure A.19 and A.20 in Annex A). The shock of the crisis has a longer tail for this group of countries. The increase in value added exported by the upper middle income countries is much smoother over the period and the trend is only affected by the crisis in 2009. The pattern for high income countries is more

27. The Figure 6b also showed that a decrease for all services in their share as origin sector in total export traded, this is mostly imputed to the highest share of natural resources as origin sector with the boom in oil prices.

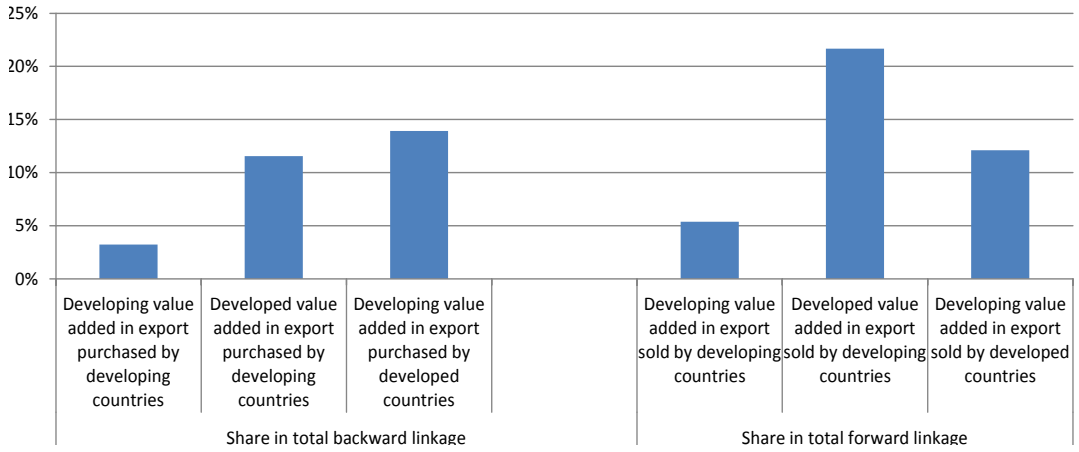
flat, as they were already well integrated, but the crisis also has a longer tail than for the upper middle income countries. Finally, the share of DVA is about the same among these groups of countries on average, and is evenly shared between final and intermediate demand.

Figure 6. Domestic and foreign value added in exports – Transport and Storage



Source: OECD-WTO TiVA ICIO 1995-2015.

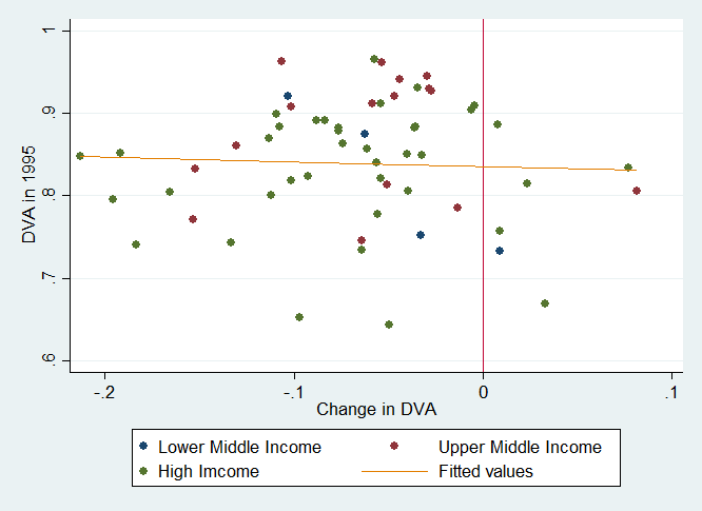
Figure 7. Purchases and sales of value added of transport and storage services in 2011



Source: Own calculations using OECD-WTO TiVA ICIO (October 2015 revision).

Interesting interactions arise when looking at value chain trade in terms of purchases and sales in T&S services. Figure 8 displays the share of purchase and sales of foreign value added according to categories of trade partners as either developed or developing economies. First, value chain trade in this sector mainly occurs between developed economies. Flows between developed economies represent 70% of purchases and 61% of sales of value added in the sector in 2011. By contrast, trade between developing economies represents less than 5% of total value chain trade. However, sales of developing economies to developed economies represent over 20% of all flows. Therefore it is worth looking at how developing countries can better engage in the sale of T&S VA to developed economies.

Figure 8. Change in DVA 1995-2011 compare to position in 1995



Source: OECD-WTO TiVA ICIO 1995-2015.

The evolution of the levels of DVA from 1995 to 2011 does not present any clear patterns. Most countries in TiVA seem to have experienced a decrease in DVA that could indicate the evolution of the sector -- innovation and increasing digitalisation of services such as banking and insurance activities, making some services easier to disaggregate and trade, has further supported the use of FVA in the T&S sector (Figure 9). Therefore, rather than information about stages of economic transformation, the evolution of the FVA content in the T&S sector might highlight the trends of creation of GVCs in services with technological progress enabling new trade in tasks in services.

4. The importance of sectors and countries as sellers and buyers of value added: evolution of the centrality of sectors and countries over the period 1995-2011

In this section, indicators using network methodologies are used to better understand the position of the three sectors relative to other sectors as well as the position of countries within each sector in the period 1995-2011. Network Analysis is a methodology particularly suited for GVC analysis (Miura, 2012). It allows indicators of centrality to be calculated which are analogous to GVC indicators of backward and forward participation. They respectively capture the centrality of the sector – or the centrality of a country – as a buyer (backward centrality) and seller (forward centrality) of value added. The methodology used to create those indicators is briefly described in the next section and further explained in Annex B.

Subsequent sections then focus first on sectors and analyse their respective positions at the aggregate level. The analysis is then narrowed down to the sector level and focuses on the position of TiVA countries as sellers and buyers of value added in each sector of interest. In particular, various assumptions are tested about the structure of GVCs and their resilience to shocks, using the economic crisis as a form of natural experiment. While further analysis is necessary to unpack these effects,[28] the analysis provides some preliminary evidence about the importance of taking into account the structure of a GVC (horizontal or vertical integration as respectively characterising sectors with relatively few specialised suppliers, and horizontal markets which feature more, less specialised suppliers) and the position a country holds within the GVC to better anticipate the potential consequences of a shock in direct and indirect partner countries in the short and longer run.

28. In particular by exploring firm level analysis to better understand firms' strategies and in particular their risk mitigation strategies.

4.1 Using network analysis of trade in value added to better understand the position of sectors and countries in the value chain

Network analysis applied to GVCs enables the creation of indicators capturing both the number of linkages between countries and the volume of trade in value added that is embodied in those links. In this way, how 'central' a sector or a country is to a GVC for a particular sector – as a seller of intermediates for the production of exports of a particular product, or as a buyer of this particular product as an intermediate for the production of exports – can be depicted.

Different centrality can be calculated according to the "node" of interest in the network. A node can be a country, a sector, or a country-sector. In this paper, centrality is depicted in two different ways and applied to the data in order to see the centrality of countries for particular sectors, as well as of the importance of sectors compared to others in the economy. That is:

1. The **backward centrality**, or **'buying for export' centrality of a country for a sector** captures the importance of a country as a buyer of value added in intermediates of a particular product for the production of its exports. It captures both the number of interactions and the size of those interactions. The backward centrality measure accounts for the number of countries from which intermediate products of interest are purchased. The importance of each relationship from the selling country to the buying country is captured – weighted – by the share of value added this flow represents over the total value added of the product of interest exported by the selling country. For example, a country will be a central buyer of MV&T value added if it has a relatively large number of suppliers, and purchases relatively large volumes of MV&T value added as intermediates for the production of its exports. This metric sheds light on how central a given country is to the GVC of a given product. Applied to the sector level, it captures information about the importance of each sectors of the economy as buyers of value added in intermediates produced by the sector of interest for the production of exports. The relative importance of the flow of value added from the selling sector to the buying sector – the weight – is given by the share of value added this flow from the selling sector to the sector of interest represents, compared to the total value added in intermediates originating from the selling sector.
2. The **forward centrality** or **'selling for export' centrality of a country for a sector** captures the importance of a country as a seller of value added in intermediates (from all industries) for the production of exports of a specific sector, for instance MV&T. Again, the concept is the importance, or centrality of a country, as a seller of value added in intermediates (from all sectors – from agro-food intermediates, to services to manufacturing parts) for the production of exports of a certain sector of interest. The importance of the seller-buyer relationship is captured – weighted – by the share of value added it represents compared to the total of intermediates bought by the buyer of intermediates from all sellers. For example, this metric captures the importance of a country as a seller of intermediates to other countries producing MV&T for exports. At the **sector level**, it captures information about the importance of the sector or interest as a seller of value added in intermediates to other sectors for their production of exports. The relative importance of the flow of values added, the weight, is given by the share this flow represents compared to the total value added in intermediates used by the buying sector for the production of exports.

The use of the eigenvector centrality presents results and features slightly different from the traditional TiVA indicators. First, while the importance of value added exchanged in size terms still matters, it does not uniquely define the centrality of a sector (or a country). Using raw flows would indeed result in a focus on large trading sectors or economies. While it is undeniable that those are an important feature of the network, small sectors or economies might still be very well connected to international trade networks in a value added setting.

A second interesting feature of computing the eigenvector of a network is for the analysis of resilience to shocks.[29] The higher the centrality of a sector or a country in the trade in value added network, the higher the sensitivity to both positive and negative shocks. However, it is important to keep in mind that the eigenvector is an indicator of the situation of a network at a certain point in time and it provides an indication of the likely impact of a shock at that exact time (that is, with the relationships that existed at that time). It does not by itself give any information about how the network might reorganise for the period following the shock (the new relationships that may be created because of the shock), reorganisation which will depend on the nature of the value chain. It is, however, possible to monitor the evolution of the eigenvector over time and, according to exogenous parameters, in particular economic shocks, to get a better sense of the evolution of the structure of the sectors and in particular of the position of different actors in the chain. Exploiting differences across sectors can therefore shed light on different responses to economic shocks in GVCs of differing structures.

Box 4. What the eigenvector tells us about resilience of GVCs

In tangible terms, the calculation of the eigenvector corresponds to the following. Consider a dollar is injected in a network from a sector *i* (called a node in network analysis). The dollar can then be passed on to another sector to which *i* is connected, a neighbour. If *i* has more than one neighbour, then the dollar has a certain probability to be found in one of the neighbouring sectors. After a few steps, it is possible to get a probability distribution of where the dollar might be. The eigenvector represents the probability that the dollar arrives at a certain node after an infinite amount of steps. As such it provides a tool for shock propagation as a long-term phenomenon (for example, if that dollar was not to be sent, or if a buying country was to stop buying the final good). Thus, such measures while being consistent with the notions of vertical integration in GVCs, explain different aspects of the relationship. As presented by Shepherd and Archanskaia (2014), it is therefore possible to show that the eigenvector represents the economic value of an extra dollar of value added traded injected at a random point in the network analysed and allowed to flow through all possible nodes. This feature of the eigenvector can be used to analyse the resilience of the value chains, by seeing what happens if it breaks at a certain point.

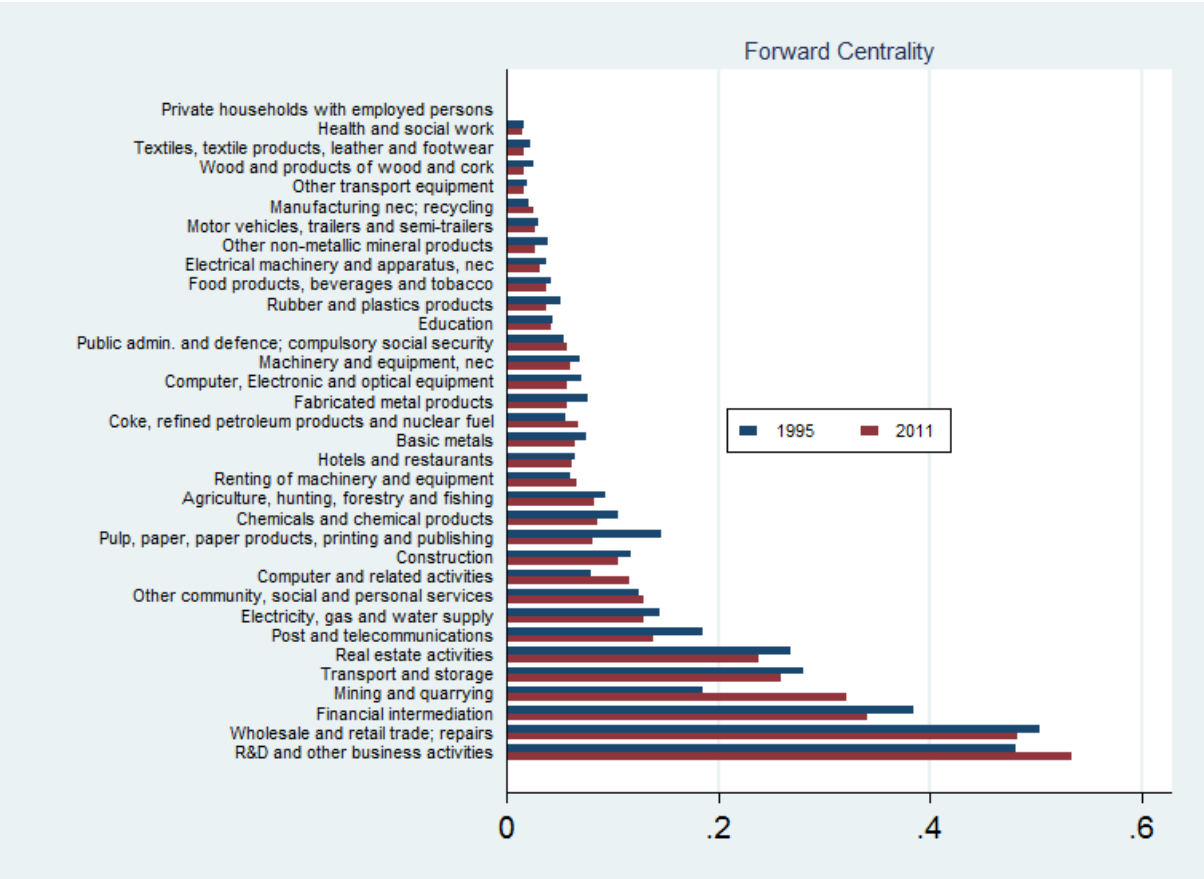
In terms of economic development paths, two things need to be taken into account: first, the impact of short term shocks according to the position in the value chain, which are larger for higher levels of centrality; and second, and maybe more damaging, the potential longer run impact resulting from the potential reorganisation of the value chain after a shock. This second type of impact is likely to be sector specific and depends on the characteristics of the integration in the value chain that can partially be identified according to the eigenvector. The assumption tested in the following analysis is that, whilst a shock is higher for more central nodes in the short run according to the structure of the value chain at the time of the shock, its consequences can actually be higher for peripheral nodes in the longer run if the shock results in a change of strategy of the value chain actors and a reorganisation of the value chain and production processes. This change would be captured by the change in respective centrality of sectors or countries in subsequent years.

4.2 Sector centrality – the relative importance of sectors as buyers and sellers of value added

In order to better understand the position of the three sectors studied in this paper, the following section looks at their relative position among other TiVA sectors at the aggregate level in the world economy as buyers and sellers of value added (Figures 10 and 11 and Annex A and Figures A.19 and A.20 for an histogram presenting changes over the period), with the objective of gathering first impressions, on average, of the relative importance and sensitivity of sectors in the global economy. As expected, the three sectors take very different positions, as buyers and sellers of value added for the production of exports. But most notable is the increasing importance of services as sellers of value added.

29. In network analysis, the centrality of a node, in this case a sector or a country, is based on a random walk model. A random walk starts at a node *i*, randomly chooses a neighbour j, moves to j and repeats the process from there. Each step, assuming that each node has more than one neighbour, increases the choices of random walks. After a few steps, various paths might have been taken, each of a probability determined by the characteristics of the network. Ranging between zero and one and respecting P i∈C v(k)i = 1them leading to a node with a probability determined by the characteristics of the network. Ranging between zero and one and respecting P i∈C v(k)i = 1.

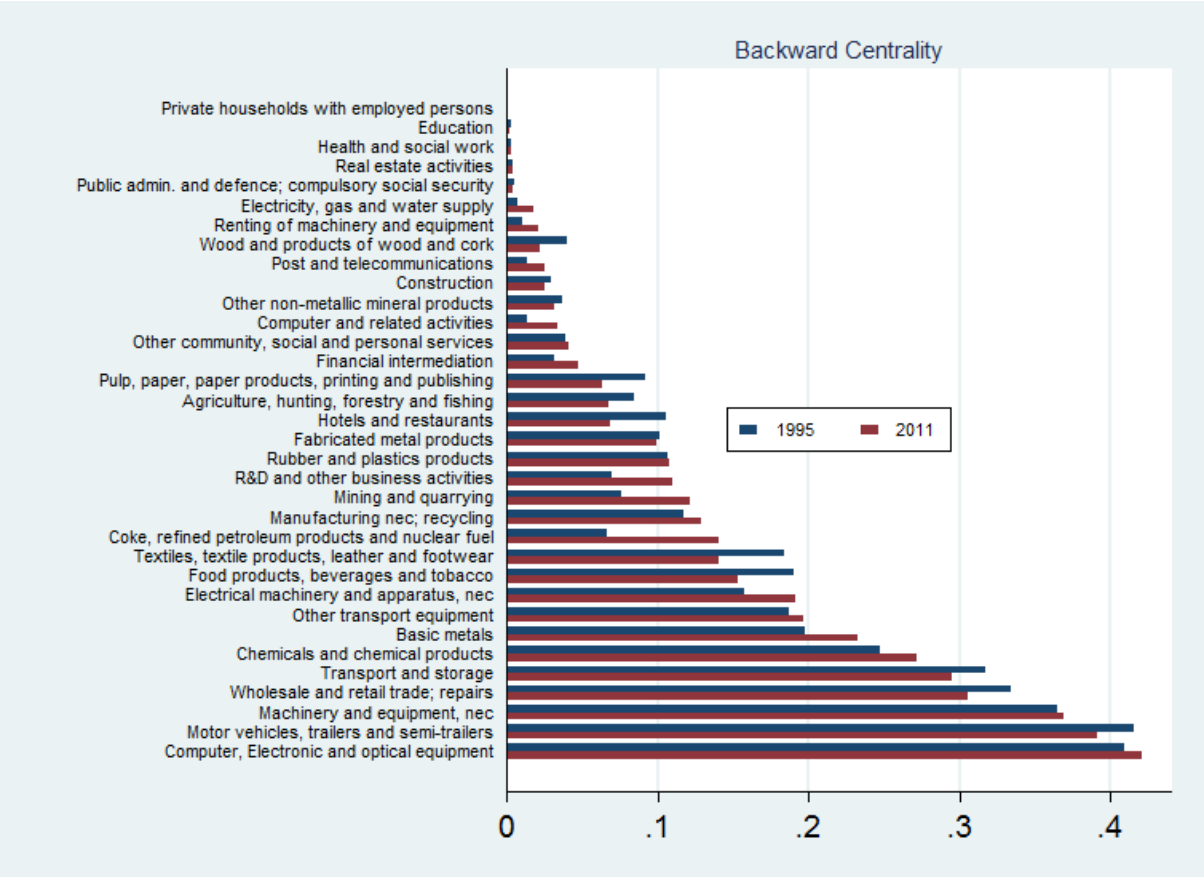
Figure 9. Importance of sectors as sellers of value added to other sectors – sector forward centrality 1995 and 2011



Source: Author's own calculations using OECD-WTO TiVA ICIO 1995 and 2011.

The relative position of the TiVA sectors as sellers of value added (forward centrality) reflects the importance of services in GVCs. R&D and other business activities appears as the most connected sector in the economy. M&Q is in fourth position in 2011 with an important change in position compared to 1995, partially explained by the increase in commodity prices over the period. However, the M&Q sector is very heterogeneous and brings together the extraction of crude petroleum and natural gas as well as the extraction of ores which are primary intermediates in many sectors. As previously highlighted in the section looking at TiVA indicators for the M&Q sectors, there have been many new entrants in the sector, both in terms of countries and products, with an increasing use of various minerals and metals in high tech industries. T&S follows M&Q in fifth position as a seller of value added in 2011. Finally, MV&T is at the very end of the ranking, consistent with its position close to final demand.

Figure 10. Importance of sectors as buyers of value added from other sectors – sector backward centrality for all sectors 1995 and 2011



Source: Author's own calculations using OECD-WTO TiVA ICIO 1995 and 2011.

The backward centrality indicator provides information about the importance of a sector as a buyer of value added. Consistent with similar analyses, the most connected sectors are *Computer, Electronic and optical equipment* followed by MV&T. T&S takes again the fifth position and M&Q is positioned around the median.

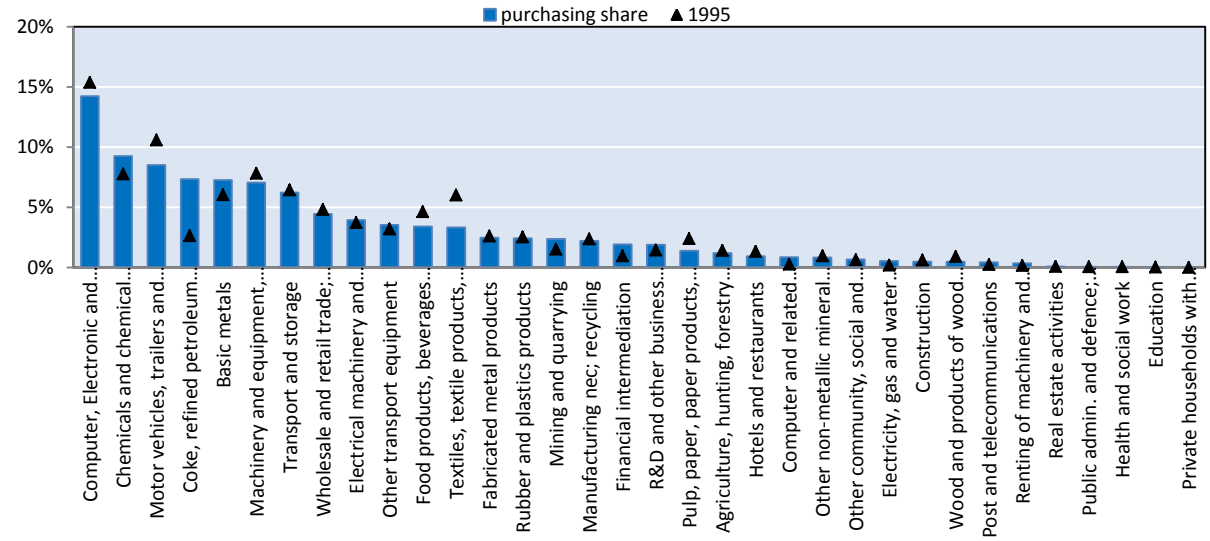
These results, whilst still consistent with traditional TiVA indicators, provide a new perspective on the importance of these sectors in the economy and for the production of exports in other sectors. This is particularly the case for M&Q and T&S. First, as expected, M&Q has a relatively high position as a seller of value added. More surprising is the position of the sector at a relatively higher position than expected as a buyer of value added. The same observation holds for T&S sector which takes the fifth position both as a buyer and a seller of value added.

This difference is better understood when looking at the importance of the sector as a seller and buyer of value added in proportion to the value added traded globally.[30] In 2011, over a third of foreign value added in exports was purchased by three sectors: electrical equipment, chemicals and motor-vehicles (Figure 12). By contrast, the originating sector for these purchases, the selling sectors, are very different: M&Q, wholesale and retail, R&D and business services and T&S, represent together close to 50% of sales into GVCs (Figure 12b). Purchases are therefore dominated by the manufacturing sectors but sales tend to be by service and natural resource sectors.

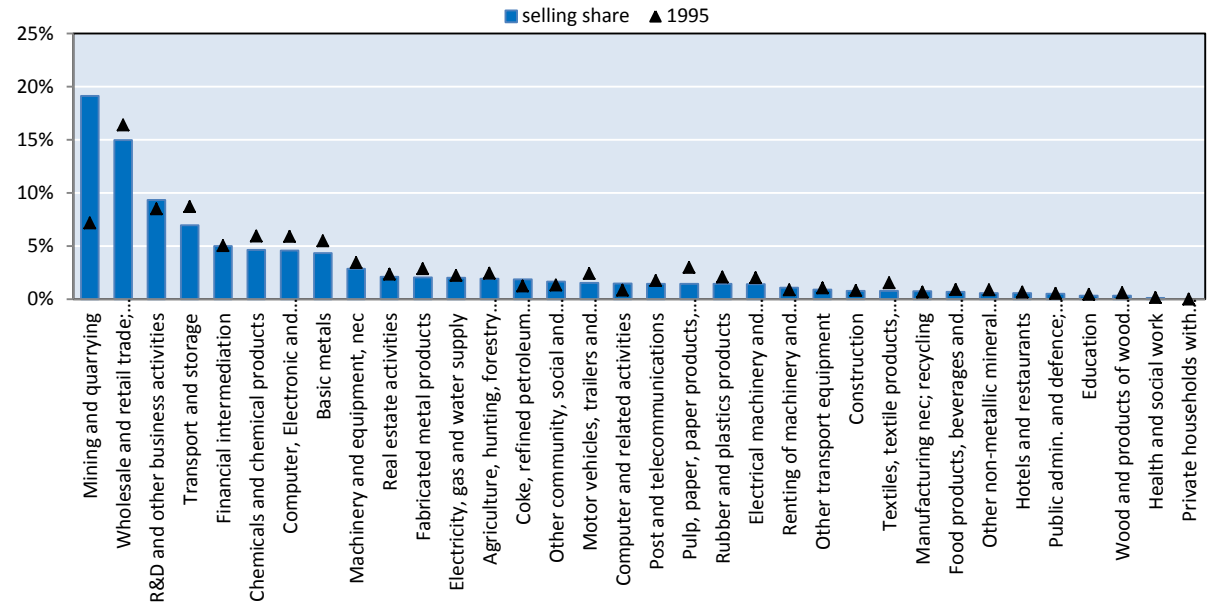
30. See also Figure 1 and Annex A Figure 2.

Figure 11. Purchasing and selling sector shares of GVC trade (2011)

A- Share of total value added exported by destination sector (percentage of total value added exported bought by the sector)



b. Share of total value added in purchased exports, by originating sector (percentage of total value added exported sold by the sector)



Note: The top panel (a) shows the foreign value added in exports by buying sector (backward linkage) divided by the sum of traded value added in exports. The bottom panel (b) shows the foreign value added in exports by selling sector (forward linkage) divided by the sum of traded value added in exports. The denominator is therefore the same in both expressions.
Source: Own calculations using OECD-WTO TiVA ICIO 2015.

The centrality indicators combine those two dimensions, traditionally captured by two different TiVA indicators, and give a more nuanced image of the importance of sectors in the economy. This is highlighted in the case of the T&S sector: while the forward linkages (intermediates in the export of other sectors) seems rather low compared to other service sectors, it is still an important seller of value added in proportion to value

added traded globally, making the sector central in the economy as a seller of value added. In other words, analysis in terms of centrality highlights that, whilst representing a small proportion of the foreign value added in exports, it still represents a large part of value added in volumes, split among a large number of transactions, making the sector central as a seller of value added through the frequency of transactions. Once again, this is not surprising, as any movement of goods between countries requires services from the sector. The position as buyer and seller of value added and the changes in relative position and different sensitivity of sectors according to the type of GVC indicators underscores their different GVC structure suggesting those sectors might react very differently to shocks in the short and longer run.

Figures 10 and 11 (and Figures A.23 and A.24) show the changes in sector centrality value between 1995 and 2011. Observing changes in eigenvector per sector between 1995 and 2011 captures the relative change in position in the network. However, they should not be taken as face value and only as a representation of a relative movement compared to other sectors. In addition to technological innovations that can change the importance of a sector in other sectors' production processes, the change in position of a sector can result from various other trends: it can be the consequence of a change in relative terms of trade between sectors, or of a deeper GVC integration in some sectors, resulting in larger trade in value added flows and increasing their importance in trade in value added.

The M&Q sector shows a large increase in centrality over the period relative to other sectors, both as a buyer and as a seller of value added. The observed increased centrality can result from both an increase in supply and an increase in unit value.[31] For the same indicator, the sector *Coke, refined petroleum products and nuclear fuel* for which the M&Q sector is the main supplier of intermediates, presents a more subtle change in position as a buyer relative to other sectors but the most important change as a seller. Keeping in mind that those changes are in relative terms compared to other sectors, the fact that the M&Q sector increases in centrality both as a buyer and as a seller of value added, and the comparison with the *Coke, refined petroleum products and nuclear fuel* sector highlights that this movement was not only the result of a shift in prices, but also the result of an increased integration in GVCs and the multiplication of suppliers. This substantial change between 1995 and 2011 may also illustrate the large increase in purchases of goods and services by the mining industry in boom times. This is also reflected in huge increases in costs during periods of high commodity prices such as the period examined. Between 2000 and 2011, the cost of extracting copper increased by over 300% in cost per tonne of extracted material (C1 copper cost curve). This specificity of the mining sector is due to the geometric progression in costs required to extract larger amounts of minerals in a given time. As commodity prices rise, so does the incentive to mine less concentrated deposits (lower ore grades); costs, and the necessity for greater inputs of outside goods and services, rises exponentially.

Although remaining the second most central sector, the MV&T decreased its relative centrality as a buyer of value added over 1995 to 2011, whilst the centrality of other high-tech sectors, such as R&D and *other business activities* and *Computer and related activities* increased. This evolution underlines the growing importance of those sectors in the world economy and their pervasiveness in other sectors with the increasing technology content of goods and services and the development of the digital economy over the period. As a sector close to final demand, it is not surprising that its position as a seller of value added did not significantly evolve.

4.3 The centrality of services

The analysis of the two centrality indicators –backward and forward centrality – developed in this paper confirmed previous GVC analysis and highlights the importance of services as a seller of value added.

Services have always been central for the functioning of value chains and trade, with the private sector referencing the role of services in facilitating coordination between sellers and buyers as support services: including logistics services but also trade finance and other business services. Trade in value added analysis

31. Bearing in mind that those sectors cover a wide range of heterogeneous commodities, from crude oil to precious ores.

has enabled a better appreciation of their importance that the lack of data for trade in services and analysis of gross trade based on customs data were previously underestimating.

Nonetheless, services have also increased in importance in supporting GVCs. In particular, two service sectors have a high centrality position both as buyers and seller of value added and appear as the sectors tying GVC nodes together: *Wholesale and retail trade, repairs* and T&S. As a seller of value added, T&S is a core service, allowing value added produced in other sectors to move from one destination to another. Wholesale and retail trade, repairs is an intermediary connecting buyers and sellers. However, the centrality of both sectors relatively decreased which, among other things, could reflect a decrease in the cost of those sectors relative to others. For instance, while the T&S sector connects sections of value chains and therefore has increased in importance for the organisation of production, it is also the increase in efficiency of this sector and the decrease in transport costs that has enabled the second unbundling. As support services for trade, the reduction in cost of T&S has been an important feature of GVC integration. Therefore, while increasing in importance in final products according to their level of GVC integration, the decrease in prices in that sector compared to others resulted in a decrease in the overall relative position compared to other sectors. Wholesale and retail trade, repairs also evolved tremendously over the period analysed. First, services liberalisation allowed an increase in competition but also the sector is experiencing a digital revolution with the development of online retail (e-tail).

Unpacking the consumption of intermediates for the three sectors analysed sheds further light on the importance of trade support services. This is particularly visible for M&Q which is often only presented as an upstream sector and mostly as a seller of value added. While the indicator confirms the importance of the sector as a seller, it also has a relatively central position as a buyer of value added and in particular in services. The six most important sectors supplying intermediates for the production of value added for exports in M&Q are services: *Wholesale and retail trade, repairs*; *R&D* and *other business activities*; T&S; *Financial intermediation*; *Electricity, gas and water supply and Real estate activities*. As an extraction sector using heavy machinery, it is not surprising to see that it is also a heavy consumer of energy, not only relying on the supply of electricity but also *Coke, refined petroleum products and nuclear fuel* (Table 1). The distribution across services from different sectors is relatively similar in most minerals-exporting countries (OECD, 2015d)

Table 1. Consumption of intermediates for the production of exports: 10 more important sectors in VA

2011

Mining and Quarrying		Transport and storage		Motor vehicles, trailers and semi-trailers	
Sector	(Million USD)	Sector	(Million USD)	Sector	(Million USD)
Wholesale and retail trade; repairs	9896	Wholesale and retail trade; repairs	109317	Wholesale and retail trade; repairs	149680
R&D and other business activities	9181	Mining and quarrying	93201	R&D and other business activities	84121
Transport and storage	8460	R&D and other business activities	77181	Mining and quarrying	48900
Financial intermediation	6790	Financial intermediation	58776	Transport and storage	44971
Electricity, gas and water supply	3511	Coke, refined petroleum products and nuclear fuel	34459	Basic metals	42591
Real estate activities	3204	Real estate activities	33921	Fabricated metal products	36574
Machinery and equipment, nec	3034	Other community, social and personal services	23419	Machinery and equipment, nec	33752
Construction	1783	Post and telecommunications	21455	Financial intermediation	33253
Coke, refined petroleum products and nuclear fuel	1526	Electricity, gas and water supply	20461	Rubber and plastics products	27620
Chemicals and chemical products	1490	Renting of machinery and equipment	15637	Real estate activities	23929

Source: Author's own calculations using OECD-WTO TiVA ICIO 1995 and 2011.

Examining the structure of value addition in minerals suggests potential growth sectors for minerals exporters: the M&Q sector can be contrasted with the other two sectors studied in that backward linkages are fewer and less deep. There are simply less opportunities for integration in GVCs for minerals exporters as compared with other sectors. Apart from the mining activity itself, only two other sectors represent over 5% of the total intermediates used for production: *wholesale and retail trade and repairs*; and T&S and overall, services are prevalent with eight of the ten main contributing sectors being services.

However, the example of Chile highlights the complexity of the cost-benefit analysis pertaining to upgrading incentives in the mining sector. As previously highlighted, geology fixes the location of mineral resources and therefore mines, implying that not only processing infrastructure should be available on site, but also transport and energy infrastructure (US Congress, 1988). In particular, processing plants must often be nearby the mine to minimize the cost of transporting great tonnages of ore. Mineral deposits are often located in poorly connected inlands and competitiveness requires local transformation to minimise transport costs. In turn, processing plants are often energy intensive. Mines in Africa, for instance, depend on local processing (smelting and refining) to minimize transport costs. However, Chile's copper mines are closer to the sea, making it profitable to export concentrates (containing between 20 to 40% copper) (Darling, 2011). In 2015, the Chilean copper regulatory body declared that Chile did not plan to increase its exports of refined copper but rather the more unprocessed copper concentrate, due in large part to differentials in transport costs and high energy needs of processing plants. In particular, it was mentioned that "Chile is going to export less added value in its copper because [the country is] more competitive in mine production".[32] This example highlights that, while efficient services have an important role in determining prospects of upgrading, they still have to be weighed against comparative advantages.

Nevertheless, the analysis suggests that, minerals exporters wishing to increase the value addition in their export sectors should facilitate the emergence of such services. *Wholesale and retail trade*, T&S, R&D, *financial services, utilities and real estate* account for over 20% of the value added in minerals exports. Investing in these sectors can include up-scaling and up-skilling through better aligning education systems to the needs of the mining sector, supporting SMEs that provide such services to the mining cluster, and reducing barriers to entry for foreign firms that may provide additional know-how, new technologies and improved business processes thereby encouraging learning-by-importing.[33]

Among minerals exporters, there seem to be two distinct patterns of services procurement in mining. On the one hand, the developed economies of Australia and Canada, as well as the Russian Federation, use a relatively high share of domestic services inputs. On the other hand, countries such as Chile and China use foreign and domestic services in relatively equal proportion (OECD, 2015d).

However, some barriers to entry in services exist. The service that accounts for the largest share of value added in mining exports is *Wholesale and retail trade and repairs*. As mining is a highly capital intensive sector, repairs to machinery may account for a large share. Some of the machinery used in the mining industry is highly sophisticated, and is produced by one or two firms worldwide that supply this niche market. Many of these costly, sophisticated machines are delivered with a warranty that can require repairs to be done by registered or certified individuals that are not present in every country. Some also require spare parts to be purchased from the producing firm or one of its partners. In some cases, adherence to a warranty programme can include the provision to purchase even regular inputs into the production process such as fuel and tyres from a certified seller. These warranty provisions will reduce the scope for minerals exporters to diversify into such activities.

32. https://www.platts.com/latest-news/metals/santiago/chile-to-produce-75-million-mt-of-copper-by-2024-21320560.

33. See *Local content policies in minerals exporting countries*, TAD/TC/WP(2016)3/PART1/REV1.

The T&S sector also relies on the provision of various services, and also, unsurprisingly, heavily relies on the commodity sectors - M&Q as well as Coke, refined petroleum products and nuclear fuel -which respectively represent the second and fifth most important intermediate inputs in terms of value added. As a consequence, the sector has been affected by the commodity super-cycle and has therefore been subject to fluctuations in both commodity prices (although counterbalanced in the longer run by more efficient technologies) and aggregate trade patterns.

4.4 Evolution of centrality, within sectors and the position of developing countries in the value chain

This section uses the information provided by the backward and forward centrality calculated at the sector-country level to identify the evolution of the country structure of the GVC over time in the three sectors analysed. A preliminary analysis looks at the concentration of connectedness between countries for each sector as a way to capture the evolution of the structure of the value chain and the relative importance of some countries compared to others in the same fashion the level of competition in a sector of the economy would be analysed. A sector presenting a higher concentration would therefore be characterised by the presence of a few important countries among less important ones, suggesting a vertical structure of the sector, whereas a low concentration index would characterise a more horizontal structure of the sector (i.e. a sector with more, and more equal, participants). This different structure would have different implications in terms of impact and resilience to shocks. The second step looks more specifically at what has happened within sectors and changes in the centrality of countries within sectors.

4.4.1 Evolution of the concentration of centrality between 1995 and 2011

The observation of the centrality indicator over time allows for exploration of assumptions about trends in GVC integration and the impact of a shock in the reorganisation of the value chain. The following preliminary analysis looking at the concentration of the indicator provides insights about three assumptions. The first is that, over time, sectors which showed an internationalisation of production processes over the analysed period, should be characterised by a decrease and spread in countries' centrality. In other words, more countries should have greater importance in trade in value added flows, resulting in a decrease in the concentration of the indicators. A second assumption is that the impact of a shock has an effect on the organisation of the value chain, which can be observed by a change in the concentration of countries' centrality. The third is that the higher the degree of concentration of the centrality indicator within a sector – meaning the more vertical the organisation of the GVC – the higher the impact of a shock and the more important the relative changes of structure of the GVC the following period. More specifically, a shock in an industry is likely to have a stronger impact in the shorter run on countries which have an important centrality than for others. As a consequence, the central country might change its purchasing or selling strategy and therefore change the structure of the GVC.

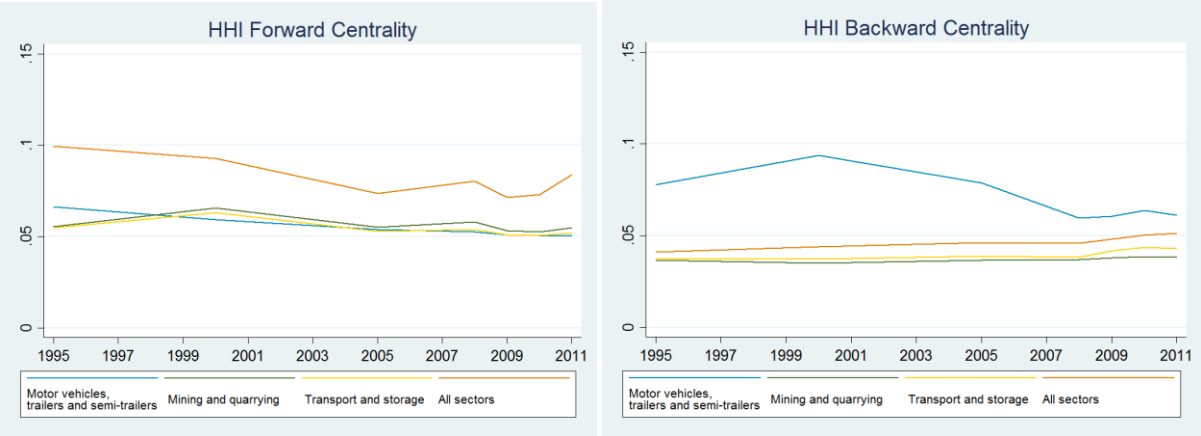
The concentration of countries' forward and backward centrality indicators is calculated using the Herfindhal Index (HHI), originally used to analyse firms' market shares and degree of sector competition, at the aggregate level with all trade in value added flows considered and for the three sectors or interest. Preliminary results all seem to support the above three assumptions. From the side of the seller of intermediate, forward centrality, the concentration of the centrality of countries decreases from 1995 to 2008 (Figure 13). In itself, this observation is a distinctive feature of the development of GVCs, with the decrease in concentration of the forward centrality capturing the increase in participation in trade in intermediates. The concentration of the importance of countries as buyers of value added, the backward centrality, does not present any clear patterns when all sectors are taken altogether, Yet, the crisis seems to have had a contraction effect, which can result from the increased importance of some countries compared to others as buyers of value added at the aggregate level.

The impact of the crisis is visible with a slight delay between the backward and forward centrality. The change in trend in the forward centrality concentration, that is of importance as a seller of intermediates for exports, appears already in 2008 with an increase in concentration for sellers of value added. The effect on the buyer side seems to occur mostly in 2009 (this may be a lag issue, for instance related to stocks). This is

suggestive that a first shockwave of the crisis was in the break on the supplying side. As highlighted in the theoretical analysis of resilience in the value chain, this can result from either a shock from the exporting country side with the impossibility to export or, a shock from the demand side for their exports -- for instance, from a decline in trade finance or a sudden drop in demand.

At the sector level, the evolution of the concentration of countries' centrality over time for the three sectors of interest – M&Q, MV&T and T&S – highlights the heterogeneity behind the aggregated data. First, looking at the backward centrality, the MV&T sector presents higher level of concentration than T&S and M&Q. Changes in concentration are most important for the MV&T sector and minimal in the M&Q and the T&S sectors. The MV&T sector presents increasing levels of concentration as a buyer of value added from 1995 to 2000, suggesting that some countries have, in relative terms, increased their centrality in the sector as buyers of value added from the sector to produce exports. This could in fact result from the first stages of creation of GVCs.

Figure 12. HHI of backward and forward centrality 1995 – 2011



Source: Author's own calculations using OECD-WTO TiVA ICIO 1995 and 2011.

The automotive industry was characterised by strong national champions, with many countries having their own car industry. It is therefore not surprising that the first stage of GVC integration presents and increases in the HHI. More than an increase in concentration, it highlights the emergence of hubs or "regional factories" and the first step toward an internationalisation of production processes. However, there are no data available in TiVA between those dates; it is therefore not possible to know whether this was the result of a continuous trend, as the figure seems to show. From 2000, as the sector experienced continued GVC integration, the concentration of backward centrality decreased. This decrease in concentration of the backward centrality in the MV&T sector can result from two non-excludable trends: a decrease in the importance of large buyers of value added, or an increasing importance of marginal buyers of value added, both of which introducing more "horizontality" to the sector. The forward centrality, the centrality of countries as sellers of intermediates to the MV&T sector does not present such important changes with only a slight decrease over time.

The M&Q and T&S sector, both "horizontal" in nature - the M&Q is a commodity sector, the supply of which is primarily determined by geology and not capabilities; and T&S because of its nature as a trade logistic service – appear to follow similar trends for both backward and forward centrality concentrations. : The concentration in backward centrality is very low and doesn't show much movement across the period. The forward centrality presents more movement, but no clear trend can be identified. However, while of changes in trends are of smaller scale, they nevertheless follow the same concentration trend as aggregate trade in value added.

Overall, analysis of the concentration of centrality over time reflects the production structure of the sector and the degree of evolution of GVC integration. Of the three sectors analysed, only MV&T shows

significant movement over the 1995-2011 period. Whilst trade in value added analysis highlights the increasing use of FVA in the production of exports and in particular the use of services, the analysis in the previous section highlighted the heterogeneous reliance on foreign inputs among the sectors, in line with their different modes of organisation and levels of reliance on GVCs. In other words, whilst on average all sectors increased their reliance on intermediate inputs originating from countries all around the world (services for the M&Q sector and fuel for T&S, for instance), the manufacturing sector represented by MV&T lent itself more readily to trade in tasks via GVCs.

For the three sectors, the crisis also seems to have had a contraction effect, meaning that it resulted in an increased centrality of some countries compared to others, both as buyers and sellers of value added. On forward centrality (importance as a seller of intermediates for the production of exports of the sector of interest), the impact on both M&Q and T&S seems to follow the trend at the aggregate level. This once again highlights the special relationship between the T&S sector and trade flows, with T&S directly related to the movements of goods between countries. However, this is not the case for the MV&T sector, which does not present any trend changes over that period on forward centrality.

In terms of backward centrality, the crisis seems to have had a contraction effect for all sectors; however, to a substantially smaller extent for the M&Q sector. Demand and prices in the M&Q sector dipped at the outset of the crisis in 2008 but the sector recovered more quickly than other sectors. (The substantially longer downturn came in 2014, subsequent to the period examined here, when demand and prices for M&Q products dropped sharply for cyclical and demand reasons). For MV&T, while the relative increase in concentration is not large compared to the evolution over the period, it is nevertheless an important change in trend. This suggests that the impact of the crisis was higher for some buyers compared to others in the sector. Finally, the same delay in the impact of the crisis compared to the aggregate level is visible in terms of forward centrality (sellers), with a shock that appears to have impacted concentration in 2008 and the backward (buyers) with a shock that seem to have impact centrality in 2009.

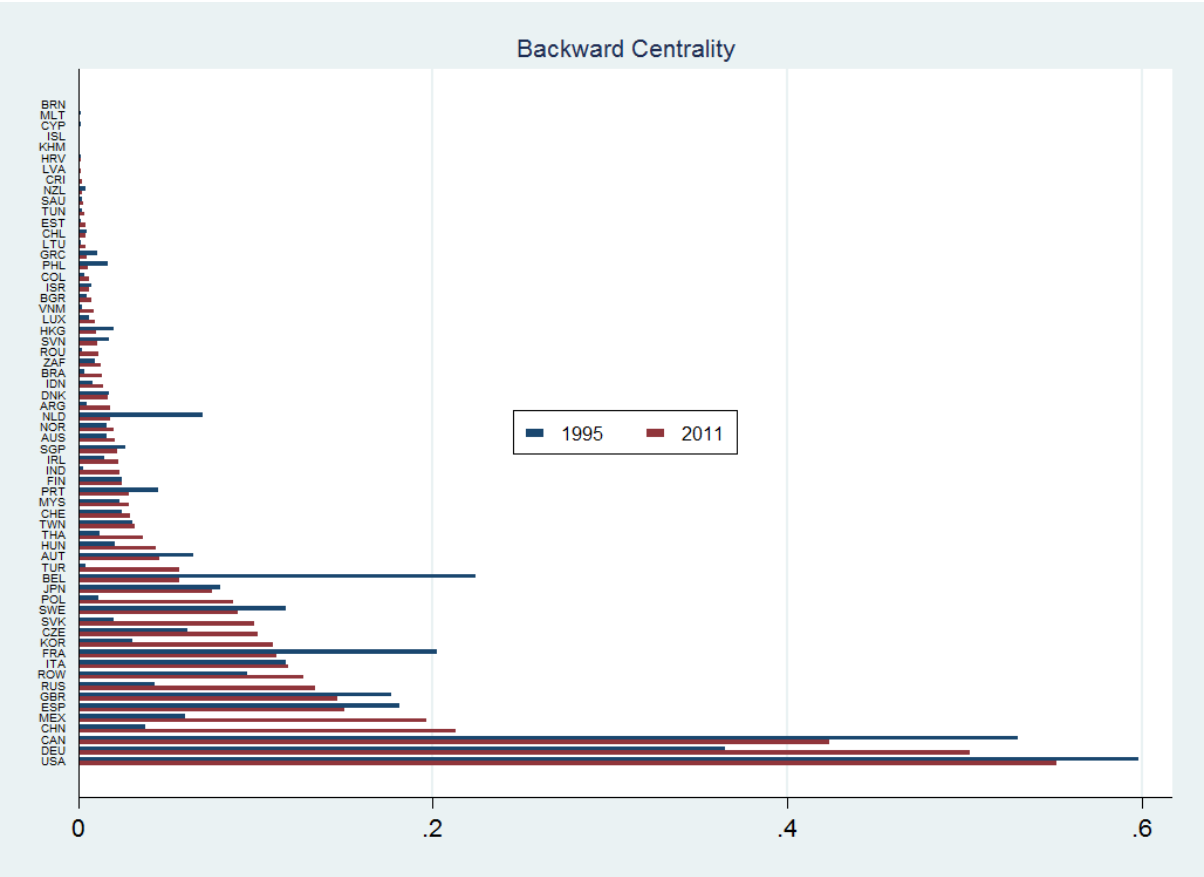
4.4.2 Changes in country centrality in the MV&T sector

Figure 14 presents the ranking of countries as buyers of value added in both 1995 and 2001, as well as the evolution of the MV&T sector over that period (see Annex A Figure A.21 and A.22 for histograms per year). The ranking is line with the finding by other analysis. In 1995, the sector was dominated by the United States and Canada, followed by a range of European countries – Germany, Belgium, France, Spain, United Kingdom, Sweden and Italy – then Japan. In 2011, the landscape of backward centrality in the sector had evolved considerably. With the exception of Germany, the composition and importance of countries in the sectors, and in particular their movement over the period 1995 to 2011, highlights the relative decline in centrality of some of the historical actors and the rise, as buyers of value added for exports, of emerging economies: China, Mexico, Russian Federation, Korea but also Thailand. There was also a decrease in the concentration of centrality on average. This large increase in the importance of emerging economies as buyers of value added in the sector follows from the development of GVCs.

The change over the period highlights diverging evolution among regions, with the increased importance of Germany as a buyer of value added in Europe, as well as various other countries in Eastern Europe, and the relative decrease in importance of other European actors; the shift in centrality in North America, with the decrease in centrality of Canada and to a lesser extent the United States but a large increase in the centrality of Mexico, which might be explained by the effect of NAFTA. Finally, the period saw the rise of emerging economies and Asia as a buyer of value added in the sector.

Following the crisis (see Annex A, Figures A.22), there is a strong regional bias in the change of centrality. Over the period 2008 – 2010, Europe, and in particular Germany, decreased its importance as a buyer of value added, to the benefit of North America, as well as, to a lesser extent, Asia. This result could be surprising at first considering that the locus of the crisis was North America. However, it is important to keep in mind that results are relative. In addition, this certainly reflects the slower recovery in Europe. This result highlights once again the important regional dynamic of GVCs with the impact of shocks spreading mostly through regional links and resulting in a shift of importance of regions in the sector accordingly.

Figure 13. Backward centrality in the MV&T sector in 1995 and 2011

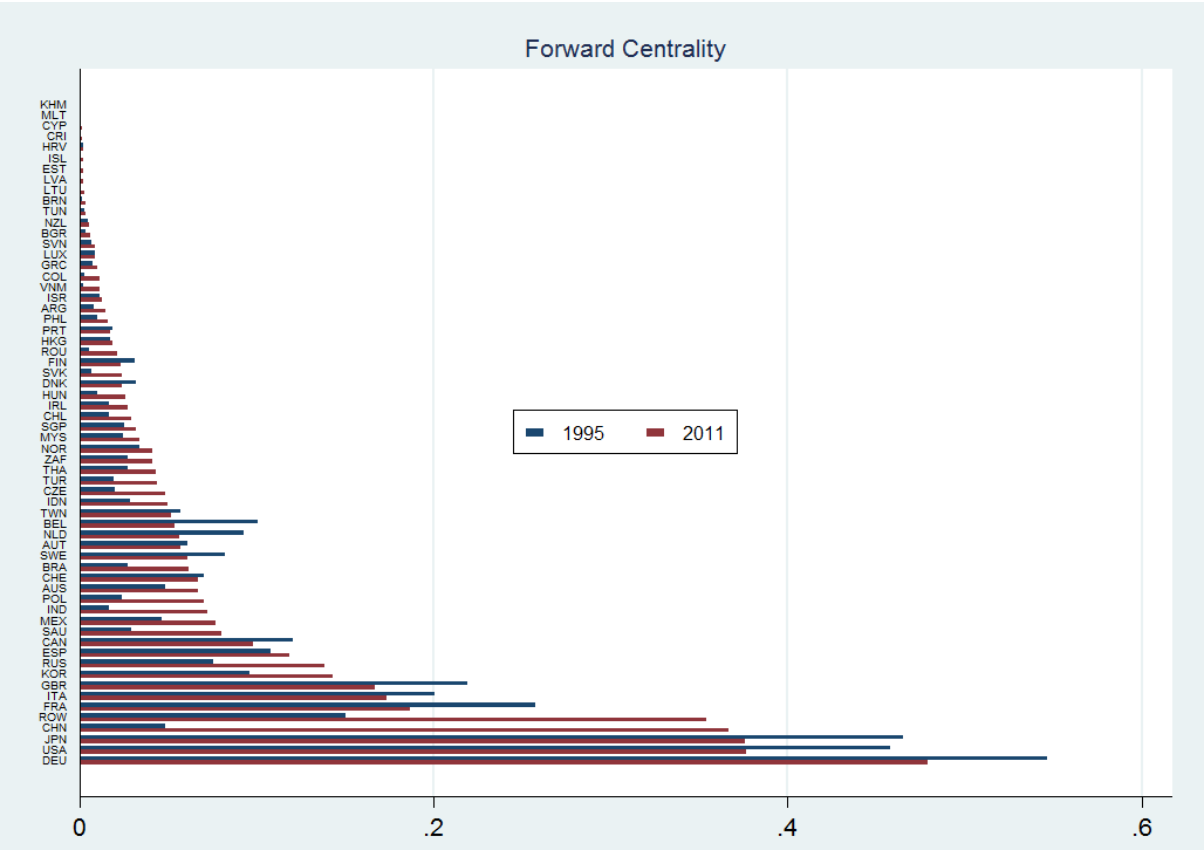


Source: Author's own calculations using OECD-WTO TiVA ICIO 1995 and 2011.

Confirming the analysis in Santoni and Taglioni (2015), the most central sellers of value added to the MV&T sector are also the most important buyers (Figures 14 and 15). However, the ranking of countries as sellers of value added did not change significantly over the period but the relative importance of various countries did. In particular, China emerged as a leading country, joining Germany, US and Japan as a hub. The increasing importance of China and of the ROW group of countries[34] is mostly at the expense of the large, traditional actors such as Japan, United States, Germany, and other European countries. Confirming the analysis of the evolution of the concentration of centrality, the impact of the crisis on changes in the relative centrality of countries as sellers of value added to the sector is much smaller than on the buyer from the sector side; however, it highlights the resilience of China and emerging economies in general compared to historical hubs, in North America and Europe, in line with the locus of the severity of the crisis and reflecting policy steps by China during the crisis.

34. It is not possible to interpret the increase in centrality of the "Rest of the World" which combines a large and heterogeneous set of countries for which disaggregated data is not available in TiVA.

Figure 14. Forward centrality in the MV&T sector in 1995 and 2011



Source: Author's own calculations using OECD-WTO TiVA ICIO 1995 and 2011.

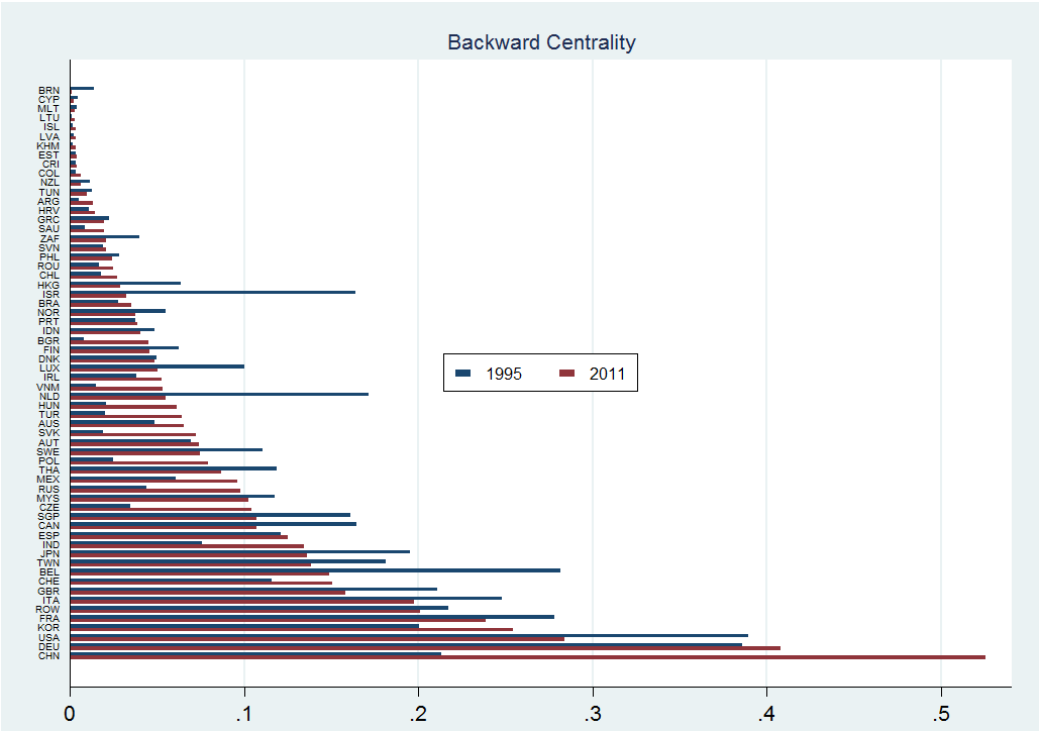
4.4.3 Changes in country centrality in the M&Q sector

For the M&Q sector, in terms of backward centrality, movements within the sector are driven by China which has become the most important buyer of value added from the sector for the production of exports, followed by increased centrality of emerging economies (see Annex A Figure A.23 for histograms per year, and in Annex A figure A.26 showing the change in backward centrality per country). OECD countries maintain their position as strong buyers of value added from the sector although their relative shares have dropped over the period. This confirms the findings of the network analysis illustrated in Annex A.1 and A.2 and outlined in section 3.1.2.

The structure of the sector the sector might have been influenced by various phenomena, including a concentration of large commodity hubs and the entry of numerous actors, including many developing countries (falling into the "Rest of the World" category in TiVA). The commodity super-cycle as well as the reduction in reserves in older extraction sites triggered investment in search of new more remote and previously less profitable sites, resulting in the entry of new actors as well as increased participation by others, for instance Nigeria and Angola. In terms of forward centrality, the increasing importance of the group of countries under ROW as a seller of value added to the M&Q sector is consistent with the increasing entry of actors and in particular developing countries. For instance, for the former, Singapore is an important actor in commodity trading[35], in particular for processed oil, but also figures at the median as a seller of value added to the M&Q sector.

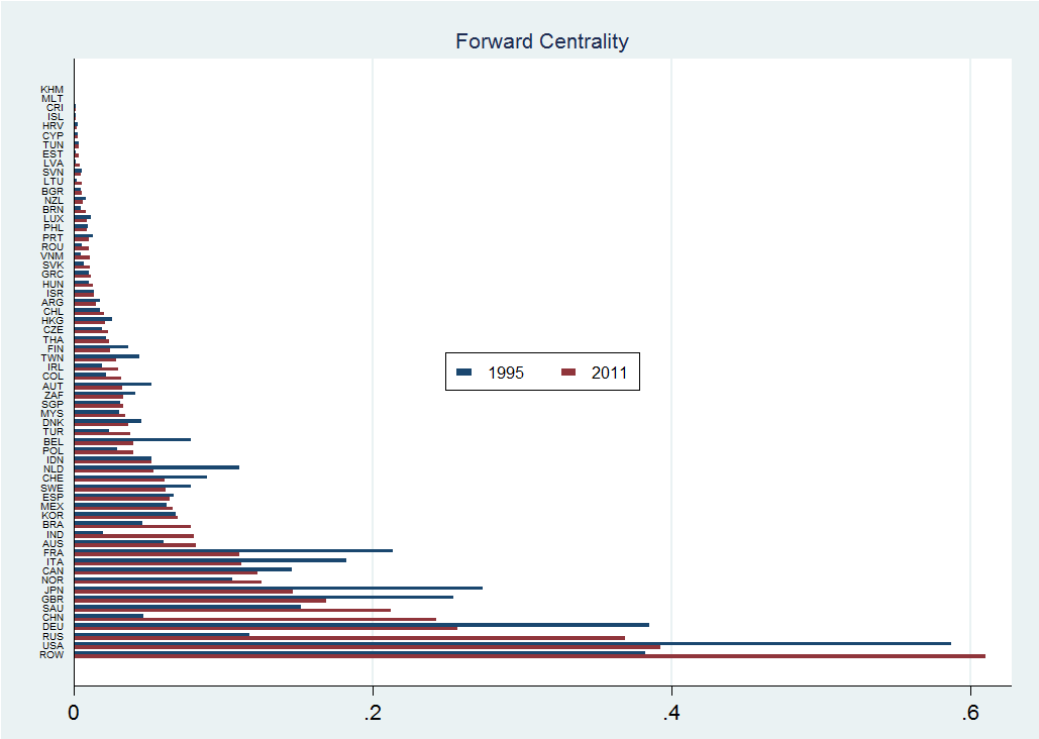
35. As TiVA is based on Input-Output tables, the role of trading hubs such as Singapore for commodities is also picked up in the data, not simply the role of producer countries.

Figure 15. Backward centrality in the M&Q sector in 1995 and 2011



Source: Author's own calculations using OECD-WTO TiVA ICIO 1995 and 2011.

Figure 17. Forward centrality in the M&Q sector in 1995 and 2011



Source: Author's own calculations using OECD-WTO TiVA ICIO 1995 and 2011.

4.4.4 Changes on country centrality in the T&S sector

For the T&S sector, changes in backward centrality between 1995 and 2011 mostly result from the large increase in the centrality of Asian countries, with a dramatic increase by China but also large increases in relative terms for India, Korea, Viet Nam, and to some extent Thailand (see Annex A, Figure A29 for histograms per year). Other emerging economies also experience an increase in centrality, in particular the Russian Federation, Brazil, Mexico, as well as some Eastern European countries. Backward centrality is dominated by both large economic hubs as well as transport service hubs (Singapore, Malaysia, Chinese Taipei, Hong-Kong or Denmark). This is less the case for forward centrality, where central hubs are large trading economies (Annex A. Figure A.31).

Looking more specifically at the period after the crisis (Annex A Figure A.30), the evolution over 2008 to 2010 shows the increase in backward centrality of Asian economies, China, Korea, Singapore, India, Chinese Taipei, Viet Nam, Thailand and Myanmar, as well as Mexico and Brazil, relative to all other countries. The decrease in centrality is particularly marked for large European economies and Japan. This once again highlights the heterogeneous impact of the crisis in various regions of the world. In terms of forward centrality, it is mostly the group of countries aggregated in the "Rest of the World" group, which shows a large decrease in centrality after the crisis, followed by a few European countries. Asia, emerging economies – with the exception of the Russian Federation – and North American countries are relatively less affected (See Figures 32 in Annex A for more detailed figures).

Because of the specificity of the T&S sector the analysis also draws on other indicators based on network analysis, which capture the number of transactions but not their value, which can be misleading as higher value added traded in T&S can simply be the result of higher costs of trading due for instance to poor connectivity.[36] Figure 18 presents the cumulative distribution of those indexes for 1995 and 2011; the lower the country's position in the cumulative frequency, the higher the position in the network[37]. The figure shows that all countries have increased the number of outward and inward links, in other words respectively the number of countries to which they sell T&S value added to and from which they buy value added in the T&S sector. It is then interesting to look at countries' relative position in the cumulative frequency, and compare their position between 1995 and 2001.

Because of the hub and spoke nature of the service, it is relevant to examine the evolution of regions. Latin American countries have on average increased their importance as buyers, but decreased their importance as sellers. In Asia most of the change happened on the selling side, with clear advances by India and China. India also increased its engagement as a buyer of value added, as did Thailand.

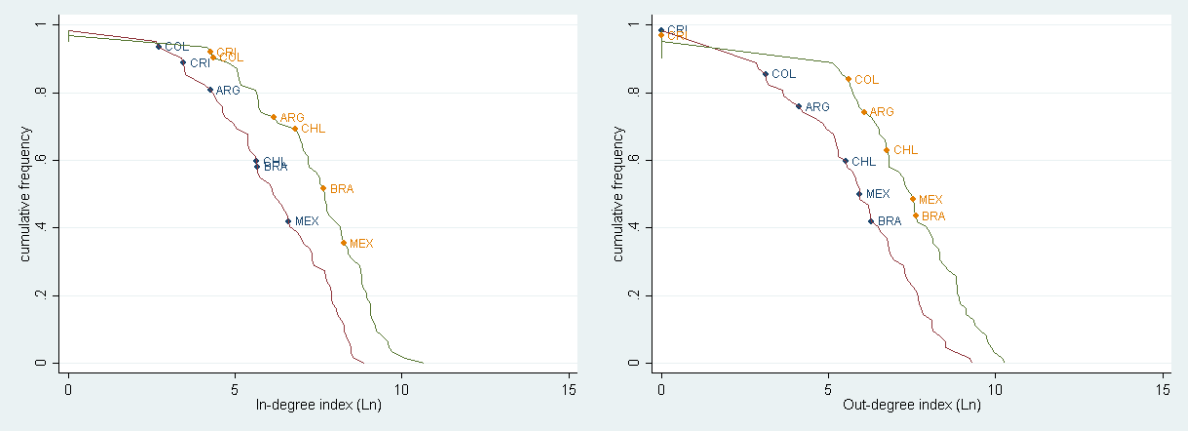
Overall, analysis of the evolution of change in centrality over the period analysed for the three sectors, M&Q, MV&T and T&S, clearly illustrates the change in economic dynamics, with an increasing importance of Asian countries and in particular of China, both as buyers and sellers of value added. These changes also emphasise the different reaction to the economic crisis shock among actors in each sector. The M&TV sector shows a greater sensitivity to the shock in the longer run, and in particular is characterised by different regional responses. In centrality terms, the most important changes appear for central buyers of value added, meaning that they reacted to the shock by changing their supply strategy, with implications in turn for supplying countries. The more horizontally organised sectors, M&Q and T&S sectors, seem to have recovered more rapidly.

36. Indeed in the T&S GVC, there can be contradictory elements determining the position of a country as a buyer or seller of value added when the centrality indicator takes the value of the flow into account. Since the cost of moving goods from one country to the other is higher for countries with poor trade infrastructure, for the same quantities exchanged, the amount of value added exchanged in the T&S sector appears as higher and therefore increases centrality. Hence a rise in centrality could be either due to a good trade facilitation performance and high volume or, to the contrary, due to high costs from poor infrastructure. It was therefore decided to analyse countries' relative centrality according to the number of transactions and not their value.

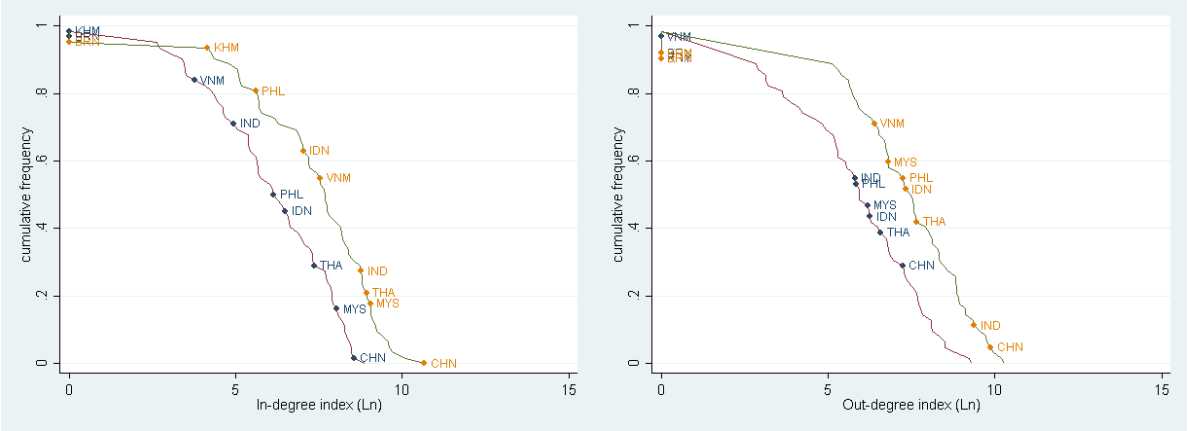
37. Since the between indexes are not bounded like the eigenvector, the 2011 distribution sits on the left of the 1995.

Figure 18. Ranking of countries according to the number of connections as buyer (in-degree) and seller (out-degree) of value added in T&S over 1995-2011

A: Latin American countries



B: Asian countries



Source: Own calculations using OECD-WTO TiVA ICIO (October 2015 revision).

5. Preliminary analysis of the relationship between FVA and sophistication in the M&Q and MV&T sectors

This section provides preliminary analysis on use of FVA through GVC integration as a pathway toward increased sophistication of exports. One assumption derived from the literature on GVCs is that GVCs tend to be characterised by more complex products. As such, for a given country, the DVA share in products exported should be negatively related to product complexity; that is, economic transformation, proxied by the complexity of exports, will be associated with lower DVA shares, again throwing into question strategies aimed at targeting higher DVA shares. However, it is only possible to test this assumption for the M&Q and MV&T sectors, as the index of product complexity used to test this assumption only exists for goods (Box 5). Analysis in this section shows that in both sectors, lower DVA is associated with exports of a more sophisticated bundle of products.

Box 5. Using the Product Complexity Index to test the relationship between the use of foreign value added and sophistication in the economy

The process of economic transformation relies on the acquisition of more complex sets of capabilities allowing a country to move towards new activities associated with higher levels of productivity. However, aggregate figures about human and physical capital are not adequate tools for the inference of capabilities when considering the heterogeneity of sets of skills and other features characterising production in different sectors. Hidalgo and Hausmann (2009) use social network analysis to develop a set of indexes based on this idea that economic development is a process of learning how to produce (and export) more complex products. The main assumption is that the capacity of a country to accumulate *capabilities* required to produce varied and more sophisticated goods determines its development path. *Capabilities* in this framework are indirectly inferred, based on country-product export relationships analysed through social network analysis methods.

Economic transformation has long been associated with an increase in economic diversification, and in particular export diversification. Hausmann, Hwang, and Rodrik (2007) provide a framework behind this relationship. Their analysis highlights the heterogeneous relationship between exports of certain products and economic development, and in particular that what matters is the extent to which the capabilities associated with the production of certain products can be redeployed or not into the production and exports of others. As summarised by the World Bank (2012), capabilities are considered to encompass human and physical capital, the legal system, institutions, etc. that are needed to produce a specific product. According to Abdon et al. (2010), at the firm level, they also more specifically integrate the "know-how" or working practices held collectively by the group of individuals comprising the firm. GVC integration and the use of foreign intermediates is a way to increase access to foreign know-how.

The following analysis uses the product complexity index (PCI) created by Hidalgo and Hausmann (2009) and their ranking of products according to the capabilities necessary to manufacture them, to evaluate the relationship between the use of foreign value added and the sophistication of the export bundle of TiVA countries. The indicator is built using social network analysis based on the ubiquity of a product, defined as the number of countries presenting a revealed comparative advantage in that product and the diversification of an economy, meaning the number of products for which it has a revealed comparative advantage. (See Annex 3 for further description of the index).

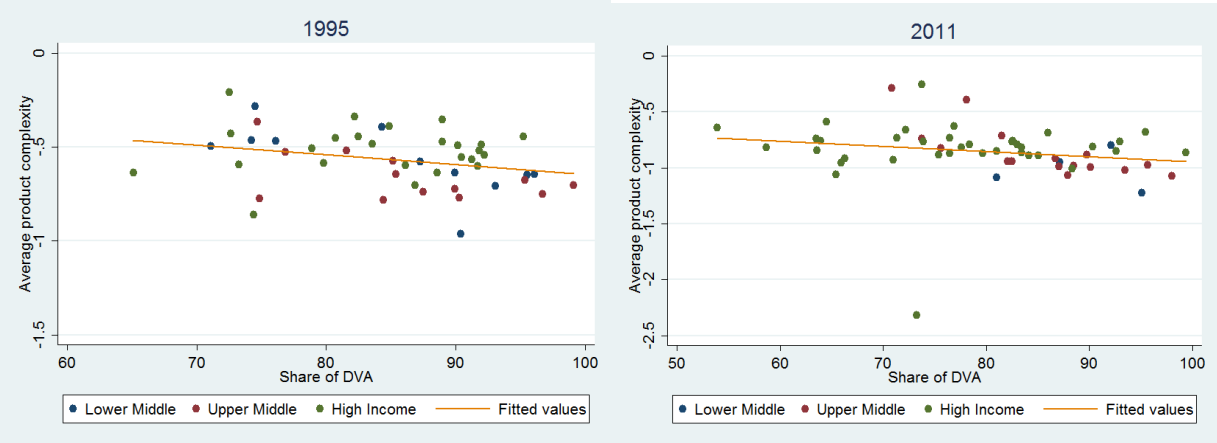
The indicator provides interesting figures now often used in development policy diagnosis. However, whilst it is useful in identifying and understanding divergence in development paths between countries and potential diversification patterns reducing the effort needed to diversify, it does not necessarily explain how to successfully increase the level of capabilities. It is assumed in the following analysis that GVC integration, and in particular the "learning by importing" process attached to the use of foreign inputs in domestic production, can be a way to increase capabilities and foster economic transformation. The PCI is used in this paper for a preliminary assessment of this assumption for the M&Q and the MV&T sector.

Whilst based on a sound methodology, there are still some caveats about the use of this indicator. The first relates to the fact that it only relates to exports and not production, and it is possible that some products have a high ranking simply because they are only exported by highly complex economies, but do not have complex production processes. The second relates to the fact that this indicator is based on gross exports which doesn't capture trade in tasks and does not control for imports of sophisticated intermediates for the production of exports. As a consequence, capacities of countries integrated in GVCs might be overstated or understated. That said, it is still a good indicator of the capacity of a country to integrate into value chains for more or less sophisticated products.

The relationship is first explored for the M&Q sector. Its average product complexity ranges between -1.2 and -0.6 with maximum value of 0.88 and minimum of -3.438 and has decreased on average compared to other traded goods since 1995. All other things being equal, such a change in relative position in the economy is to be expected considering the entry of new actors in the sector (ubiquity). Figure 19 contrasts the share of DVA in exports with the level of complexity of the bundle of exported products. It presents a first indication of a potential relationship, revealing a decreasing share of DVA associated with increased export complexity. However, while there is a negative relationship suggested overall, there does not appear to be any differentiation among countries according to their income group. This relationship points to an underlying implication for policymaking: as product sophistication rises, the share of DVA will naturally fall, at any level of development. The policy implications for keeping markets open, lowering trade barriers and ensuring trade logistics are efficient are therefore correlated with countries that move toward more sophisticated exports, whatever their initial level of development.

38. All products considered, the product complexity index in 2011 ranges between -3.047 and 2.77 with non-petroleum gas and crude petroleum as the two lowest ranking products and blown glass and nickel pipes as the highest ranking products.

Figure 19. Weighted average product complexity of M&Q sector per country and by income group in 1995 and 2011



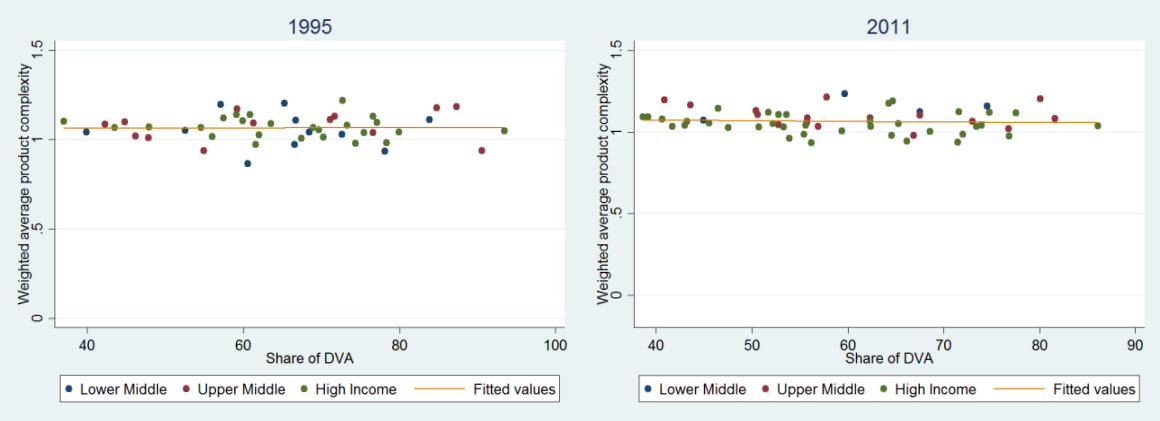
The relationship is further explored, testing the assumption over time and looking at the correlation between the level of complexity of the bundle of products exported[39] and share of DVA in exports, controlling for total trade (as well as for other factors through country and year fixed effects). It establishes a significant negative correlation between the level of complexity of the bundle of exported products and the share of DVA in exports. In other words, countries exporting more complex products to more diverse countries import more FVA for the production of their exports (see Table B.1 in Annex B).

The relationship, however, has not been stable over the period examined. The significance of the correlation between the level of DVA (correcting for the size of total exports) and the level of complexity of exports for the M&Q sector increases if 2008 is excluded from the analysis. This result suggests that the crisis had an immediate disruptive impact on the transformation relationship, which we already observe to have impacted the concentration (in centrality terms) of sellers of value added in 2008 while buyers were hit the following year. The immediate impact of the disruption of the relationship in the sector is likely due to the M&Q sector holding an upstream position as a provider of primary intermediates to the GVC and an important seller of value added. Furthermore, the short-term impact of the crisis in the M&Q sector was just that – the disruption of the relationship appears to have lasted a single year only.

The level of complexity of the MV&T sector is much higher than for the M&Q sector. The average product complexity ranges between 0.63 and 0.98, with a maximum value of 2.1 and a minimum of -1.22. Preliminary analysis of the distribution of the weighted product complexity over DVA share of exports for 1995 and 2011 does not seem to present any correlation, with a flat fitted line (see Figure 20). Whilst the average product complexity of the bundle of products stayed relatively stable over time, there has been an increasing spread in the values of the share of DVA. Values concentrated between 60% and 80% in 1995 are scattering between 40% and 80% in 2011 with an increased concentration around 50%. There also does not seem to be any trend differences among countries from different income groups.

39. Weighted by the number of trade partners for that product.

Figure 20. Weighted average product complexity of MV&T sector per country and by income group in 1995 and 2011



However, further analysis highlights that the MV&T sector is in fact characterised by a stronger relationship between the level of DVA and the complexity of the bundle of exported product before 2008, but that the relationship was more strongly disrupted by the crisis than the M&Q sector. Testing the correlation between DVA in value (controlling for total trade value and weighted average product complexity with the same setting as for the M&Q sector), does not show any significant results when regressing over the whole period,40 whether on the whole country sample or clustering by income group or region (see Table B.2 in Annex B). However, a negative correlation appears when testing the period preceding the 2008 economic crisis. More specifically, a negative and highly significant correlation links DVA with the complexity of the bundle of exports before 2008, suggesting that countries exporting more complex products to more countries were using more FVA for the production of their exports.

In an attempt to identify whether specific country groups or regions were particularly disrupted, various tests are conducted, controlling for crisis and pre-crisis period as well as other clustering. None of those allow identifying any clear patterns from 2008.[41] The crisis seems therefore to have disrupted the pre-crisis relationship governing GVC integration in the MV&T sector at least until 2011, the last year for which data on DVA is available. One of the reasons for the difference between the two sectors seems to be related to their different structure. However, they could also have been influenced by the way the crisis was handled by policy makers. According to Van Biesebroeck and Sturgeon (2010), there was no coordination of capacity reduction internationally. Rather, policy interventions created a competition shift from inter-company to inter-country.

Another way to explore the issue of transformation and GVC integration is to explore whether export product complexity is related to a country's backward and forward centrality in the sector (controlling for year and country fixed effects). In this way, economic transformation could be faster through greater integration into GVCs (proxied through more central GVC positions). However, as for other results, over the whole period of available data, from 1995 to 2011, no correlation seems to appear between the two indicators. Yet when considering the period preceding the crisis only, the relationship between both backward and forward centrality is significant. Whilst both the centrality as a buyer and a seller of value added seems to be positively related to export complexity weighted average, the relationship is somewhat stronger for the latter.[42] Such a relationship between the two indicators is not surprising. While both indicators are not calculated using the

40. Using all TiVA available years between 1995 and 2011.

41. Various clustering and crossings have been tested: controlling for income group, region, crossing those clusters with the crisis dummy, or even for the centrality in the sector. None of those allowed for controlling for the change in correlation between DVA and product complexity.

42. The tests put the PCI on the left hand side for the first set of tests on DVA, and then put it on the right hand side. This paper does not intend to infer causality. It is only testing controlled correlations.

exact same data, they are both based on trade flows and network analysis. This said, product complexity does not take into account values and is based on the ubiquity of the product and only the calculation of the weighted average for the sector makes the index country specific. The eigenvector calculated in this paper is country-sector specific and based on flows of value added exported to other countries for their exports (or imported from other countries for the production of exports). Whilst these regressions say nothing about causality, they nonetheless support the notion that exporters of higher complexity bundle of products have on average a higher centrality and therefore sensitivity to shocks as sellers of value added.

Overall, the results provide evidence to support the use of FVA as a means to progress economic transformation. However, they also highlight that the relationship has been disrupted, to varying degrees, by the economic crisis in 2008. The shock in the M&Q sector was temporary while the shock in the MV&T transport had a longer tail, disrupting trends in the years following the crisis. Unfortunately, the data coverage of the TiVA database does not allow for the identification of whether the disruption was temporary or whether it changed the dynamic of the sector on a more permanent basis after 2011. It remains an area for future work. However, the different impacts of the crisis on both sectors, and the relationship to their levels of GVC integration, is evidence of the need for governments to seek to create tools to manage risks of shock contagions by identifying issues for and monitoring resilience of value chains at the sector level. The experience of the automotive industry and the lack of international coordination might have increased the effect of the crisis in the sector in the longer run. Furthermore, as highlighted in the case of MV&T, the results suggest that policy responses enacted in the short term, if left in place, may have longer term unintended impacts on GVC development in highly traded vertically structured sectors – with this effect potentially lessening the ability of GVC development in these sectors to be drivers of economic transformation and development.

6. Trade in value added in services to support GVC integration

The following section explores the GVC integration in the T&S sector with a particular focus on the role of regulation. As highlighted above, GVC integration, though various means, has been shown to be associated with different measures of economic transformation. However, a key reason for the development of GVCs has been the improvements seen in the T&S sector. As such, for countries overall, the functioning of their T&S services will be an important determinant of the potential for GVC engagement to contribute to economic transformation. While acknowledging the difficulty of disentangling the direct relationship of the sector with trade from its GVC components, the analysis conducted explores the relationship between country specific indicators that depict differences in regulatory performance (in terms of trade costs) and how they relate to centrality in the T&S sector. The section first highlights the role that T&S regulation plays in influencing the centrality of countries and then extends the analysis by specifically focusing in detail on maritime transport services.

6.1 The role of T&S sector regulation in trade costs and GVC integration

Connectivity and in particular the efficiency of T&S services are critical for GVC participation. Greater efficiency implies making these processes work faster, more reliably, and at lower cost and thus is critical in enabling developing countries to participate in GVCs in other sectors. Additionally, investments in infrastructure and trade facilitation could allow better connectivity within a region, enabling the development of regional transport hubs, providing a base for integration into both regional and global production networks.

The ESCAP-World Bank Trade Cost Database estimates that only 0-10% of trade costs are tariffs, while 10-30% correspond to natural trade costs (i.e. geographical and cultural factors). The remaining 60-80% relates to non-tariff policy measures, which can be divided in three sub-components: i) Infrastructure (quality and quantity), ii) Trade Facilitation and iii) Regulation in Transport and logistic services. Those can be indirect costs of trade procedures, maritime connectivity[43] and services, the business (regulatory) environment,

43. Hence Fugazza (2015) suggests that the absence of a direct maritime connection is associated with a drop in exports value of 55%.

currency fluctuations and the availability/use of ICT services (ESCAP, 2014). Those three elements impact the efficiency of trade logistics and in particular T&S. Transport services represent therefore an important part of trade costs. Table 2 shows that investment in infrastructure and trade facilitation in South East Asia has contributed to the low intra-regional trade costs (68.8%).[44] Nevertheless South East Asia still has some way to go in catching up with the trade costs seen in the EU (34.3%) or North America (14.8%). By contrast, South Asia and Latin America, which spend much less on physical infrastructure and where regional co-ordination on trade facilitation are lagging, display high intra-regional trade costs (92% and 93.6% respectively).

Table 2. Region by region trade-weighted trade costs in 2010

	EU	Europe and Central Asia	Latin America	North America	South Asia	South East Asia
EU	34.3					
Europe and Central Asia	67.3	64.8				
Latin America	109.5	158.4	93.6			
North America	65.5	102.6	92.3	14.8		
South Asia	94.8	136.5	183.8	88.6	92.0	
South East Asia	88.0	119.5	127.9	71.9	103.6	68.8

Note: Figures show *ad valorem* equivalents of trade costs calculated from Arvis et al. (2013) using the trade cost measure proposed in Novy (2013). Data is trade-weighted average costs of trade by region for the year 2010.

6.1.1 Transport infrastructure: Quality and quantity

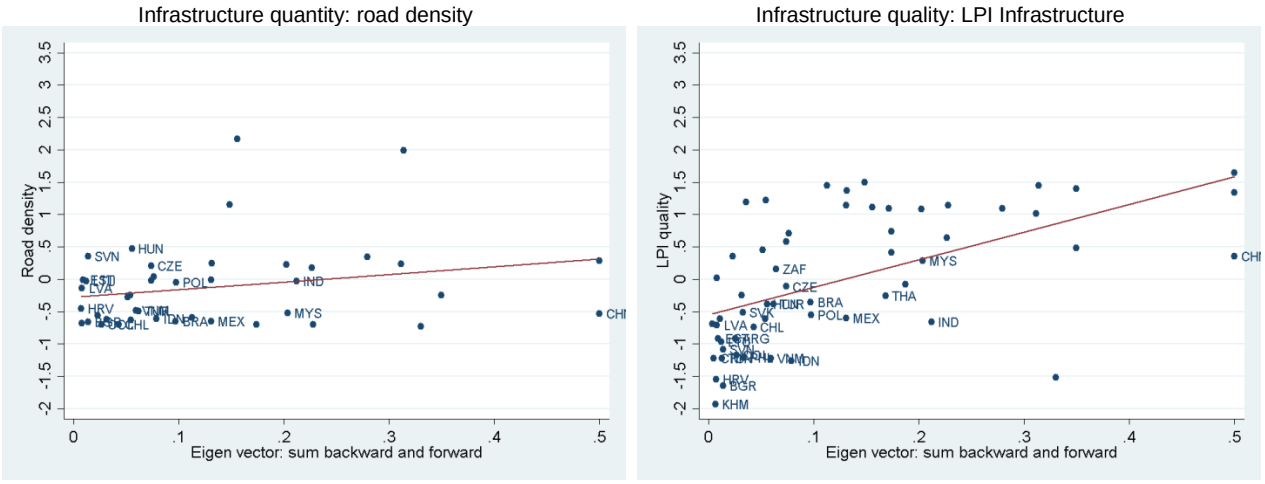
Testing various indicators shows that a country centrality in the T&S value chain is primarily a question of quality rather than quantity. Figure 24 maps the degree of centrality of countries in the T&S value chain – computed as the sum of the backward and forward centrality indicator – with two indicators. The first reflects the provision of hard transport infrastructure, proxied by road density. The second relates to the quality of trade and transport infrastructure, as measured by the infrastructure component of the World Bank Logistic Performance Index (LPI). The quantity of infrastructure seems to be only weakly related to the central positon in the T&S value chain; however, the quality of infrastructure seems to matter more. That said, most of developing countries in Figure 24 are well below the average of the LPI index on infrastructure.

East Asia is frequently praised for its regional policies which have successfully decreased trade costs. In terms of infrastructure quality, China, Malaysia and Thailand lead the way in the region. Unsurprisingly, given their lower level of development, Cambodia and Viet Nam have the lowest quality of infrastructure in the region. In South Asia, the quality of infrastructure is below average in all countries including India. By comparison, transport infrastructure in Latin America is organised differently, with denser railway networks and sparser road coverage (World Bank, 2015).[45]

44. Although distances also play a role since these are trade-weighted measures.

45. A caveat is that measures of road and railway densities are imperfect indicators of the quantity of transport services relevant for the development of cross-border linkages to the extent that they do not convey whether production centres are effectively connected to markets. The quality of the road network, proxied by the share of unpaved roads, in LAC is relatively poor when contrasted with other developing regions: almost 70% of the roads in LAC are on average unpaved, contrasting with less than 30% of the roads in SEA and less than 50% of the roads in South Asia.

Figure 21. Transport Infrastructure and centrality in T&S value chain in 2011



Note: LPI quality represents the infrastructure component of the World Bank Logistic Performance Index (LPI).

6.1.2 Trade facilitation

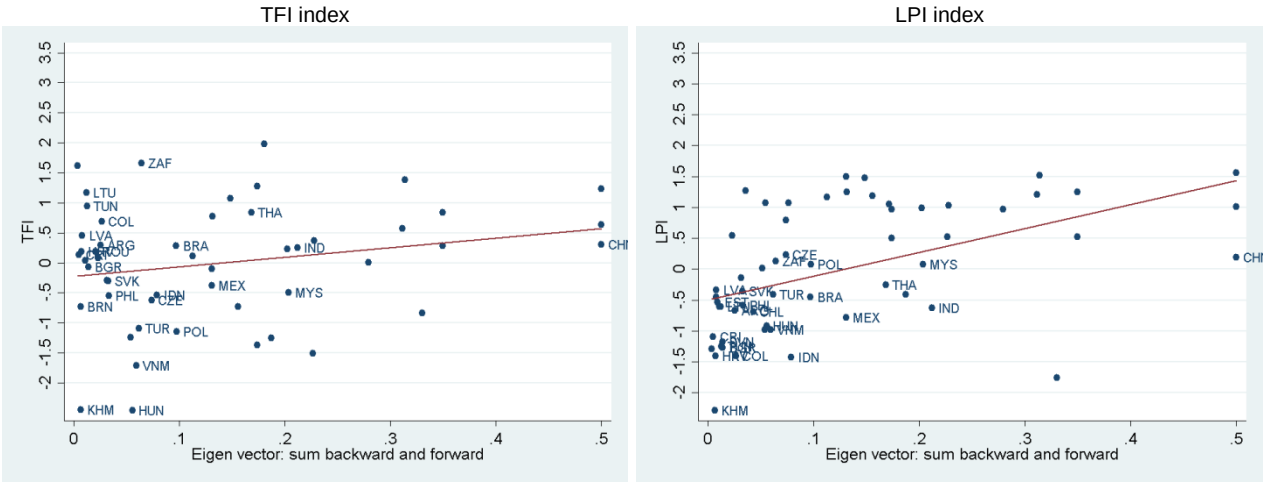
Improved trade facilitation has the ability to reduce trade costs for all products. As such, better trade facilitation performance has the potential to increase trade (both imports and export)[46] and also the demand for a country's T&S services. This greater trade and demand can fuel improvements in the sector, and to its position in the T&S GVCs.[47] The relationship between border performance and GVC participation in the T&S sector is assessed using two sets of indicators: the Trade Facilitation Indicators (TFIs) and the Logistic Performance Index (LPI).[48] Overall, there does not appear to be a clear correlation between a high score in the TFIs and centrality in the T&S GVC. The LPI covers a wider range of issues, including behind the border, which are more difficult to address and more aligned with countries' business environment. For instance, the LPI captures the level of competition in logistic services. It is therefore not surprising to see that the centrality in the T&S value chain appears to be more sensitive to outcomes captured in the LPI index. However, whilst a correlation exists, it is not possible to draw any conclusions about the causality between the two indicators.

46. See Flaig and Sorescu, TAD/TC/WP(2016)15/REV1.

47. As for the analysis in section XX of the position of countries in the T&S GVC, it is acknowledged that there can be contradictory elements determining the position of a country as buyer or seller of value added when the centrality indicator takes the value of the flow into account. Indeed, the cost of moving goods from one country to the other is higher for countries presenting poor trade infrastructure, which, for the same quantities exchanged, would increase the amount of value added exchanged in the T&S sector and therefore would increase centrality. While this effect can disrupt the correlation between centrality and trade facilitation indicators, it is assumed in this paper that the drop in centrality due to poor trade facilitation performance is stronger than the rise due to the cost effect.

48. The TFIs rely on data provided by government with the support of the private sector. They were developed by the OECD to help governments schedule and prioritise action in the policy areas covered by the Trade Facilitation Agreement. Data for the LPI are collected through an online survey of operators in charge of moving and trading goods. The TFIs cover the broader definition of trade facilitation with components covering aspects referring to inputs to the supply chain (customs, infrastructure and services quality) or to the outcomes (timeliness, international shipments and tracking and tracing). Developing countries seem to be performing relatively better under assessment based on de jure regulations (TFI approach on regulatory framework) than on de facto output (LPI approach based on operator survey). However, this is only recent and in response to the 2013 TFA whilst TiVA data are only available up to 2011.

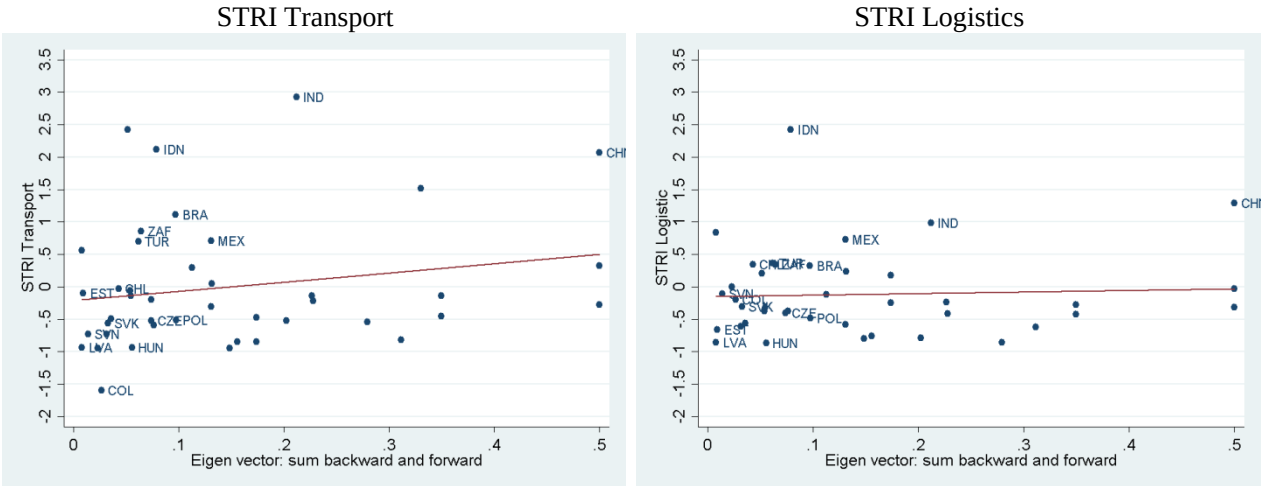
Figure 22. Trade Facilitation and centrality in T&S value chain in 2011



6.1.3 Regulation in the Transport and storage sector

The T&S sector is a relatively broad sector made up of a number of parts. Some of these parts will be more important for the sector in terms of engaging in GVCs than others. From a regulatory perspective, although only a very weak correlation exists, it appears that the centrality in T&S GVCs is more sensitive to transport regulations rather than in logistics regulations, based on results from the Services Trade Restrictiveness Index (STRI) (Figure 23). Part of the reason for this is likely to be related to differences in the stock of regulations directed at each sub-sector. Professional and transportation services are among the most protected industries in both developed and developing countries (OECD, 2014). A lack of competition can therefore make for a less efficient sector, limiting its ability to participate in GVCs. Despite this, the weak correlation provides little insights overall, with no discernible trend seen in logistics regulatory restrictiveness.

Figure 23. Transport and Logistics Regulation and centrality in T&S value chain in 2011



6.1.4 Maritime services

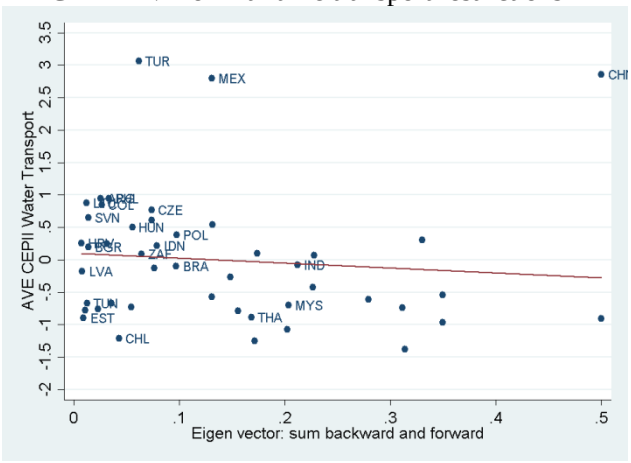
All things being equal, restrictions in the T&S sector have been associated with a decrease in competition, and therefore in the quality and efficiency of services supplied resulting in lower GVC engagement. To gain a better understanding of these effects, a closer look was taken at the maritime transport

sector; a service sector particularly relevant for GVC integration in general as close to 80% of international trade continues to be transported by sea.

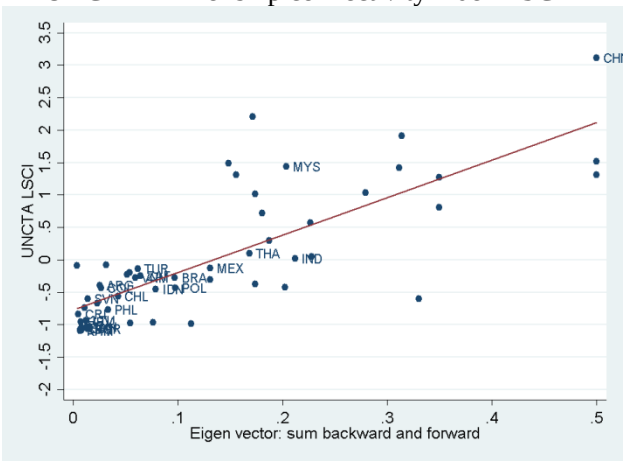
The high volumes of trade occurring by sea means that ports are crucial nodes in global supply networks and their regulation can significantly affect country's integration in GVCs and the T&S value chain. Similarly, with the majority of international containerised cargo transported by regular liner shipping services, regulations imposed on these operations are also likely to play a significant role. To gain insight into these two areas, two indicators of port and ship liner regulation and their impact in T&S GVC centrality have been explored. The first is the ad-valorem equivalent of protection in maritime transport services as estimated by CEPII (Fontagné et al, 2016)[49]. The second is UNCTAD's maritime connectivity index (LSCI)[50], which uses attributes of liner shipping 'connectivity' to describe the market condition and service level.

Figure 24. Maritime features and centrality in T&S value chain in 2011

CEPII AVE of Maritime transport restrictions



UNCTAD Liner ship connectivity index LSCI



The results point towards a high significance of maritime regulations on T&S centrality compared to other tested indicators above (Figure 24). Similarly, mapping the number of available services and the number of shipping lines operating direct services from the LSCI with centrality indicators in T&S value chain highlights a strong relationship. Interestingly China performs poorly in terms of restrictive regulation in maritime transport which nevertheless does not seem to affect its integration in the T&S value chain. This is certainly resulting from the fact that those correlations do not correct for the size trade flows and other factors influencing centrality in GVCs more broadly. Therefore the central position of China is driven more by its performance as a producer and therefore trade flows and less by the performance of its trade logistic services.

6.1.5 Testing the importance of policy factors on T&S GVC engagement

This series of indicators mapped above to the T&S sector centrality highlight a correlation between the provision of hard and soft (regulations) infrastructure and participation in the T&S value chain. However, the

49. Fontagne et al. (2016) use a reduced form of the gravity approach to estimate maritime transport services trade. Hence the tariff equivalents are inferred by comparing the inward multilateral resistance term for each country with that of a benchmark country and assuming a common elasticity of substitution across countries and sectors.

50. The higher the index, the easier it is to access a high capacity and frequency global maritime freight transport system and thus effectively participate to international trade. The LSCI is generated from five components that capture the deployment of container ships by liner shipping companies to a country's ports of call: (a) the number of ships; (b) their total container-carrying capacity; (c) the number of companies providing services with their own operated ships; (d) the number of services provided; and (e) the size (in TEUs) of the largest ship deployed.

correlations depicted do not control for the many factors potentially influencing the volumes of trade flows to disentangle the trade volumes effect from the more specific T&S elements.

To gain a better understanding of the effects of policy, a more robust analysis was undertaken that controls for various other parameters, in order to get a better sense of their significance and their respective importance. To do so, in addition to the backward and forward centrality used in previous sections, the analysis also tests two other network analysis indicators: the Indegree and Outdegree which are respectively based on the total number of inward and outward flows of value added, that partially eliminates the potential inflation of centrality due to high costs in the T&S sector associated with poor trade facilitation performance and centrality; and the intensity of the Eigen vectors.[51]

The results of the analysis confirm that large and rich countries are more central in the T&S value chain (see in Table B.2 and B.3 in Annex B). But above all, the correlation is strongly significant with all types of centrality measures for indexes capturing maritime connectivity (LSCI) and de facto liberal regulation in maritime transport (AVE CEPII). Efficient maritime connectivity improves significantly the central position in T&S GVC, and conversely de facto restrictions on foreign maritime transport impedes achievement of a more central position. While due to data availability, the number of observations is small, this nevertheless attests to the importance of maritime aspect.

A recent UNCTAD report (2016) found that most of the improvement in maritime connectivity (measured with the LSCI index over 2004-2014) has occurred since 2010, while in early periods, improvements stagnated for a large majority of country in the immediate aftermath of the 2008 economic crisis. In 2016, the best-connected countries in various regions of the world were Morocco, Egypt and South Africa in Africa; China and Korea in East Asia; Panama and Colombia in Latin America; Sri Lanka and India in South Asia; and Singapore and Malaysia in South-East Asia. The LSCI of a country is not only determined by its trade volume, but increasingly by its position within the global liner shipping network. The relevance of hubs becomes evident in countries characterised by a high level of connectivity despite the geographic size of the country (Singapore) or relative low level of trade (examples are Morocco, Panama and Sri Lanka). The centrality of these countries in the global network is highly relevant for the regions in which they are located: they are the gateway to international markets for landlocked countries or countries with weaker port infrastructure.

The creation of a maritime trade logistic hub relies on the presence of various conditions. First, the infrastructure able to manage a large volume of cargo in port hinterlands (that is, to expand the market for services in ports) is needed, including physical infrastructure to accommodate ever-larger vessels, increasing water depth and ship-to-shore container handling cranes and to adopt modern tools to increase the efficiency of cargo management. Second, the means to facilitate international trade and transit are needed, so that cargo from clients from neighbouring countries may more easily reach the port. Third, markets need to be competitive and shippers to have the possibility to choose among different terminals as well as a choice of trucking and shipping companies and no cargo reservation regimes in trucking or cabotage restrictions in shipping.

OECD work (2014) on a Transport STRI is very informative on restrictions in Maritime transport regulation. Restrictions on foreign entry have the greatest impact, with several countries restricting foreign ownership in the sector. Most other sector specific restrictions are found in the cabotage market and in ports. Among countries included in the STRI for maritime services, very few are without restrictions on cabotage and according to OECD (2014) impediments in ports are also widespread (barriers to foreign entry as port operators). There are few restrictions on international maritime transport, even though several countries

51. The tested specification is the following: $CI = \alpha + X\beta + Z\gamma + S\delta + dy + \epsilon$
Where CI stands for Centrality Index in Transport and Storage (successively Outdegree, Indegree, Forwardeigen and Inwardeigen), X are country characteristics variables (GDP per capita, Population, Distance to the markets), Z represents the performance in maritime connectivity (LSCI UNCTAD), S de facto restriction in foreign martime transport services (AVE_CEPII) and *dy* year fixed effect The regression is run on all 42 countries for which we had those variables over three years: 2005, 2008 and 2011.

maintain cargo reservation schemes on their books[52]. Therefore, restrictions very much happen once the ships reach the shores. Restrictions in maritime transport services are further explored in the next section.

6.2 Maritime transport services: the glue that binds GVCs together

The importance of T&S services in supporting other GVCs is further examined by looking at aggregated trade in value added but also more specifically at the two other sectors analysed in this paper, the M&Q and MV&T sectors. Using the same framework of analysis as in the previous section, the empirical approach here tests the impact of restrictions in freight maritime transport services and bilateral maritime connectivity on bilateral trade in value added, by the T&S, MV&T and M&Q sectors.

First we follow a forward type approach where the outcome variable is, for a country (exporter), its domestic value added embodied in partners' exports (importers) using trade in value added data retrieved from TiVA. Next, we use a backward-type approach to look at determinants of FVA embodied in the exports of a country for a particular sector. This provides two angles of analysis of the role of regulations in the maritime sector on integration in GVCs. Then the analysis subsequently studies the forward and backward T&S value added presence for the whole economy (aggregate sectors) and then for the MV&T and M&Q sectors.[53]

Overall results show that both restrictions in freight maritime and performance in maritime connectivity play a strong and significant role on GVC integration in all sectors examined. Maritime connectivity variables are determinants for the flow of foreign T&S value added embodied in the other sectors. As regards the two other sectors, restrictions on foreign freight maritime transport are a particularly important determinant of flows of foreign T&S value added embodied in MV&T exports. Maritime connectivity is important for both MV&T and M&Q sectors, but with a stronger impact on forward integration.

The results show that restrictions in maritime services in developed economies are particularly constraining for the integration of T&S value added originating from developing countries (backward integration of developed economies).[54] Similarly, protection in developing countries impedes the integration of T&S value added from developed economies in their exports (forward integration of developed economies).[55] This is verified when looking at the MV&T as a recipient sector. Such observations can result from gaps in maritime transport regulations between developed and developing economies, suggesting the importance of making progress on this issue.

Much of the value chain trade in T&S sector occurs between developed countries (70% of purchases and 61% of sales of value added in 2011). In contrast, value chain trade between developing countries is relatively minor but sales of developing countries to developed countries represent over 20% of all sales. However,

52. Cargo reservations, however, may not be enforced, due to the difficulties of monitoring compliance in modern shipping hub and spoke networks, with extensive transhipment that have developed to support containerised cargo.

53. This approach allows for differentiating between developing and developed economies in their roles in purchasing and selling T&S value added to see if this can explain the heterogeneity in buying and sailing shares between developed and developing economies observed in Figure 8.

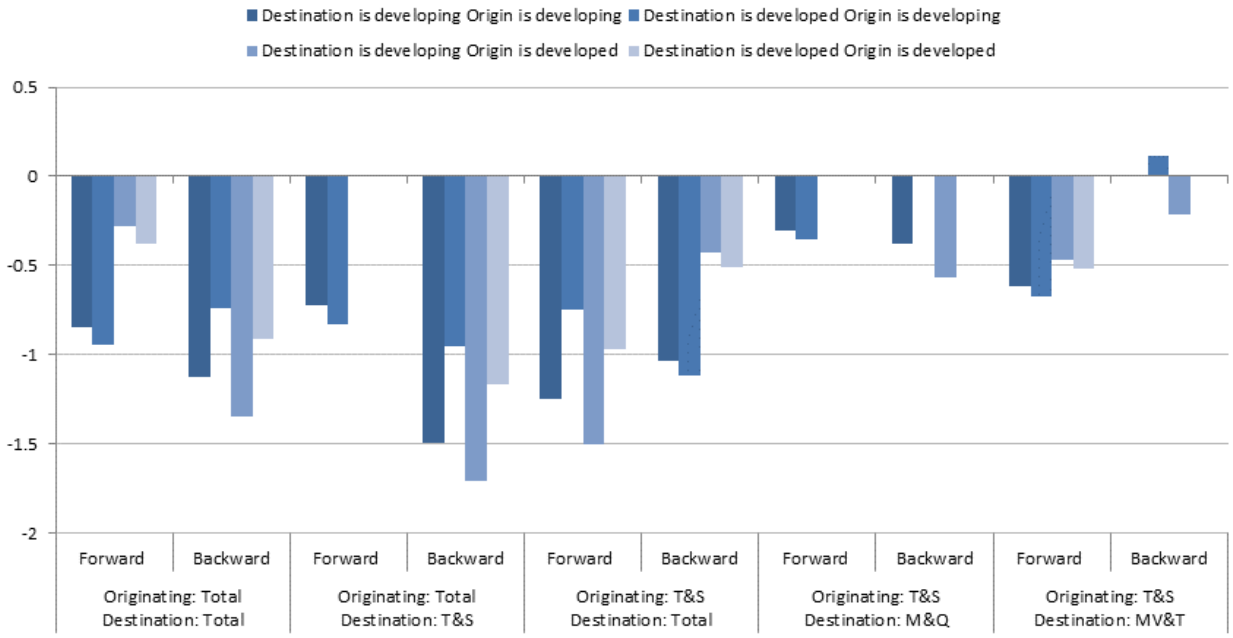
54. Backward integration and forward integration are successfully tested following the same specification of the bilateral gravity model presented in Annex E. An important caveat is that bilateral value added flows depend not only on bilateral trade costs but also on costs with third countries through which value added transits from source to destination. As a result, the standard gravity is expected to be less performant in for the analysis of value-added flows compared to gross exports. As illustrated in Table A3 in Annex 1, the model still yields intuitive results on core variables: proximity in geography and culture or existence of free trade agreement increases value-added flows between two partners whilst distance reduces them

55. Besides difficulties in interpreting gravity results in a standard fashion, empirical complications also arise in trying to capture these indirect effects. As shown by Noguera (2012) their relative importance can be high, although it varies significantly across countries and types of trade costs.

given differences in regulatory approaches and regulatory quality between developed and developing countries, it is interesting to explore the extent to which policies influence these observed trends.[56]

The decomposition across types of flows shows that maritime connectivity is not so much an issue for the flow of T&S value added between developed economies, but it is a significant issue for flows between developing economies (Figure 25). The results highlight a strong sensitivity to the additional costs associated with regulations (estimated as a tariff equivalent), among clusters and especially between developing countries. Forward integration of the T&S sector in developing countries is more affected by protection in developed countries. Equally, backward integration is constrained mostly by protection in developing countries which prevents them from integrating foreign T&S VA from developed economies in their exports.

Figure 25. Impact of maritime transport restrictions on foreign VA in the economy and in three specific sectors for different types of flows



Notes: Coefficient depicted are results from the set of estimation clustering by country groups and presented in annex A for restriction in maritime transport (AVE_CEPII).

Looking more specifically at the M&Q and the MV&T sector, restrictions in maritime transport are even more constraining on the domestic T&S value added embodied in a partner's exports of M&Q (forward linkages) as well as the T&S FVA embodied in a country's own exports of M&Q (backward linkages). For the MV&T sector, this highlights the importance of regulations in partner (importing) countries, while for M&Q, it is domestic regulations that matter. This outcome possibly results from the different structure of the value chain, with own policies being more important for GVC integration in horizontal sectors whilst partner countries policies are more important for integration in vertical GVCs.

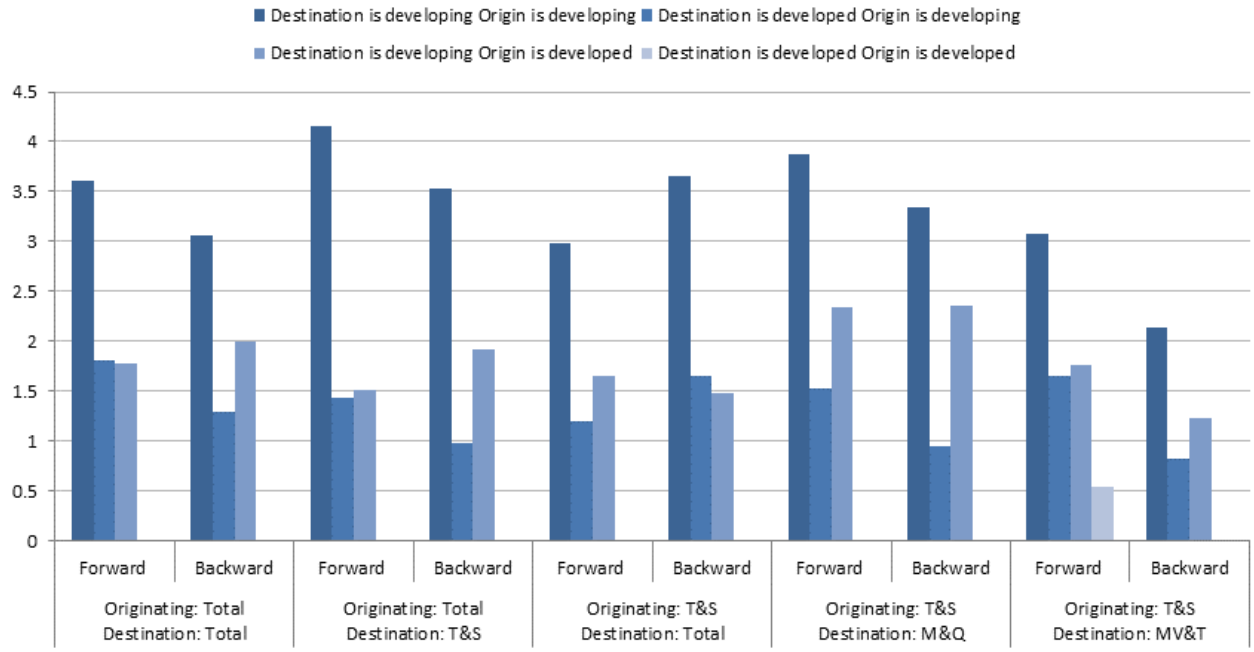
It is nevertheless important to keep in mind that bulk minerals products and exports of crude petroleum are transported in parallel maritime transport sectors that are not affected by liner shipping connectivity and obey to different criteria. Bulk minerals are shipped on very large vessels *en vrac*, as opposed to containers, and follow a regular schedule of stops in major ports. Infrastructure is generally specific to that product and whilst the depth of ports is an important determinant, proximity to liner hubs is less. Similarly, petroleum is shipped in tanks that are reserved on an ad hoc basis. However, the M&Q sector is strongly affected by

56. To do so, the gravity specification used in the analysis was expanded by interacting variables of interest according to the direction of value added flows (between developed and developing economies – see Table B4).

transport costs which make up 24% of export value of industrial raw materials compared with 5% of manufactures and 4% of crude oil (Korinek and Sourdin, 2009).

Another way to explore the impact of regulations in the maritime sector on GVC engagement is to look at the effects of linkages rather than costs as when testing restrictiveness. Higher linkages, prompted by better regulatory environments, should provide for positive estimates of GVC engagement. To explore this dimension, a similar specification is tested but using the LSBCI index, capturing levels of market condition and service, for testing bilateral maritime connectivity (LSBCI_UNCTAD). Better connectivity appears to significantly influence flows of FVA to all sectors (Figure 26). Levels of maritime connectivity significantly impact cross border trade in T&S value added at the aggregate levels, for the MV&T and also for the M&Q sectors, despite the difference in maritime transport markets previously mentioned. . Results by cluster underscore that, the flows of value added between developing economies are more affected by the levels of maritime connectivity.

Figure 26. Impact of bilateral maritime connectivity on foreign VA in the economy and in three specific sectors for different types of flows



This bilateral perspective further opens up the possibility of taking a closer look at the level of competition. The LSBCI index analysed in detail in the UNCTAD (2016) report shows that only 32% of all bilateral connections (11 650 in 2015) have five or more providers.[57] The authors observe that competition is limited on the remaining 68% as the number of companies offering services is smaller or equal to four, a situation which affects small economies in particular. They also observe that the most competitive routes for direct container shipping services appear to be intra-Europe but also intra-Asia.

Indeed through various waves of unilateral liberalisation and regional co-operation, East Asia has become more outward oriented and linked to global production networks. Effective implementation of programmes under the AEC blueprint signed in 2007 would keep ASEAN vibrantly integrated into global markets. More generally, for developing countries the Aid for Trade agenda is key to supporting them in improving their maritime transport performance and in particular to catch up with the digitalization of maritime transport.

57. Including options with trans-shipments, according to UNCTAD (2016).

This analysis confirms that GVC integration is particularly sensitive to maritime connectivity and more specifically to restrictions in foreign freight maritime transport services. Moreover, connectivity and restrictions not only affect integration into the T&S value chain, but also GVC integration overall. The effect is nevertheless very different according to sectors and country groups with a divide in terms of impacts between developed and developing economies. Focusing on the T&S value chain, restrictions in maritime services in developed economies are especially constraining for the integration of T&S value added originating from developing countries in their exports. The corollary also holds with restrictions in developing countries affecting integration of T&S value added from developed economies. This could indicate also a potential gap between maritime transport regulation between developed and developing economies, suggesting this as an area for future work. Maritime connectivity is positively correlated with the use of foreign T&S value added in exports except when trade partners are both developed economies. The coefficient of the correlation is also much higher when it involves two developing economies. This underlines the importance of pushing further agenda of regional trade facilitation in developing regions.[58]

On this matter the digitalisation and adoption of information systems[59] to facilitate data sharing has been recognised as a determining factor for shippers, forwarders and brokers as well as transport operators (OECD, 2014). Such digitalisation strategies are currently restricted to large international port such as Hamburg, Rotterdam or Singapore. Innovation and digitalisations expected to reduce logistics costs and increase transparency, including by making on-time information available to consumers and increasing reliability and predictability of delivery dates, as well as an overall reduction in trade costs through an increased efficiency. For instance, such tools enable businesses to compare routes, according to prices and expected delivery time and modes of transport. For freight forwarder, it can be a way to consolidate cargo. However, such systems require access to ICT infrastructure and potentially the implementation of various sets of regulations, including on cybersecurity, which can be challenging for developing economies. Yet, developing countries should not miss the opportunities digitalisation can bring for reducing trade costs, including for instance for the implementation of the trade facilitation agreement (See OECD/WTO, forthcoming), increase efficiency as well as participate in digitalization megatrends, in particular in trade logistics, to enable competitiveness and prevent increasing the connectivity divide between developed and developing economies, both physical and digital. Indeed, missing the digitalisation step could be a new trade disruption and barriers to market access as large operators might have the tendency to work with ports which will present digital systems interoperable with their own, leaving behind the non-connected infrastructure.

7. Conclusion

The analysis developed in this paper tests various findings and assumptions from the GVC literature at the sector level. More specifically, it tests various findings related to the domestic value added content in trade, by further exploring linkages between GVC integration and economic transformation. It focuses on three sectors, defined according to sectors in TiVA, and presenting different GVC structures and characteristics: natural resources represented by the TiVA sector *mining and quarrying* (M&Q); the automotive industry represented by the TiVA sector *motor vehicles, trailers and semi-trailers* (MV&T); a services sector particularly important for developing countries' connectivity and integration in GVCs, the TiVA sector *transport and storage* (T&S). To do so, it uses various methodologies and indicators. First it undertakes a literature review and TiVA indicators are used to describe the anatomy and dynamics of each sector as well as their position in the GVC landscape from a trade in value added perspective. It then adopts social network analysis methodologies, using TiVA and other data sources, to test various assumptions about the degree of resilience of each sector, their relationship to economic transformation and the importance of

58. For instance initiatives such as the Blue print 2025 for the ASEAN which elaborated a long terms plan to facilitate production networks in the region, and support its integration into global markets

59. Those advanced port information systems are open electronic platform that optimise manage and automate smooth port and logistics processes through a single submission of data, thus eliminating number of paper documents and clerical work in port operation (OECD, 2014).

services. Finally, it tests the importance of the regulatory environment in T&S services for GVC integration, in particular maritime services.

The evidence gathered supports previous findings of the GVC literature at the aggregate level, but nevertheless provides a new perspective about the importance of understanding the structure of various sectors to better target policies intending to support economic transformation. It highlights that policy makers should better understand and take into consideration the characteristics and structure of sectors when defining their strategies to adapt and manage expectations in terms of economic transformation. In addition, when the structure of the value chain suggests greater susceptibility to risks; they should ensure that buffers prevent the contagion of potential shocks throughout domestic and international value chains. These can include enabling diversification into sectors presenting different risk profiles, for example in the context of policy strategies related to FDIs and more broadly the creation of an enabling environment supporting the sustainable transformation of all sectors.

The three sectors have, in the aggregate, increased the use of foreign intermediates for the production of exports, following different trends related to sectoral characteristics, making some sectors more or less suitable to unbundling and internationalisation of production processes. Despite this, it is possible to identify some evidence of the existence of a u-shaped relationship between stages of integration in GVCs and the share of domestic value added, further proof of the non-linearity of the process of GVC integration and its relation to economic transformation.

Despite important differences in structure, the M&Q and the MV&T sectors both display a relationship between the use of FVA and the sophistication of exports. This means that upgrading is not only related to vertical integration of GVCs, but also through the opportunity to import inputs. However, the relationship between the level of sophistication of exports (and thus economic transformation) and the use of FVA appears to have been disrupted by the 2008 crisis. For M&Q, the disruption was short lived. For MV&T, it has persisted over the period for which data are available (2011). This could relate to both a higher sensitivity to shocks by countries exporting more sophisticated bundles of products and the greater integration of these sectors in GVCs. Further analysis could also aim at identifying whether this may also be rooted in the policy responses enacted during the crisis and persisting afterward.

For the natural resources sectors examined, at the aggregate level, they appear more resilient to the shocks caused by the economic crisis. For countries involved in these sectors, opportunities opened by the sector to support economic transformation should not rely on strategies directly aiming at increasing DVA share by upgrading in the production chain, as many current policies seem to intend, unless these are underpinned by comparative advantages. Rather, the analysis suggests that learning by importing opportunities may also exist here, likely around the support services that are provided from within the sector. For resource rich developing countries, it is also important that policies are in place to avoid the potential capture of the resource value by few economic actors creating new bottleneck risks and inequalities. Capabilities associated with production in the M&Q sector are not necessarily useful to develop productive capacities in the next steps of the value chain. They are associated with fewer diversification opportunities. However, the sector offers opportunities on the upstream as a buyer of a large array of services. Building capabilities in those services, which themselves support many other sectors in the economy, offers more perspective than building capabilities directly in the M&Q sector. Finally, it is important to emphasise that separating oil-and-gas from mining rich countries underscores the conventional wisdom about more potential for upstream linkages in the mining sector compared with the oil-and-gas sector.

The MV&T sector is of a very different nature, particularly as it is a vertically integrated GVC. The relationship to economic transformation is more straightforward and significant than for the two other sectors. However, it is also more sensitive to shocks, as shown by the longer run disruption of the structure after the financial crisis – including in a number of the transformation relationships. More generally, sectors presenting similar innovation and fragmentation potential – whilst presenting leapfrogging opportunities as marketed in the GVC literature and illustrated by many success stories – are also creating new vulnerabilities and risks.

Whether through trade in value added or FDI, a high reliance on industries concentrated around a few important regional multinational companies is also a risk, as supply or demand relies on a handful of actors.

This was illustrated by the economic effect of the departure of Intel from Costa Rica which has been considered to be the main cause of the 3% GDP drop experienced by the country in 2015 (OECD, 2016). Low-tech industries with a broader competition environment and therefore higher substitutability of business partners as well as more prone to technology spillovers such as the garment sector present some of the advantages of trade in tasks, with less dependency than high-tech sector. Clothes designs contain less innovation and are easier to adapt than cars or computers designs. Whilst promising as a shortcut to economic transformation, policy makers should be attentive that wealth and capabilities created by integration in such GVC also supports diversification into other sectors presenting uncorrelated or different sensitivity to local or global shocks.

Finally, the T&S sector is central to trade in value added, not only as a seller but also as a buyer of value added. In particular, the increase in use of foreign intermediates in the sector, whilst partially resulting from the increase in prices of energy, also potentially results from the trends of creation of GVCs in services with technology progress and in particular digitalisation of logistics services, enabling new trade in tasks in services.

Whilst the sector is highly correlated with the movement of goods, and therefore mimics the regional factory geography of the manufacturing sector, it is nevertheless possible to identify the effect of the regulatory environment on the use of FVA and efficiency of the sector. Further analysis is required to refine the finding and better identify causality, yet, evidence gathered in this paper clearly points toward the detrimental effect of barriers to trade in logistics services on GVC integration in the T&S sector as well as in other sectors, further supporting the consideration of tacking competition issues in the sector to reap the benefits of infrastructure investments and support the success of the Aid for Trade agenda.

GVC integration is particularly sensitive to maritime connectivity and more specifically to restrictions to entry of foreign freight maritime transport services. Connectivity and restrictions not only affect integration into the T&S value chain, but also GVC integration overall. Differences of sensitivity to connectivity and regulations are nevertheless noticeable between M&Q and MV&T. The transport of products from those two sectors requires different types of fleets which might involve in a different competitive environment. More granular analysis of the conditions of competition between those two sectors could better explain this difference in sensitivity to barriers to entry into the foreign freight maritime transport services.

Finally, there is a divide in terms of impacts between developed and developing economies of maritime connectivity and services restrictions. Restrictions are particularly problematic for the integration of T&S sectors between developed and developing economies. Maritime connectivity is particularly important in the development of GVCs among developing economies. This could indicate a potential area where progress could reap significant gains in terms of GVC integration. Analysis in this paper also underscores the importance of pursuing regional and global integration as important tools for promoting economic transformation in developing countries.

References

Acemoglu, D. et al. (2012), The network origins of aggregate fluctuations. Econometrica, 80(5), 1977-2016.

Antràs P. et al. (2012), "Measuring the Upstreamness of Production and Trade Flows", in *NBER Working Paper Series*, N. 17819.

Arvis, J.-F. et al. (2012), "Connecting to Compete 2012: Trade Logistics in the Global Economy", World Bank Group, Washington, DC.

Auty, R. (1993), Sustaining Development in Mineral Economies: The Resource Curse Thesis (Routledge: London).

Auty, R. (ed.) (2001), Resource Abundance and Economic Development (Oxford University Press: Oxford).

Baldwin, R. (2012), "Trade and Industrialisation after Globalisation's Second Unbundling: How Building and Joining a Supply Chain are Different and Why it Matters", in Globalization in an Age of Crisis: Multilateral Economic Cooperation in the Twenty-First Century, R. Feenstra and A. Taylor (eds.), University of Chicago Press.

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

Beltramello, A., K. De Backer and L. Moussiegt (2012), "The Export Performance of Countries within Global Value Chains (GVCs)", *OECD Science, Technology and Industry Working Papers*, No. 2012/02, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/5k9bh3gv6647-en.

Bhattacharyya, S. and R. Hodler (2010), "Natural resources, democracy and corruption", European Economic Review, Vol. 54, Issue 4, May 2010, Pages 608-621.

Borchert, I. et al. (2012), "Landlocked or Policy Locked? How Services Trade Protection Deepens Economic Isolation", *Policy Research Working Paper* 5942, World Bank.

Bridge, G. (2008), "Global production networks and the extractive sector: governing resource-based development", *Journal of Economic Geography* 8 (3): 389-419.

De Backer, K. and S. Miroudot (2013), "Mapping Global Value Chains", OECD Trade Policy Papers No. 159, OECD Publishing Paris, DOI: http://dx.doi.org/10.1787/5k3v1trgnbr4-en

Carvalho, V.M. (2014), From micro to macro via production networks. *The Journal of Economic Perspectives*, 28(4), 23-47.

CDP (2014), "Climate Change Resilience in Europe: A Snapshot of the Private Sector". London: CDP.

Dasaklis, T.K. and C.P. Pappis (2013), 'Supply Chain Management in View of Climate Change: An Overview of Possible Impacts and the Road Ahead'. *Journal of Industrial Engineering and Management* 6(4): 1124-1138.

Darling, P. (2011), SME mining engineering handbook (Vol. 1). SME.

Elmqvist, T. et al. (2003), Response diversity, ecosystem change, and resilience. Frontiers in Ecology and the Environment, 1(9), 488-494.

Ernst and Young (2015), Mining uncovered: The role of innovation in mining, http://www.ey.com/au/en/industries/mining---metals/ey-september-2015-mining-uncovered-the-role-of-innovation-in-mining, September.

Fontagné, L., C. Mitaritonna, and J.E. Signoret (2016), "Estimated Tariff Equivalents of Services NTMs", *CEPII Working Paper*, N°2016-20.

Fugazza, M. and J. Hoffman (2016), "Bilateral Liner Shipping Connectivity Since 2006", Policy Issues in International Trade and Commodities, *Study Series* No. 72.

Fujita, M. (1999), "Industrial Policies and Trade Liberalization—The Automotive Industry in Thailand and Malaysia." Industrial Policies and Trade Liberalization 1999:149– 87.

Greenville, J., K. Kawasaki and R. Beaujeu (2017), "How policies shape global food and agriculture value chains", *OECD Food, Agriculture and Fisheries Papers*, No. 100, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/aaf0763a-en.

Hallegatte, S. (2014), Economic Resilience: definition and measurement. Policy Research working paper, No. WPS 6852. Washington, DC: World Bank Group.

Hausmann R. et al. (2011), The Atlas of Economic Complexity. Puritan Press. Cambridge MA.

Hausmann, R, J. Hwang and D. Rodrik (2007), "What You Export Matters", *Journal of Economic Growth*, Vol.12:1-25.

Hausmann, R. and B. Klinger (2007), "The Structure of the Product Space and the Evolution of Comparative Advantage." *CID Working Paper* No. 146, Center for International Development, Harvard University, Cambridge, MA.

Hirschman, A.O. (1977), "A generalized linkage approach to development, with special reference to staples", *Economic Development and Cultural Change*, 25 (supplement: 67–98).

Hoekman, B and B. Shepherd (2015), "Services Productivity, Trade Policy, and Manufacturing Exports", *RSCAS Working Papers* 2015/07.

Humphrey, J. (1995), Industrial organization and manufacturing competitiveness in developing countries. *Special Issue of World Development*, 23(1), 1–7.

Humphreys, D. (2015), The Remaking of the Mining Industry, Palgrave-Macmillan, ISBN 978-1-137-44201-7.

Kommerskollegium (2010), "Servicification of Swedish manufacturing", Kommerskollegium 2010:1, The National Board of Trade.

Korhonen, J., and T.P. Seager (2008), Beyond eco-efficiency: a resilience perspective. *Business Strategy and the Environment*, 17(7), 411-419.

Korinek, J. and J. Kim (2010), "Export Restrictions on Strategic Raw Materials and Their Impact on Trade", *OECD Trade Policy Papers*, No. 95, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/5kmh8pk441g8-en

Korinek, J. and P. Sourdin (2009), Maritime Transport Costs and their Impact on Trade, August, http://www.etsg.org/ETSG2009/papers/korinek.pdf.

Lemma A., M-A Jouanjean and E. Darko (2015), Climate change, private sector and value chains: Constraints and adaptation strategies, ODI, *PRISE Working Paper*.

Los, B., M. Timmer and G. De Vries (2015), "How Global are Global Value Chains? A New Approach to Measure International Fragmentation", *Journal of Regional Science*, Vol. 55-1, pp. 66-92.

Maur J.C and B. Shepherd, (2015), "Connecting Food Staples and Input Markets in West Africa", World Bank Other Operational Studies 22276, The World Bank.

Mottaleb, K.A. and T. Sonobe (2011), An inquiry into the rapid growth of the garment industry in Bangladesh. Economic Development and Cultural Change, 60(1), 67-89.

Miura, H. (2012), Stata graph library for network analysis. *Stata Journal*, 12(1), 94.

Natsuda, K. and J. Thoburn (2013), Industrial policy and the development of the automotive industry in Thailand, *Journal of the Asia Pacific Economy*,18(3), 413-437.

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

OECD (2013a), "Trade Costs - What Have We Learned?: A Synthesis Report", *OECD Trade Policy Papers*, No. 150, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/5k47x2hjfn48-en

OECD (2013b), *Aid for Trade and Value Chains in Transport and Logistics*, OECD Publishing, Paris.

OECD (2014a), "Global Value Chains: Challenges, Opportunities and Implications for Policy", OECD Report.

OECD (2014b), "Services Trade Restrictiveness Index (STRI): Transport and Courier Services", *OECD Trade Policy Papers* No. 176, OECD Publishing, Paris.

DOI: http://dx.doi.org/10.1787/5jxt4nd187r6-en

OECD (2014c), *Export restrictions in raw materials trade: facts fallacies and better practices*, OECD Publishing, Paris.

OECD (2015a), "Developing countries participation in global value chains and its implications for trade and trade related policies", OECD *Trade Policy Papers*, No. 179, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/5js33lfw0xxn-en

OECD (2015b), "Participation in global value chains in Latin America - Implications for trade and trade related policy: Preliminary draft", *Working paper*. TAD/TC/WP(2015)28.

OECD (2015c), "Global value chains and small and medium sized enterprises. A focus on Southeast Asia - preliminary draft", *Working paper*, TAD/TC/WP(2015)25.

OECD (2015d), "Diagnostic of Chile's engagement in global value chains", TAD/TC/WP(2015)27.

OECD (2015e), "GVC participation in the agricultural and food sector", TAD/TC/CA/WP(2015)6.

OECD/WTO (Forthcoming), Chapter 3: Getting it shipped and delivered, Aid for Trade at a Glance 2017: Promoting Connectivity, OECD Publishing, Paris. Pack, H. and K. Saggi (1997), Inflows of foreign technology and indigenous technological development. Review of development economics, 1(1), 81-98.

Pietrobelli, C. and R. Rabellotti (2004), Upgrading in clusters and value chains in Latin America: the role of policies. Inter-American Development Bank.

Prebisch, R. (1950), The Economic Development of Latin America and Its Principal Problems (Lake Success, NY: UN).

Reis, J.G. and T. Farole (2012), Trade competitiveness diagnostic toolkit. World Bank Publications.

Ruta, M and A. Venables (2012), "International trade in natural resources: practice and policy", *WTO Staff Working Paper* ERSD-2017-07.

Santoni G. and D. Taglioni (2015),"Networks and Structural integration in global value chains", in The Age of Global Value Chains: Maps and Policy Issues, (eds.) J. Amador and F. di Mauro, VoxEU eBook, Centre for Economic Policy Research.

Sachs, J.D. and A.M. Warner (1997), *Natural-resource Abundance and Economic Growth* (Center for International Development and Harvard Institute for International Development, Harvard University, Cambridge, MA).

Sachs, J. and A. Warner (1999), "The big push, natural resource booms and growth", *Journal of Development Economies*, 59: 43–76.

Shepherd, B. (2015), Infrastructure, trade facilitation, and network connectivity in sub-Saharan Africa. Background paper for the DFID project Regional Infrastructure for Trade Facilitation, Overseas Development Institute (ODI).

Shepherd, B. and E. Archanskaia (2014), "Evaluation of Value Chain Connectedness in the APEC Region." Publication No. 214-SE-01.28, APEC.

Shepherd, B. and S. Stone (2013), "Global Production Networks and Employment: A Developing Country Perspective", *OECD Trade Policy Papers*, No. 154, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/5k46j0rjq9s8-en.

Stevens, P., G. Lahn and J. Kooroshy (2015), "The resource curse revisited", Chatham House Research Paper, August 2015.

Sturgeon, T.J. and R. Florida (2004). "Globalisation, Deverticalisation and Employment in the Motor Vehicle Industry", in M. Kenny (ed.) Locating Global Advantage: Industry Dynamics in a Globalising Economy, Palo Alto, Stanford University Press.

Sturgeon, T.J. et al. (2008), "Globalisation of the automotive industry: main features and trends", *International Journal of Technological Learning, Innovation and Development* 2, no. 1-2: 7-24.

Shepherd, B. (2011), "Logistics Costs and Competitiveness: Measurement and Trade Policy Applications", *Transport Research Support Working Paper*, World Bank.

Tang, V.T. (2015), "Does learning by importing, self-selection of markets and financial innovation matter for exporting firms in special economic zones?." *Investment Management and Financial Innovations*, Vol. 12, Issue 1.

Timmer, M.P. et al. (2015), "An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production", *Review of International Economics*, 23(3), 575–605, 2015.

UNCTAD (2016), Review of Maritime Transport.

Congress, U. S. (1988), Office of Technology Assessment, Copper: Technology and Competitiveness. OTA-E-367, US Government Printing Office, Washington, DC.

Van Biesebroeck, J. and T.J. Sturgeon (2010), "Effects of the 2008-09 Crisis on the Automotive Industry in Developing Countries: A Global Value Chain Perspective", in O. Cattaneo, G. Gereffi and C. Staritz (eds.), *Global Value Chains in a Postcrisis World*, The World Bank, Washington.

Wad, P. (2009), "The automobile industry of Southeast Asia: Malaysia and Thailand", *Journal of the Asia Pacific Economy* 14, No. 2 (2009): 172-193.

WEF (2012), Global Enabling Trade Report 2012, Geneva: World Economic Forum.

WEF (2012), "New Models for Addressing Supply Chain and Transport Risk", World Economic Forum, Geneva.

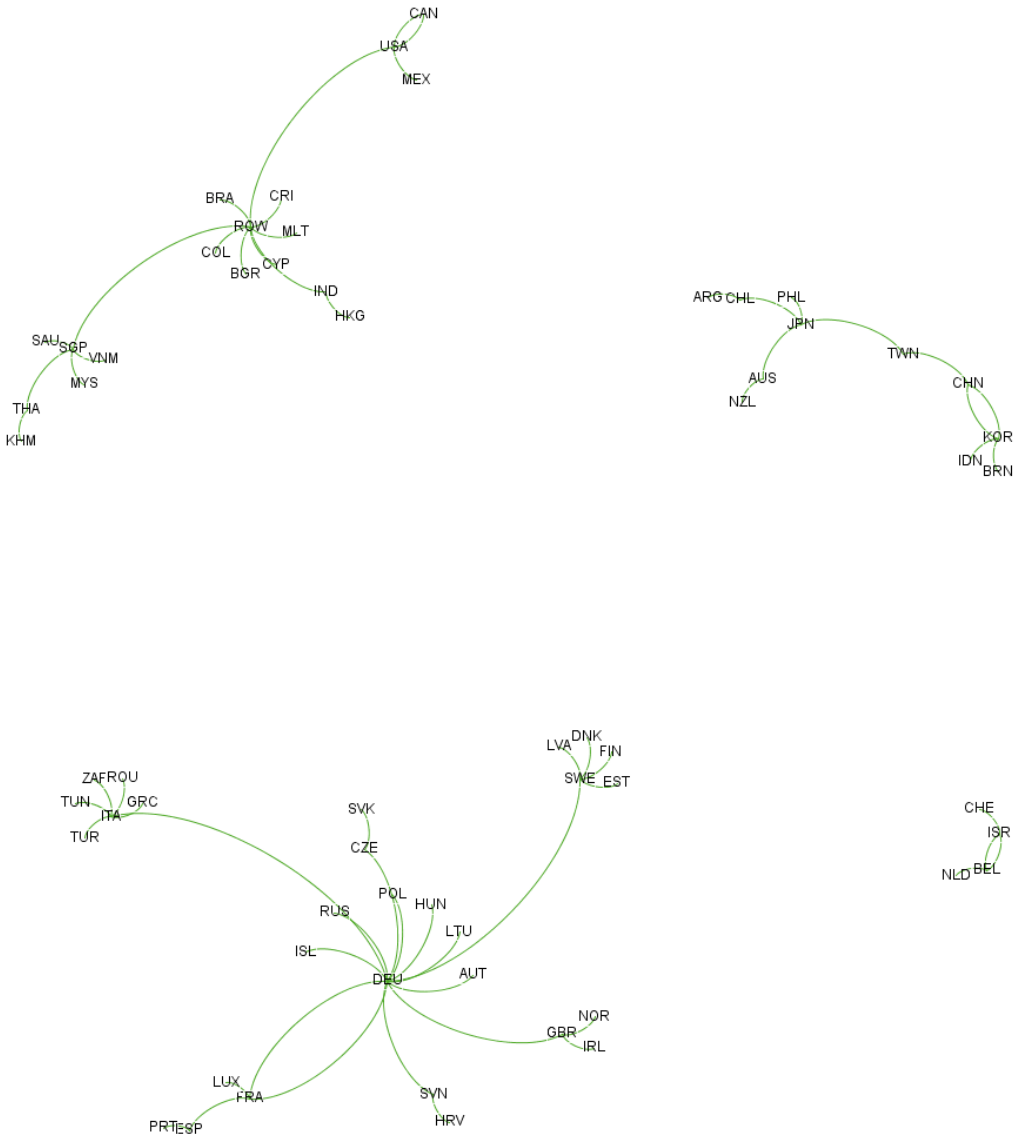
Data

Center for International Development at Harvard University, "The Atlas of Economic Complexity", http://www.atlas.cid.harvard.edu.

Annex A.

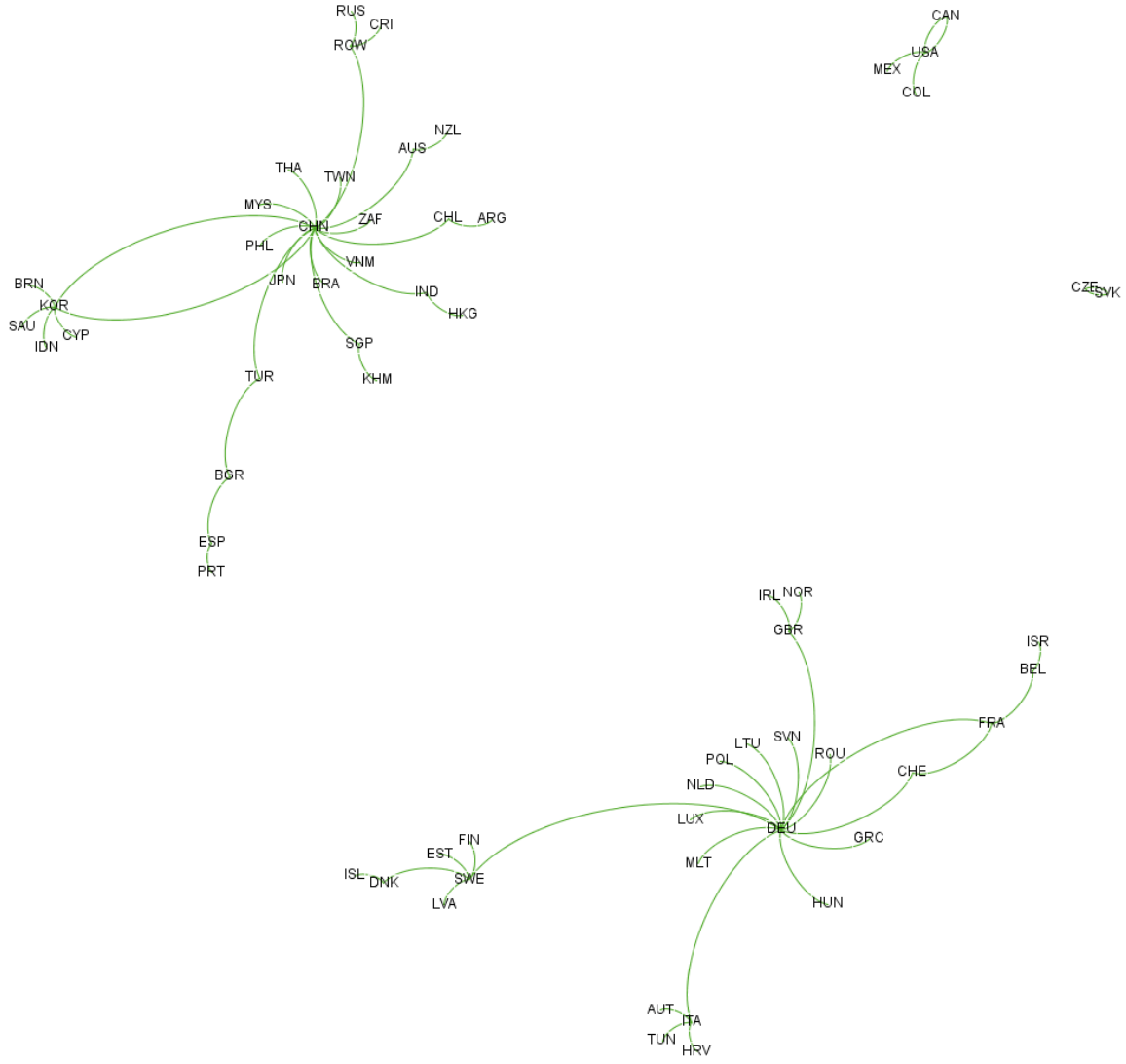
Figures

Figure A.1. Network of value added in 1995 for M&Q: more important flows per exporter represented



Note: Computed by the authors using the OECD ICIO and the programme Gephy. Curbs are representing exports in value added, the connexion “from-to” represented clockwise. For instance, Sweden and Italy largest exports of value added in the M&Q sector are toward Germany

Figure A.2. Network of value added in 2011 for M&Q: more important flows per exporter represented



Note: Computed by the authors using the OECD ICIO and the programme Gephy. Curbs are representing exports of value added, the connexion from-to represented clockwise.

Figure A.3. Domestic and Foreign Value Added in Exports – Mining and Quarrying – High Income Countries

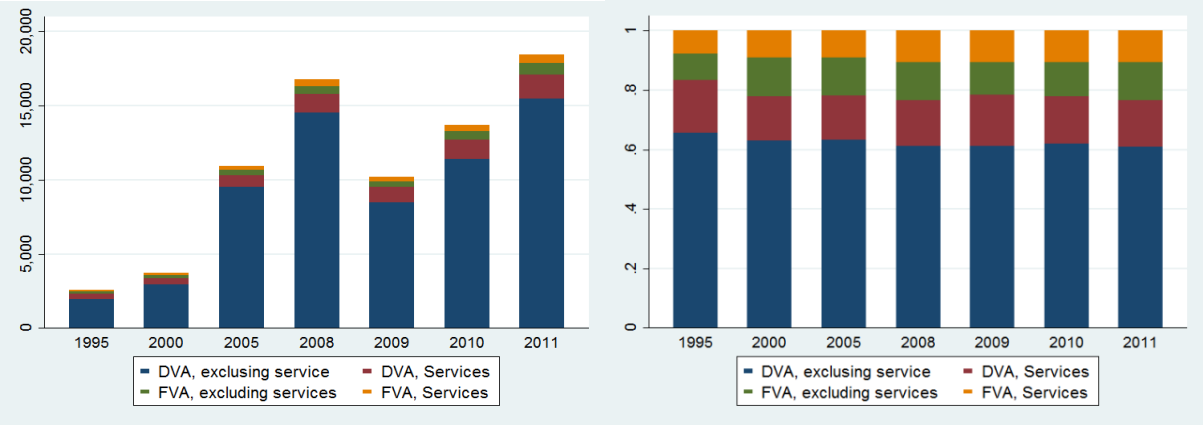
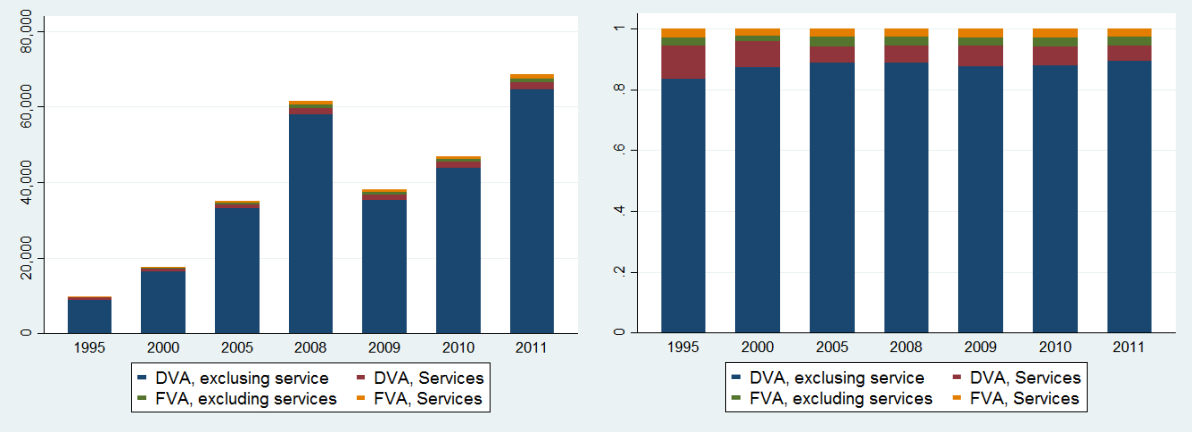
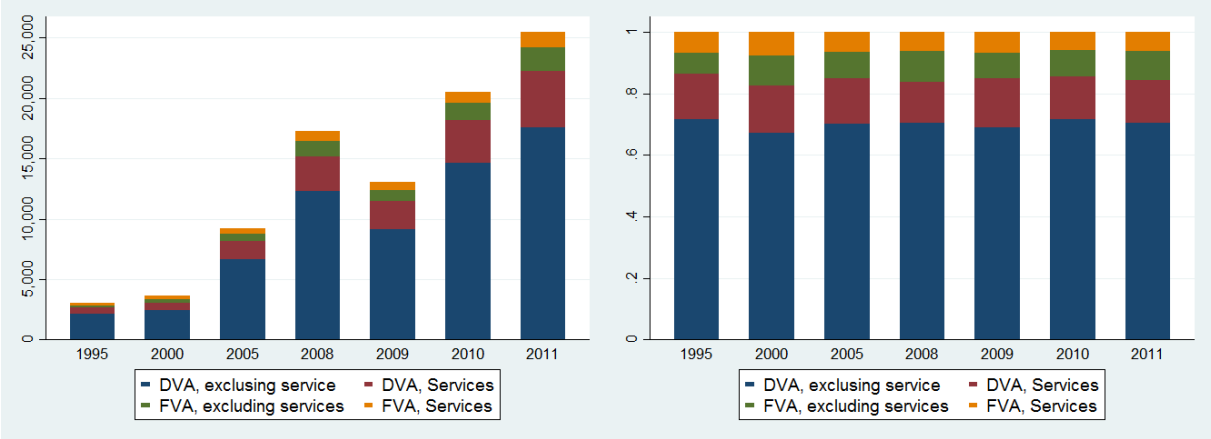


Figure A.4. Domestic and Foreign Value Added in Exports – Mining and Quarrying, Oil and Gas exporters



Note: countries included are Argentina, Brunei Darussalam, Malaysia, Mexico, Norway, Colombia, Saudi Arabia

Figure A.5. Domestic and Foreign Value Added in Exports – Mining and Quarrying, Mining products exporters



Note: countries included are Australia, Chile, Sweden, Turkey, China, India, South Africa, Philippines

Figure A.6. Mining and Quarrying - DVA in exports of final and intermediate products as a share of gross exports

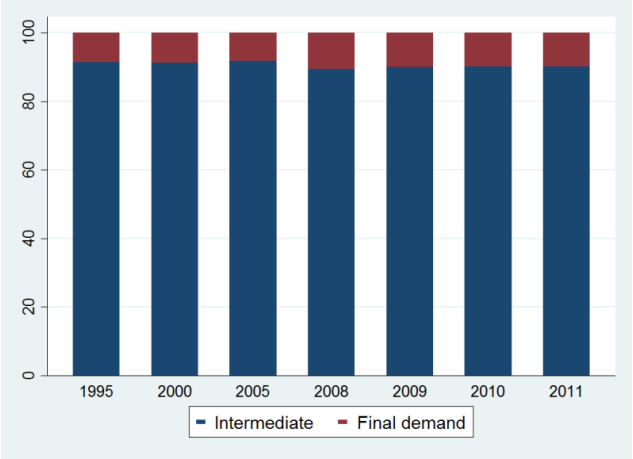


Figure A.7 Network of value added in 1995 for MV&T: more important flows per exporter represented

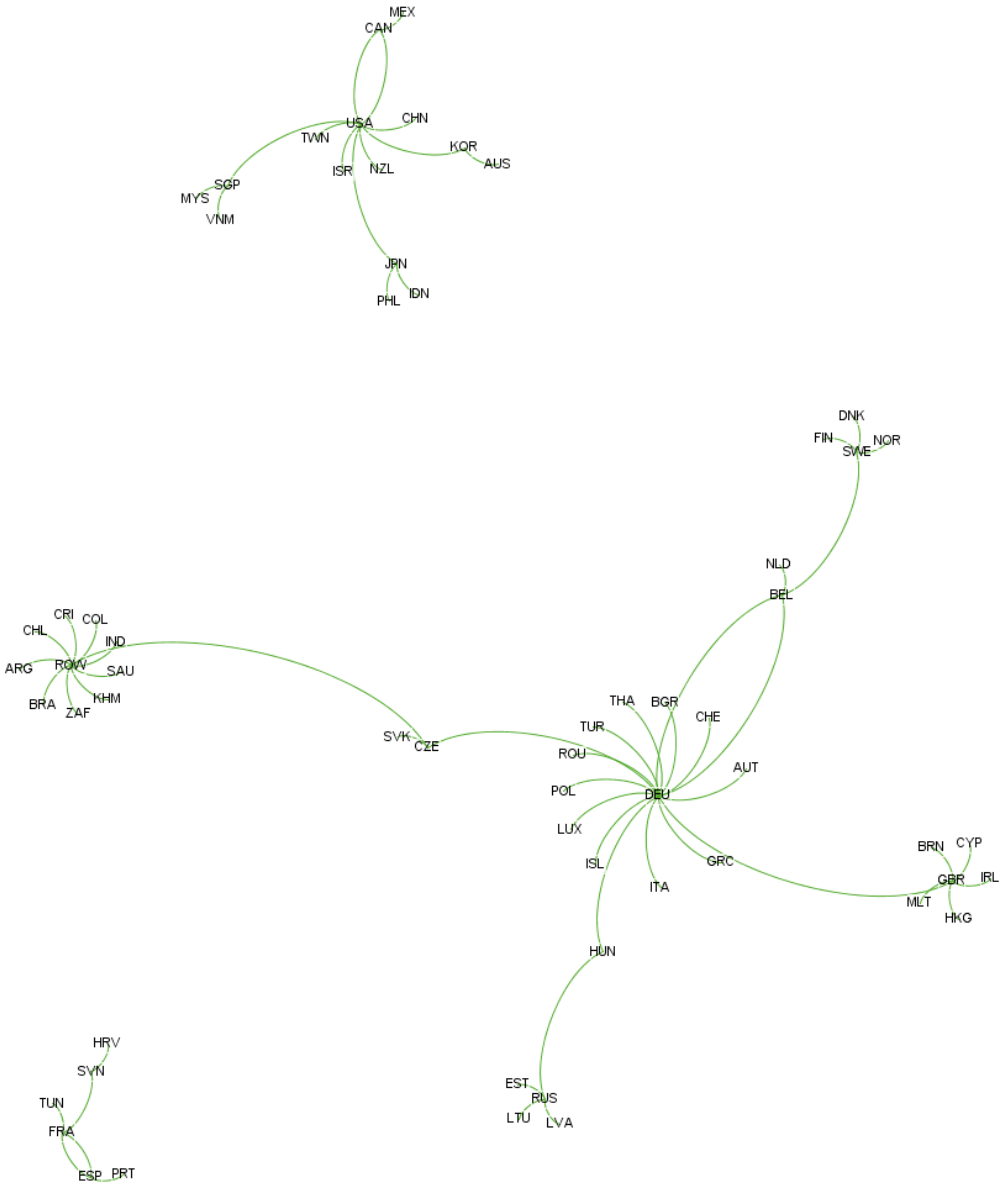


Figure A.8. Network of value added in 1995 for MV&T: more important flows per exporter represented

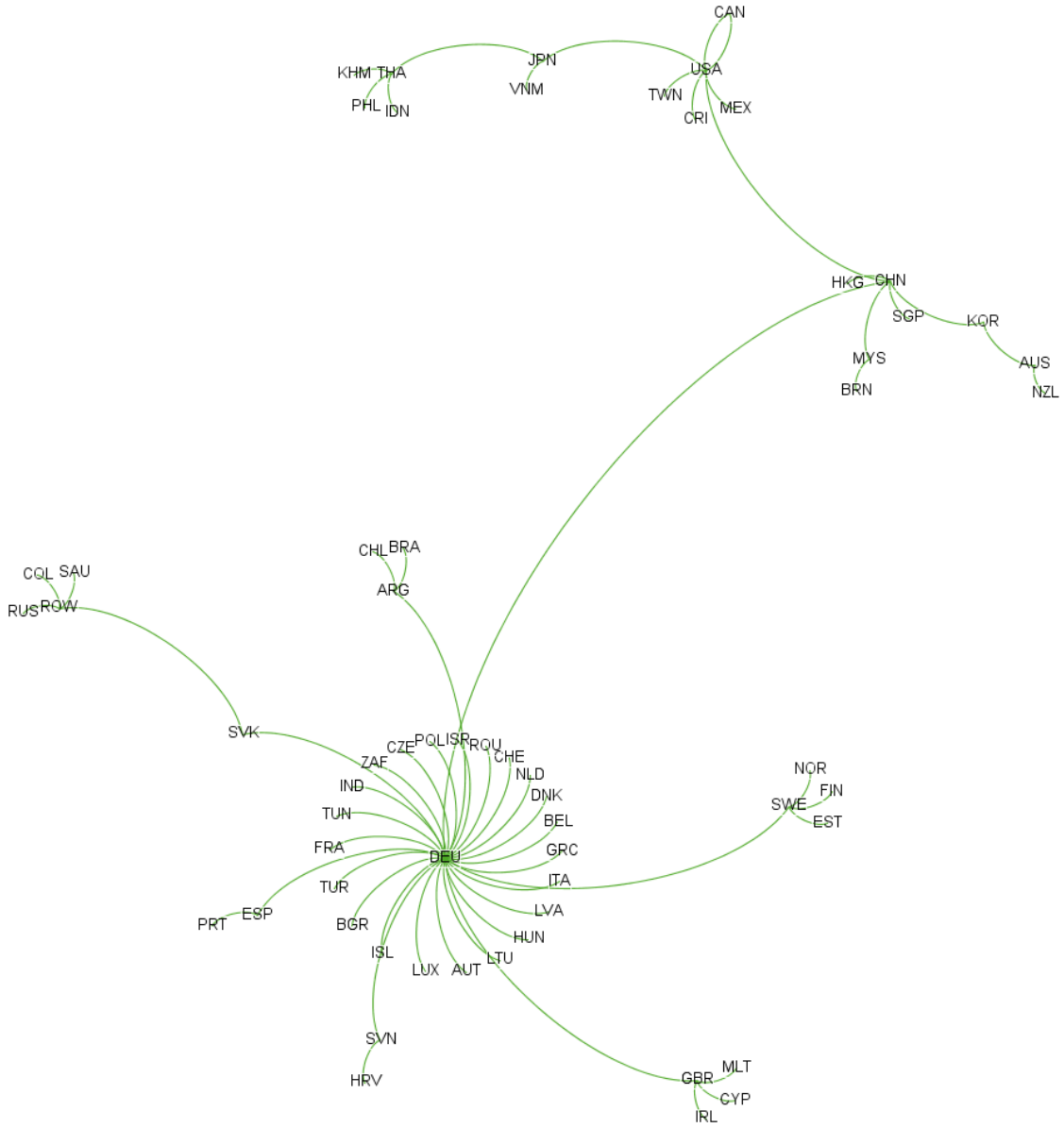


Figure A.9. Lower Middle Income Countries - Domestic and Foreign Value Added in Exports – Motor vehicles, trailers and semi-trailers

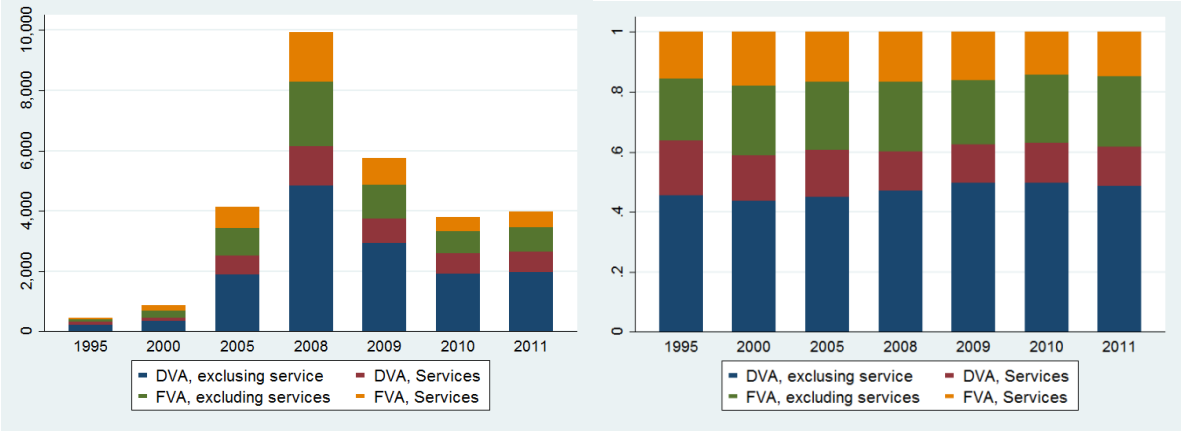


Figure A.10. Upper Middle Income Countries - Domestic and Foreign Value Added in Exports – Motor vehicles, trailers and semi-trailers

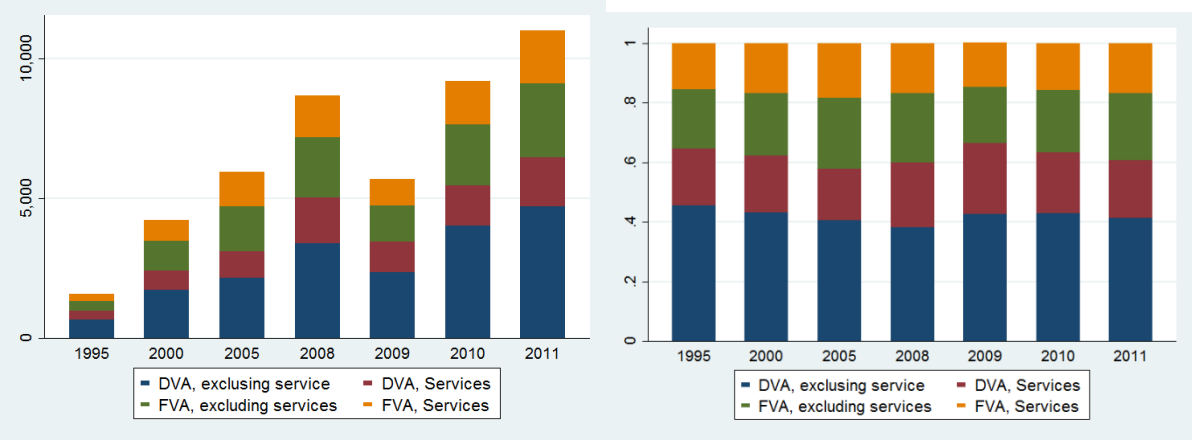


Figure A.11. High Income Countries - Domestic and Foreign Value Added in Exports – Motor vehicles, trailers and semi-trailers

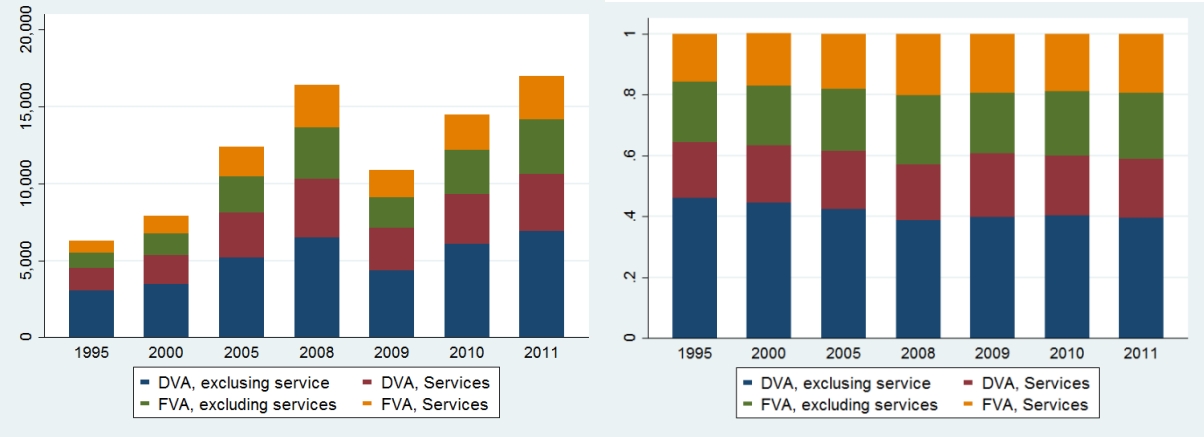


Figure A.12. MV&T - DVA in exports of final and intermediate products as a share of gross exports

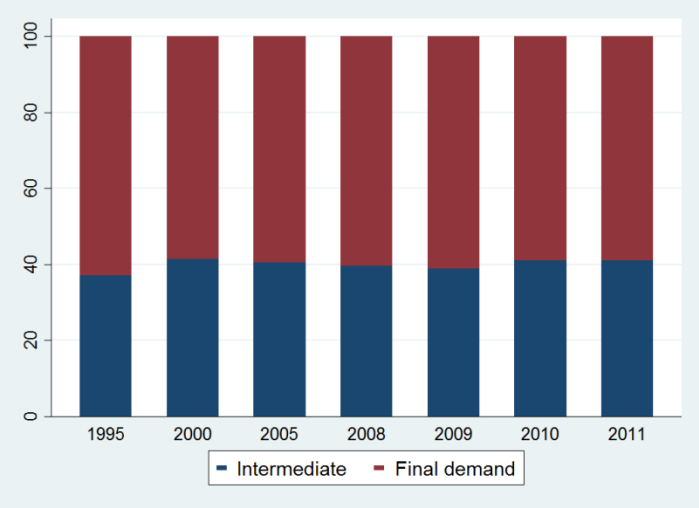


Figure A.13. Network of value added in 1995 for T&S: more important flows per exporter represented

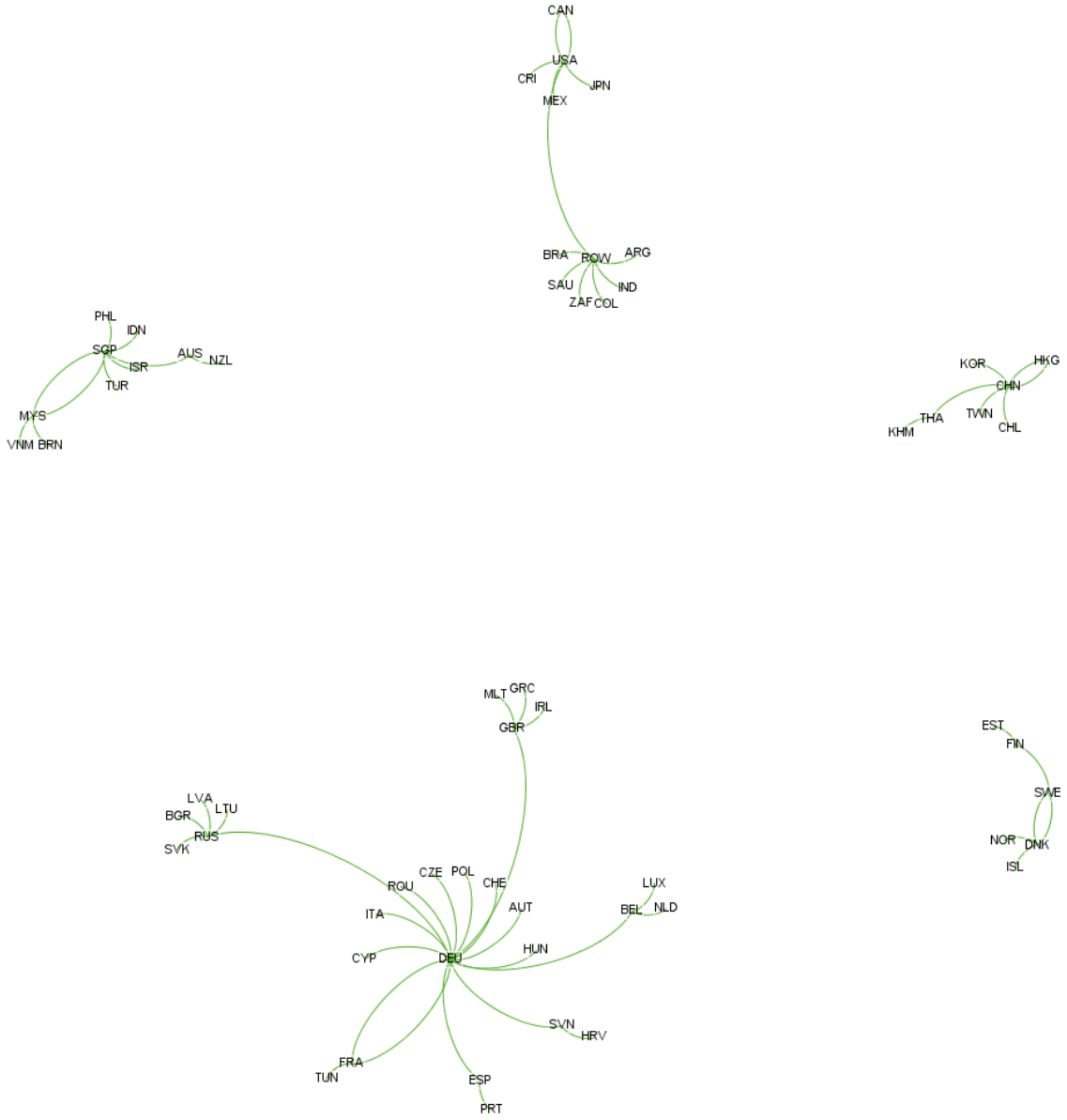


Figure A.14. Network of value added in 2011 for T&S: more important flows per exporter represented

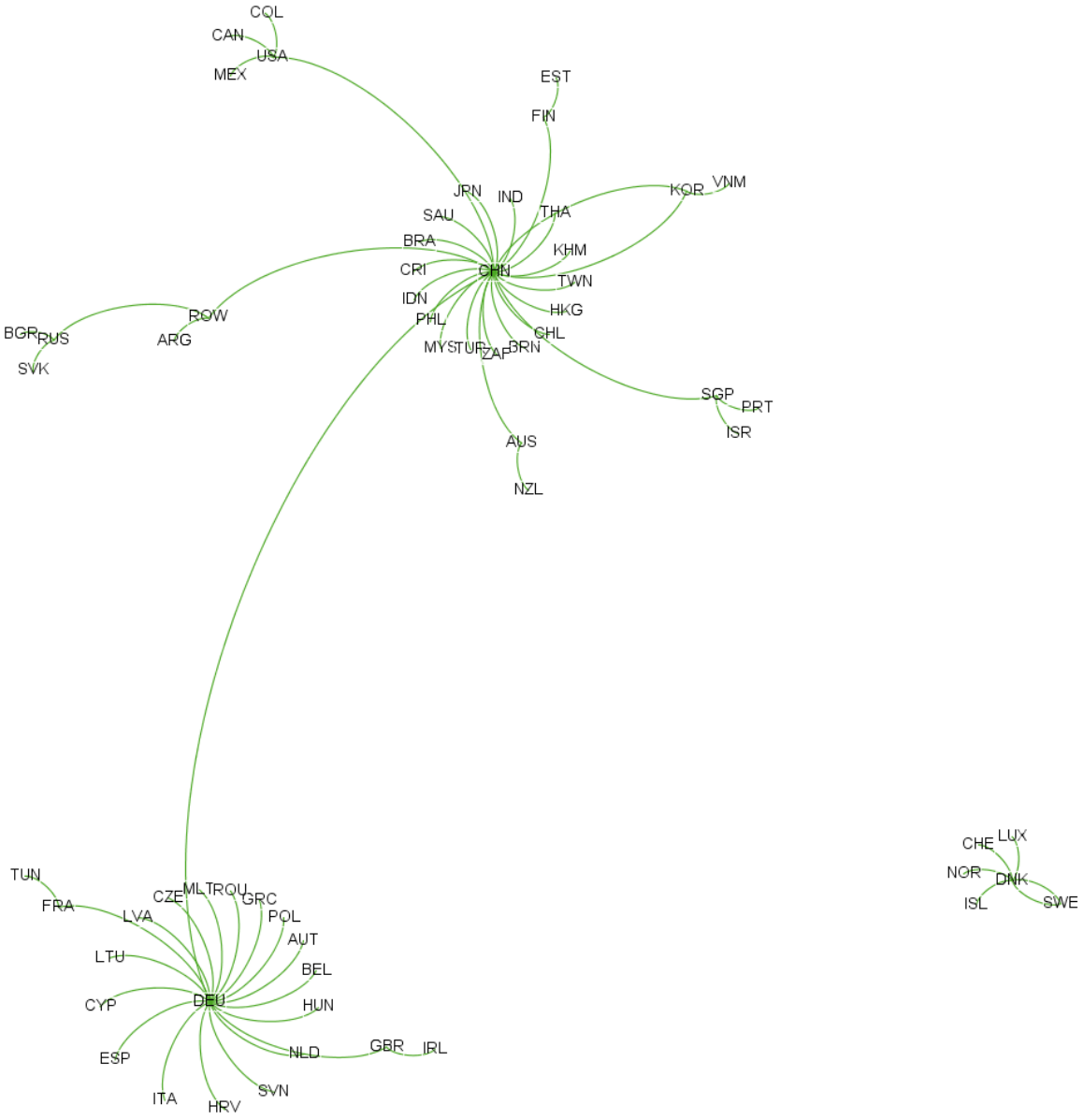


Figure A.15. Lower Middle Income Countries - Domestic and Foreign Value Added in Exports – Transport and Storage

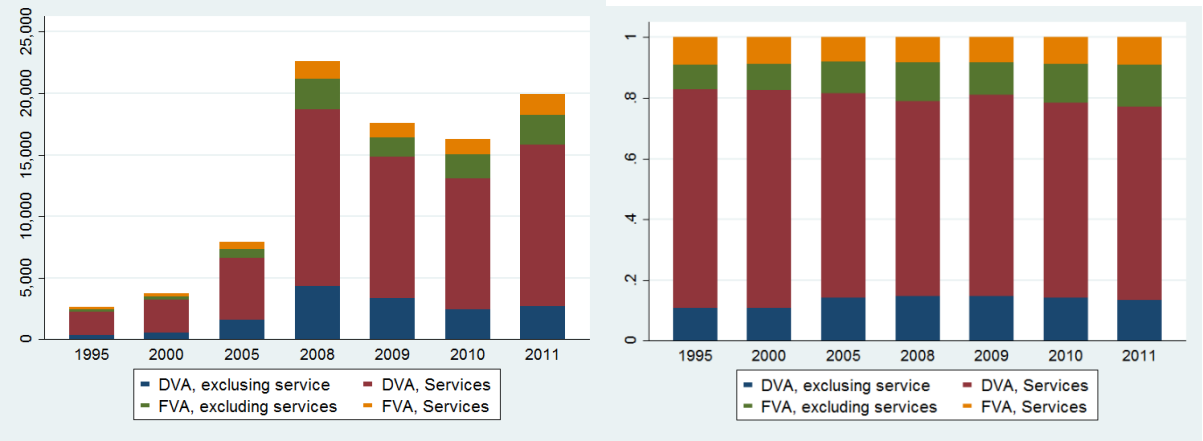


Figure A.16. Upper Middle Income Countries - Domestic and Foreign Value Added in Exports – Transport and Storage

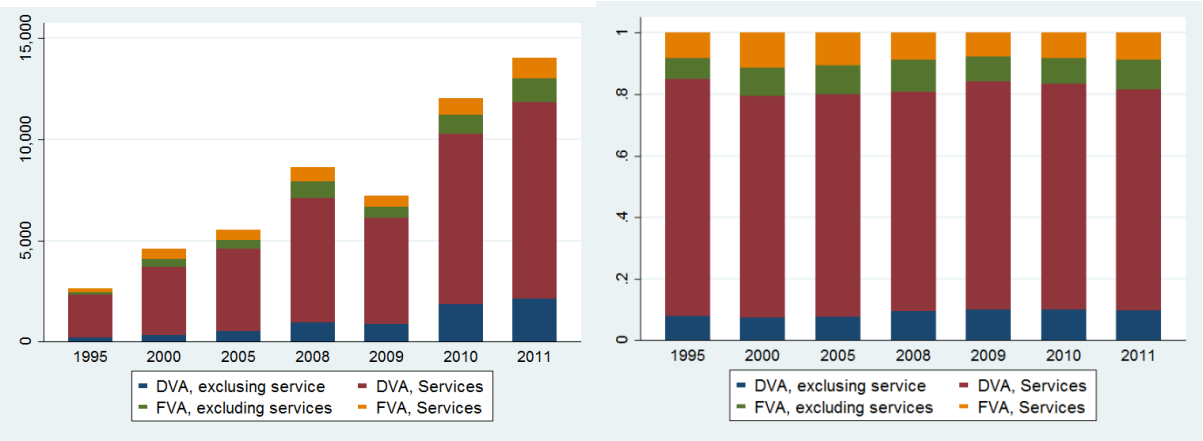


Figure A.17. High Income Countries - Domestic and Foreign Value Added in Exports – Motor Transport and Storage

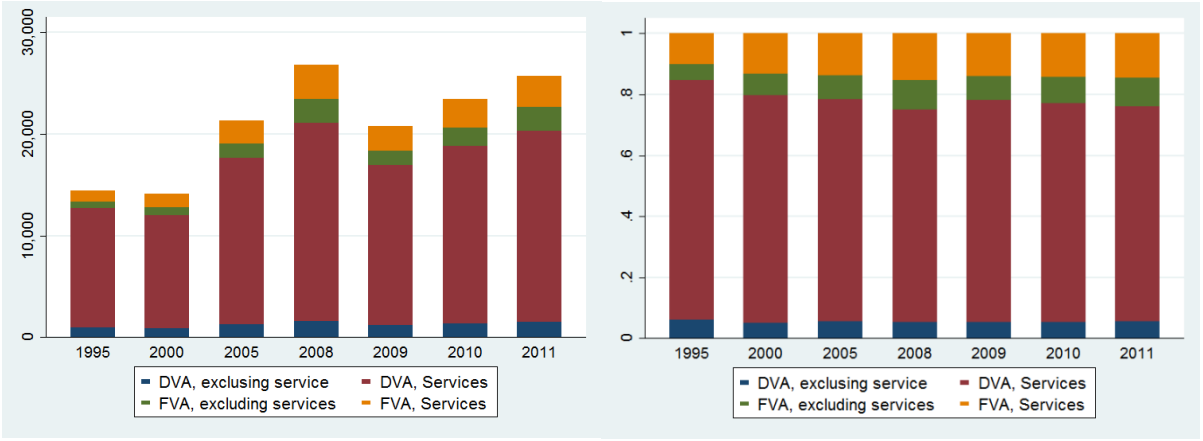


Figure A.18. T&S - DVA in exports of final and intermediate products as a share of gross exports

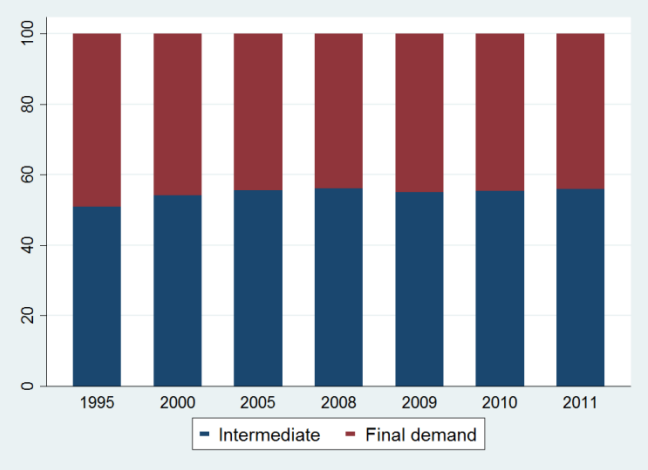


Figure A.19. Change in centrality of sectors as buyers of value added 1995 and 2011

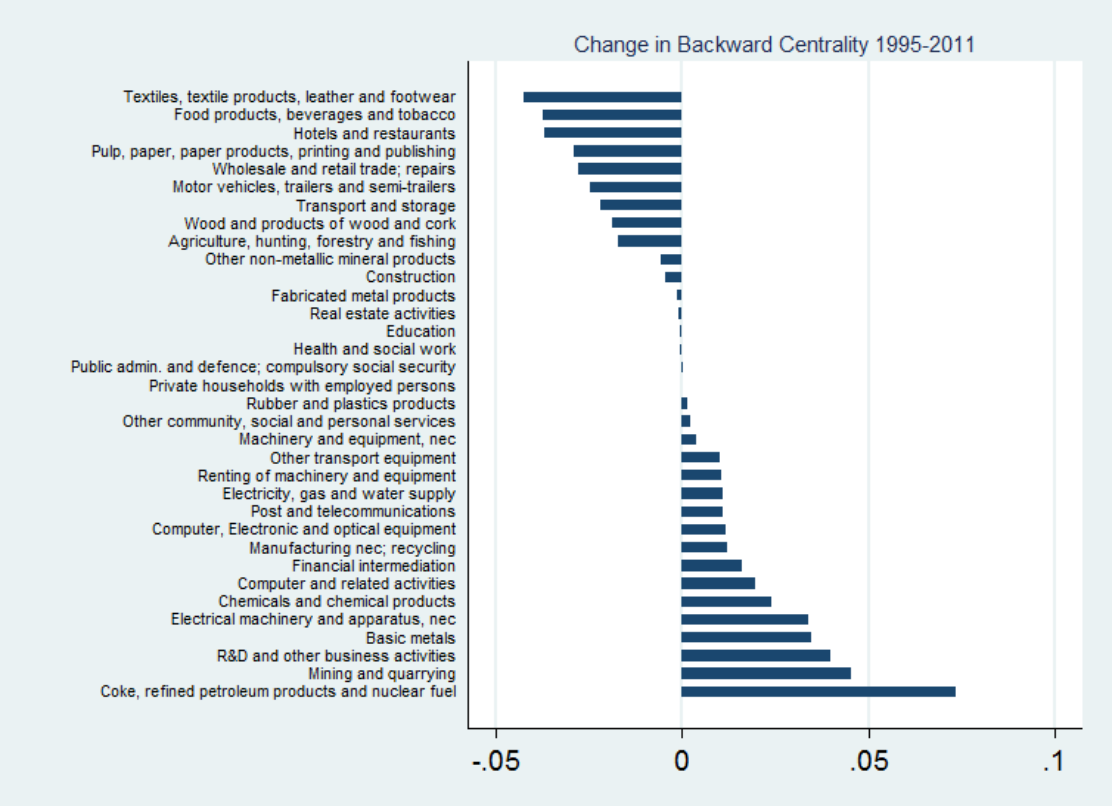


Figure A.20. Change in centrality of sectors as seller of value added 1995 and 2011

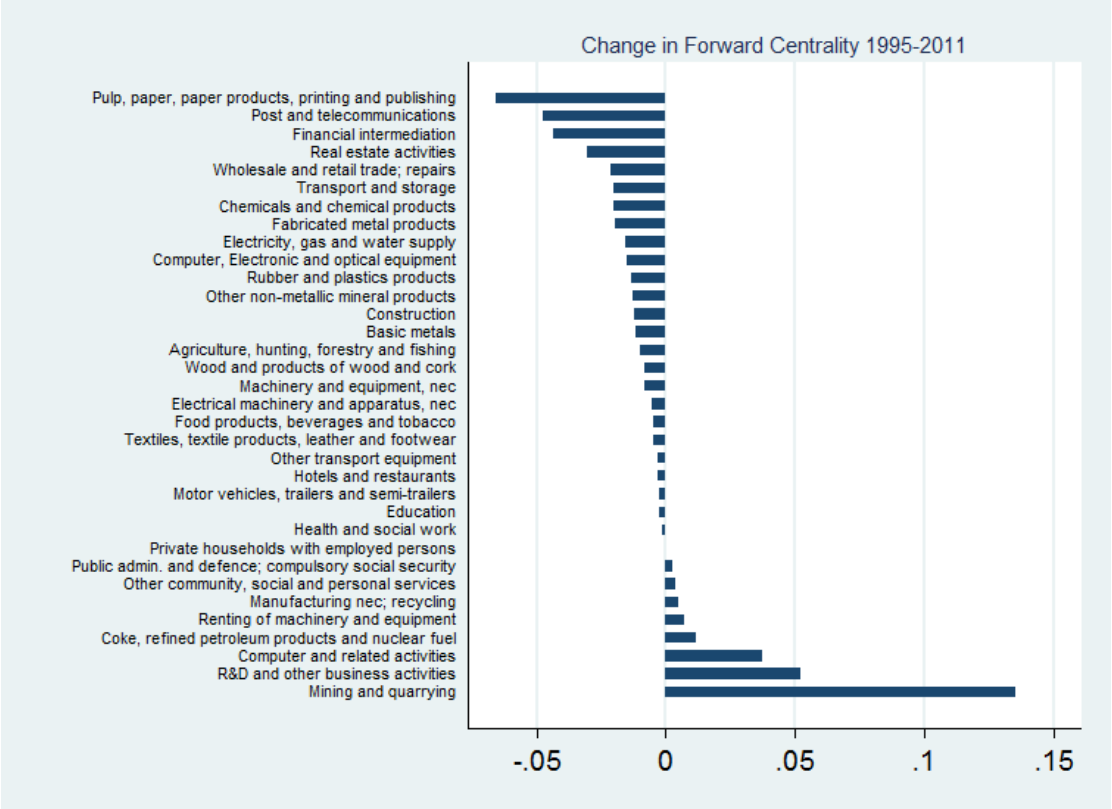


Figure A.21. Backward centrality in the MV&T sector in 1995 and 2011

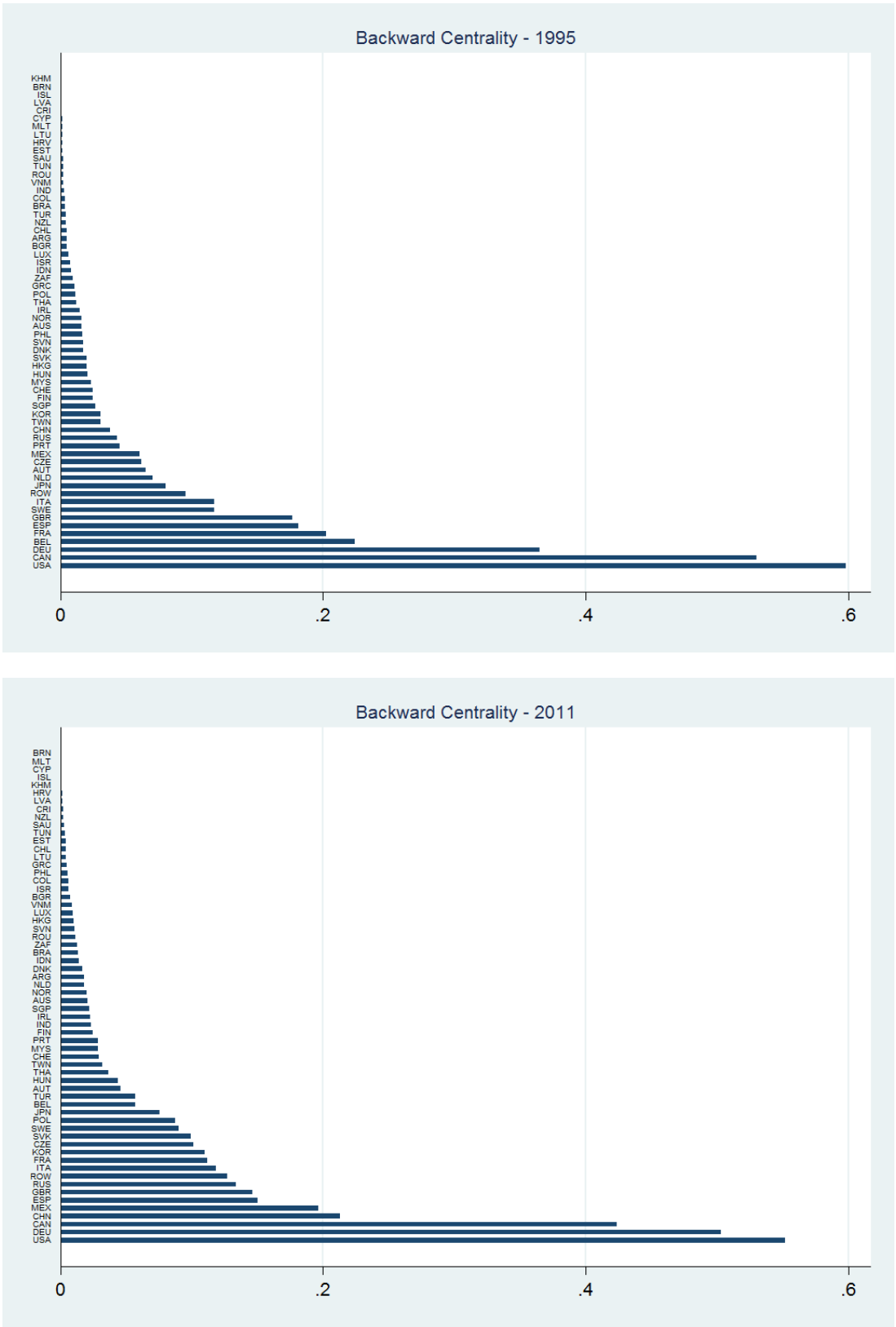
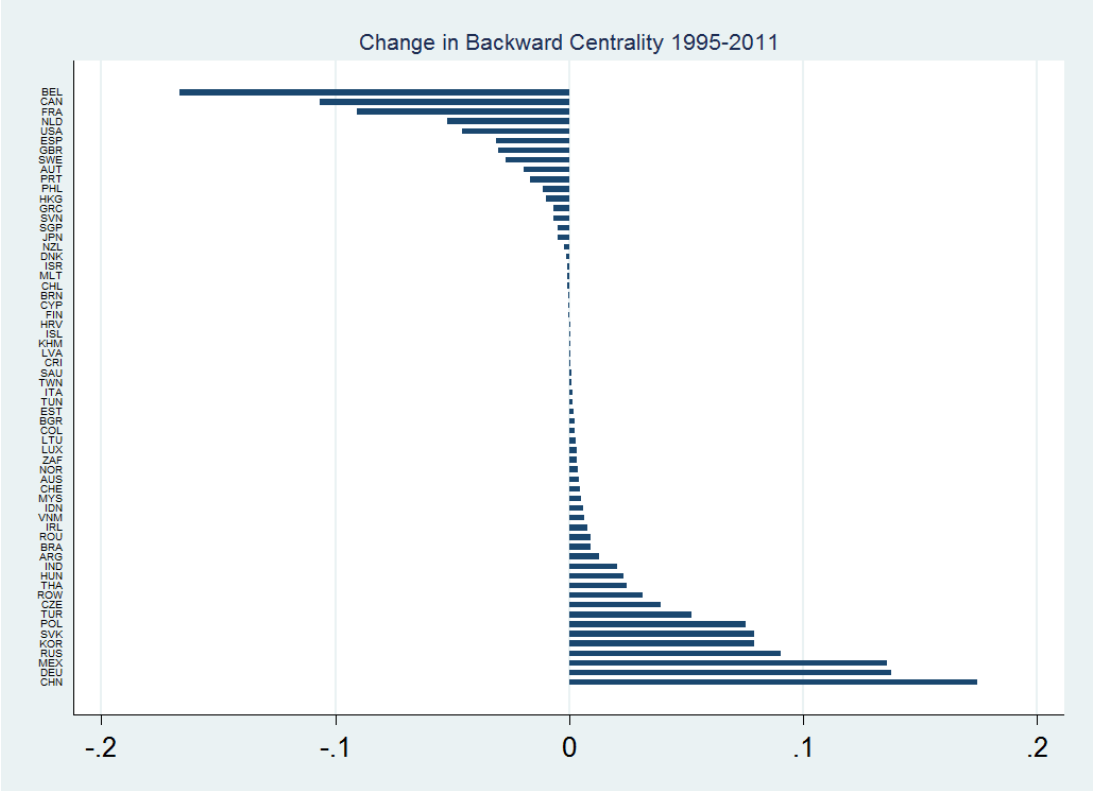


Figure A.22. Evolution of the backward centrality over 1995 – 2011 and 2008 – 2010 in the MV&T sector



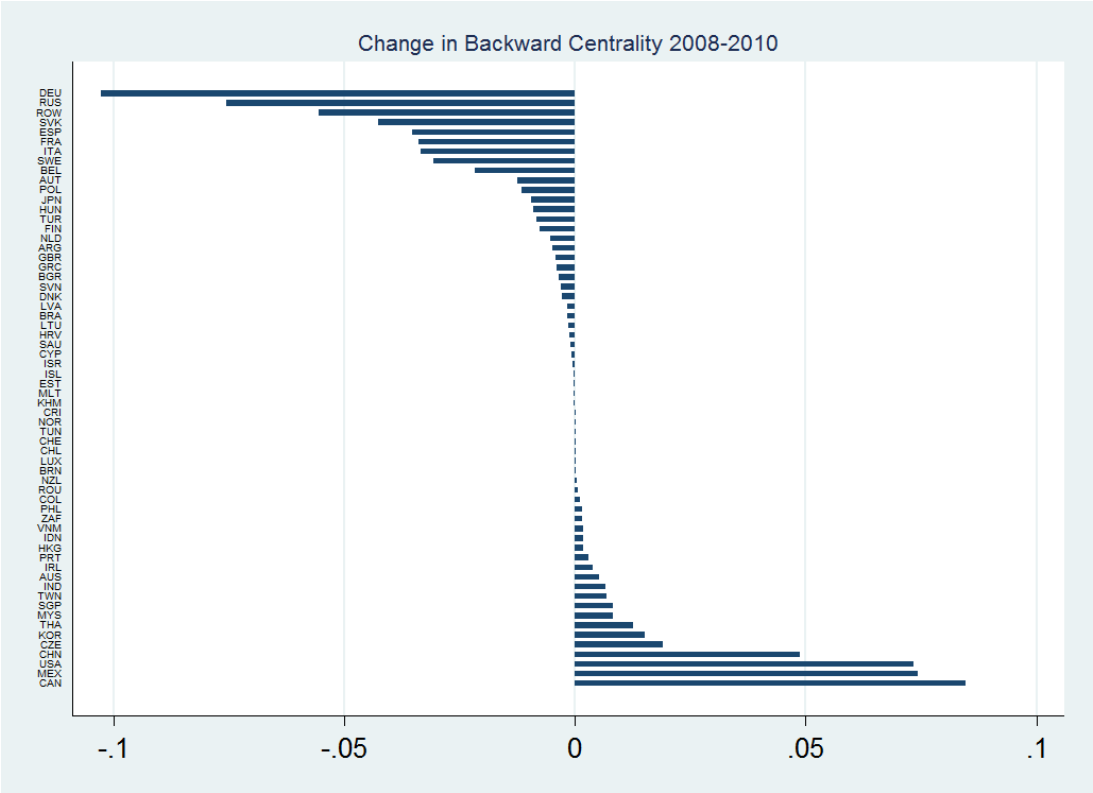
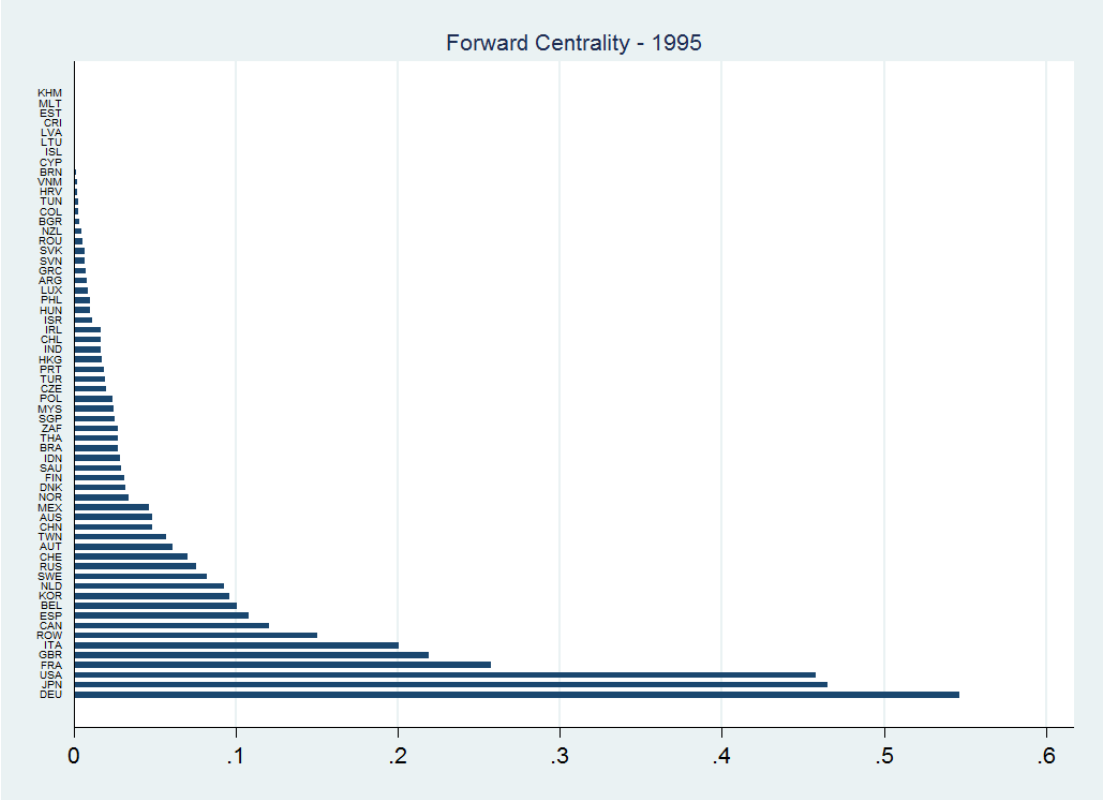


Figure A.23. Forward centrality in the MV&T sector in 1995 and 2011



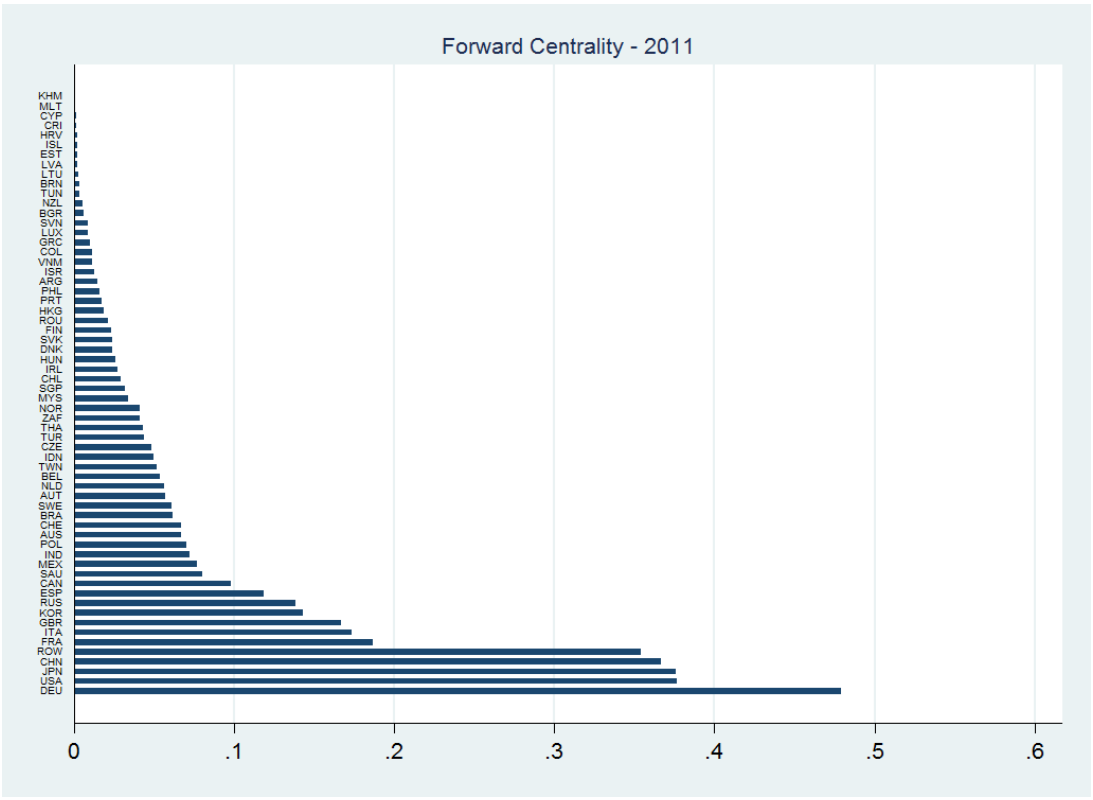
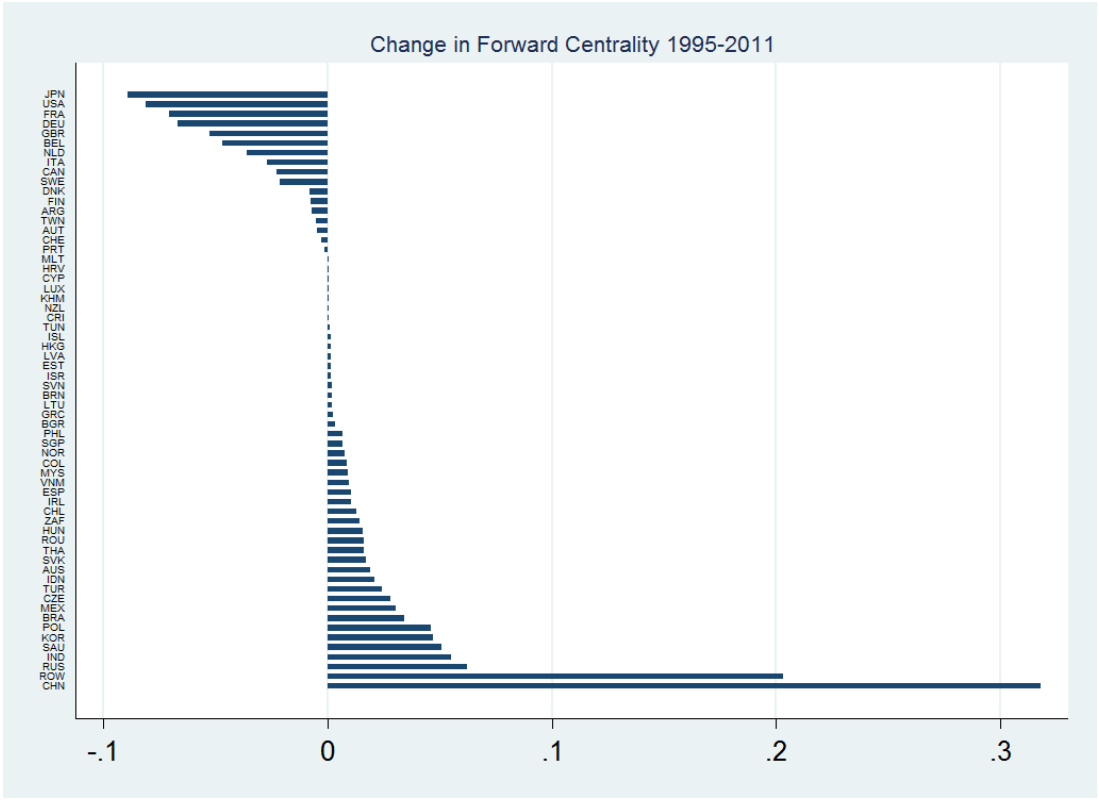


Figure A.24. Evolution of the backward centrality over 1995 – 2011 and 2009 – 2011 in the MV&T sector



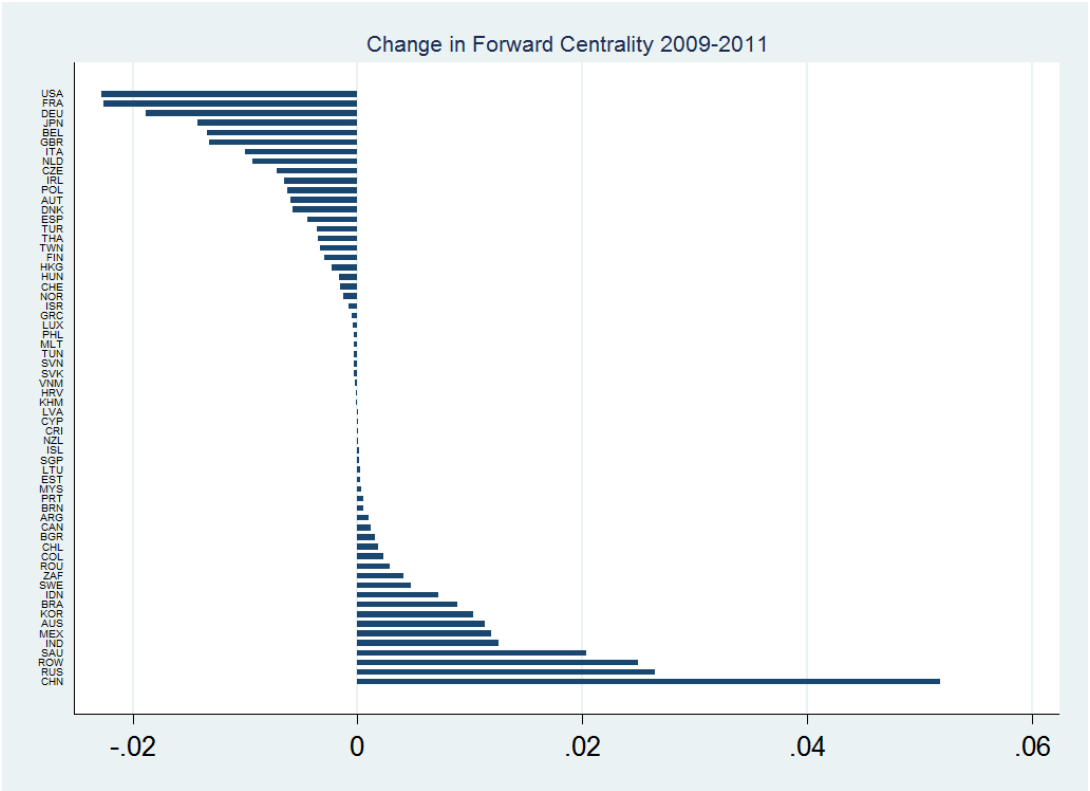
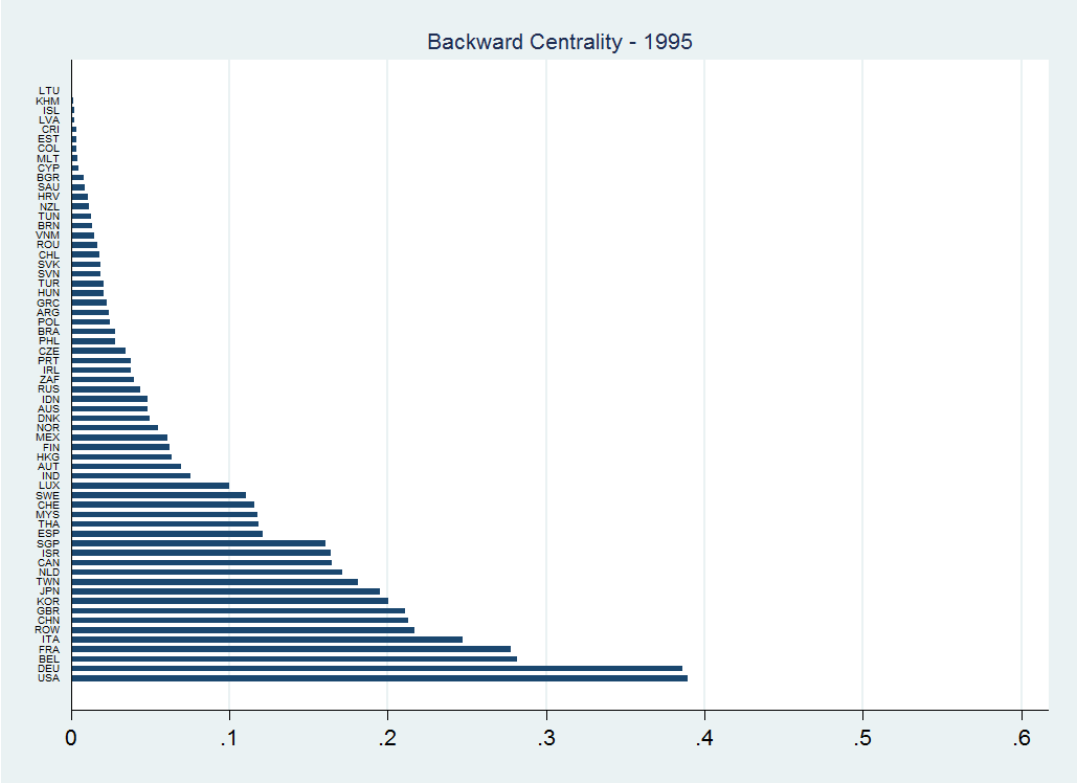


Figure A.25. Backward centrality in the M&Q sector in 1995 and 2011



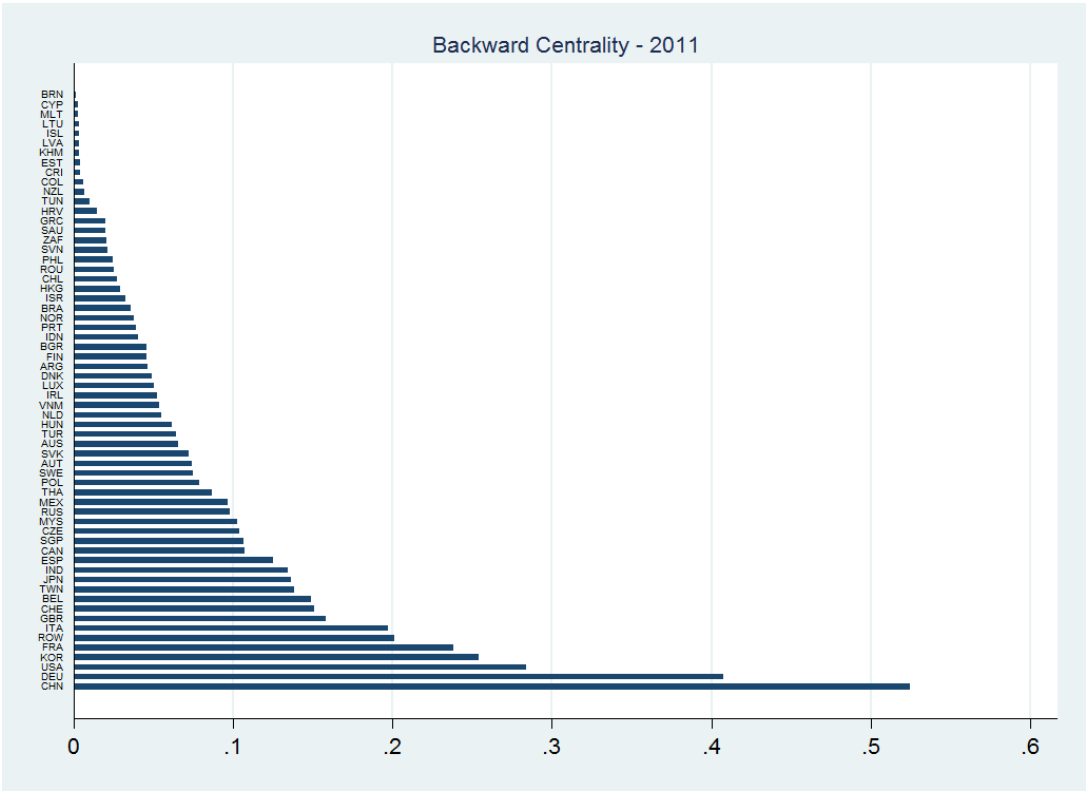


Figure A.26. Change in backward centrality in the M&Q sector in 1995 and 2011

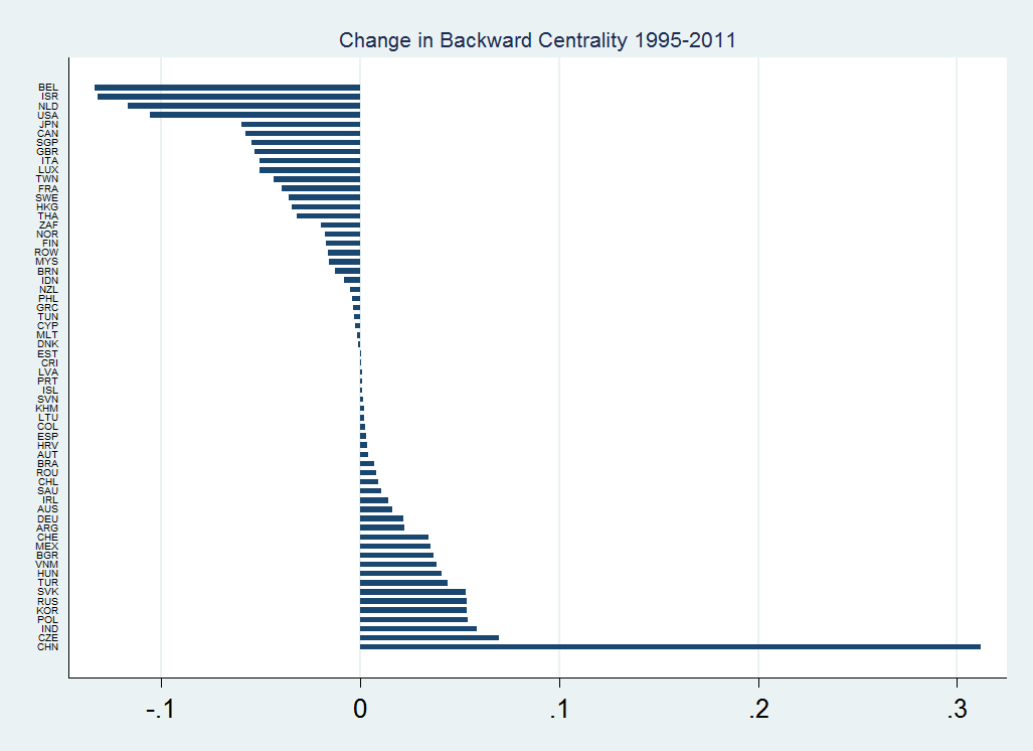


Figure A.27. Forward centrality in the M&Q sector in 1995 and 2011

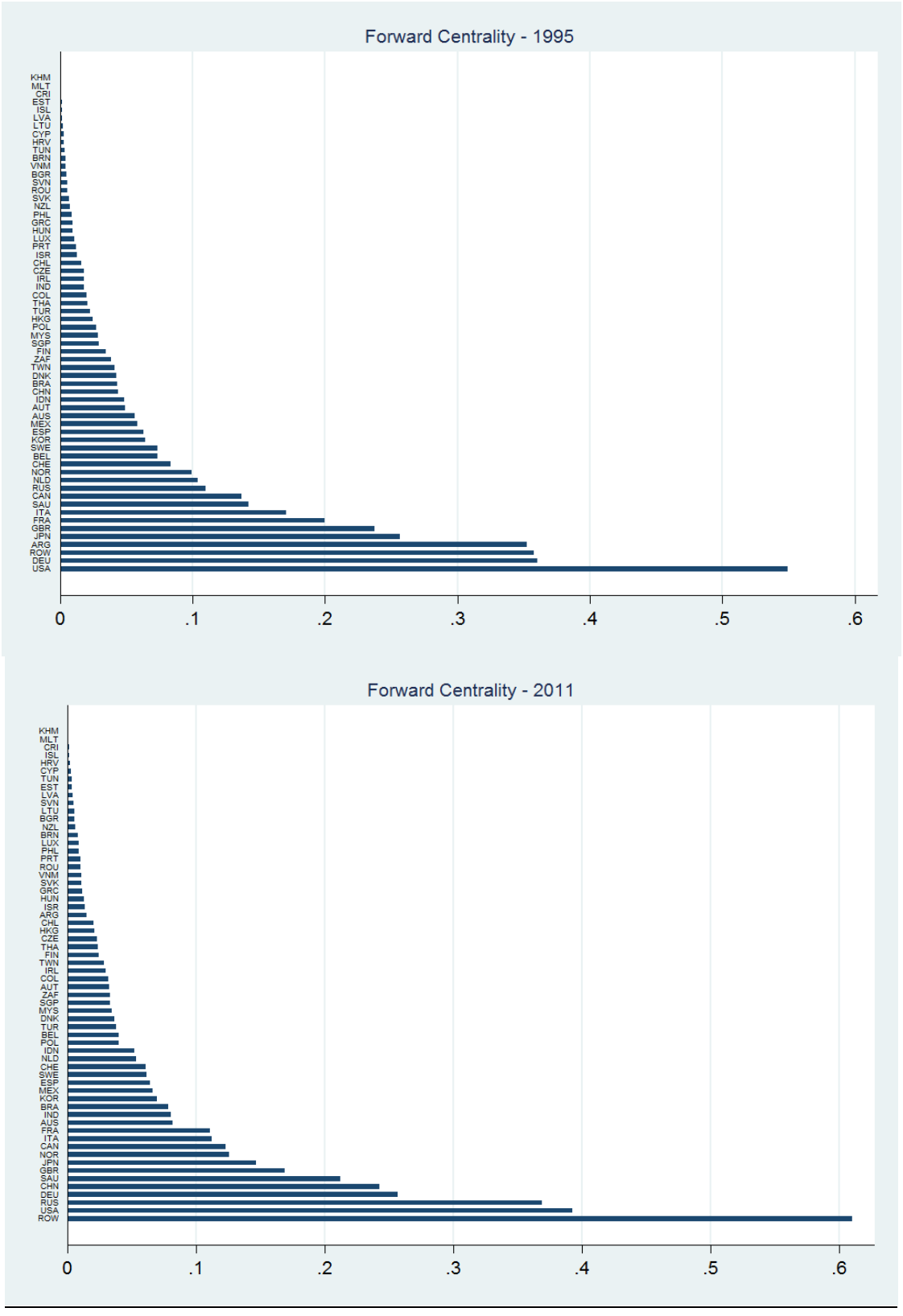


Figure A.28. Change in forward centrality in the M&Q sector in 1995 and 2011

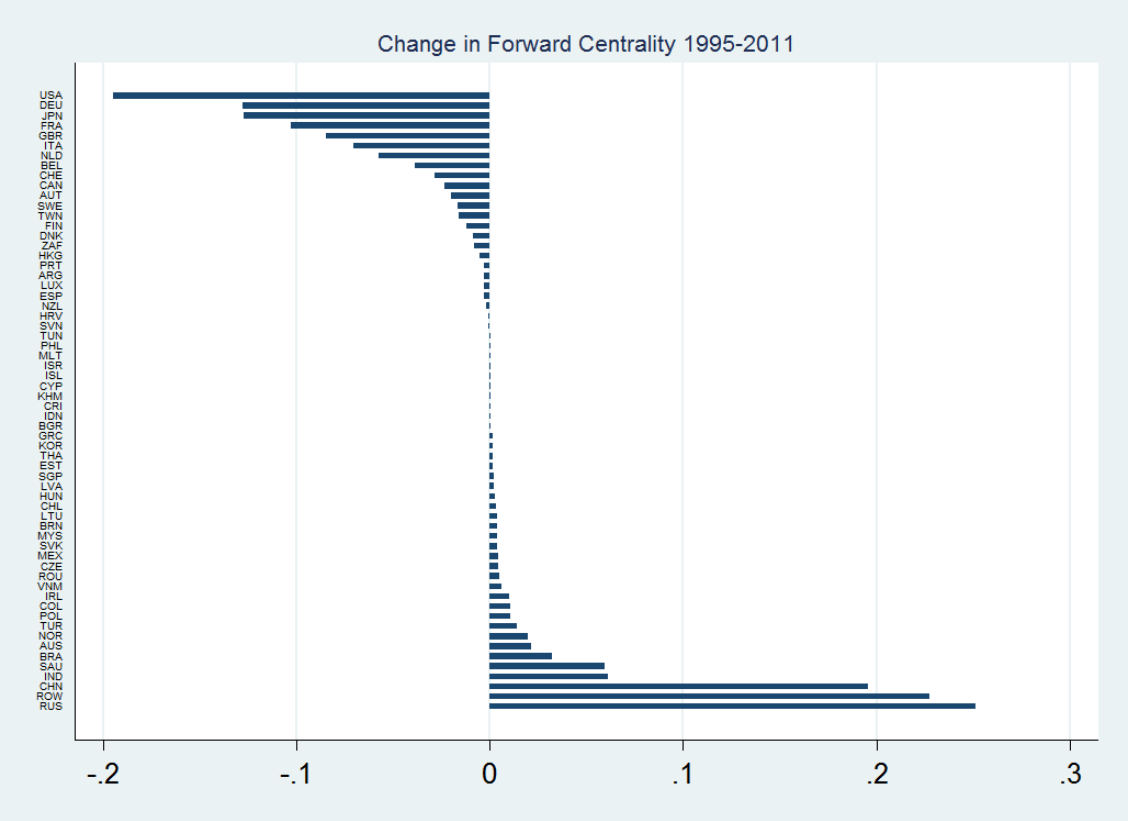


Figure A.29. Backward centrality in the T&S sector in 1995 and 2011

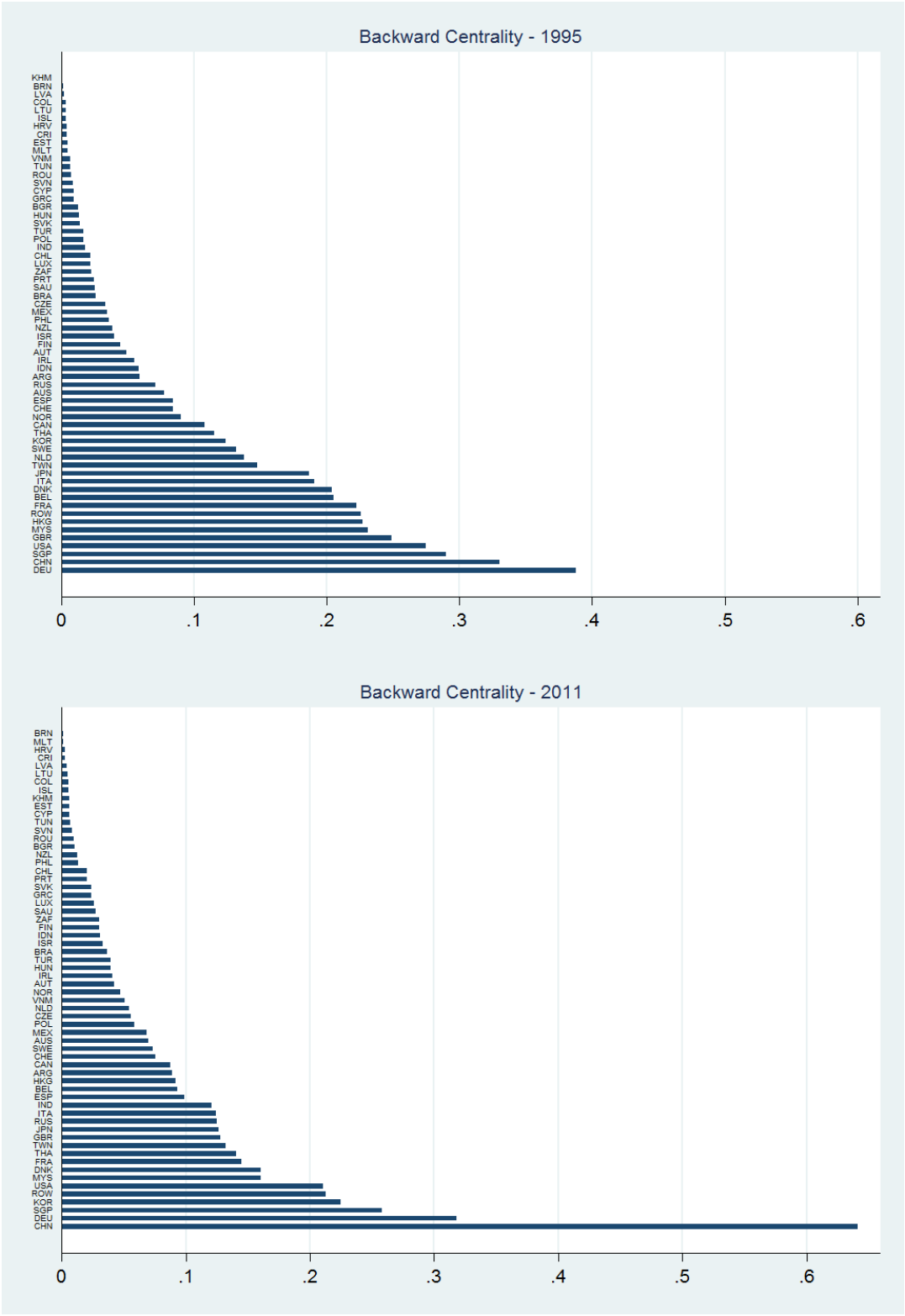
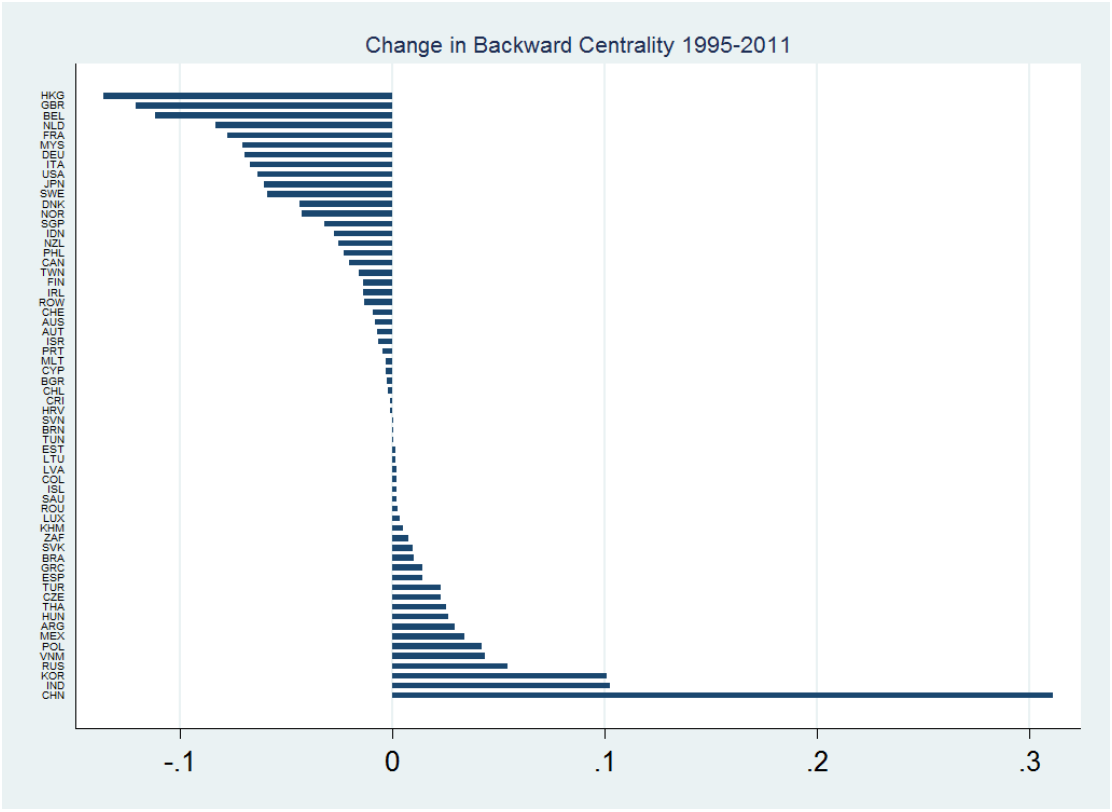


Figure A.30. Change in backward centrality in the T&S sector



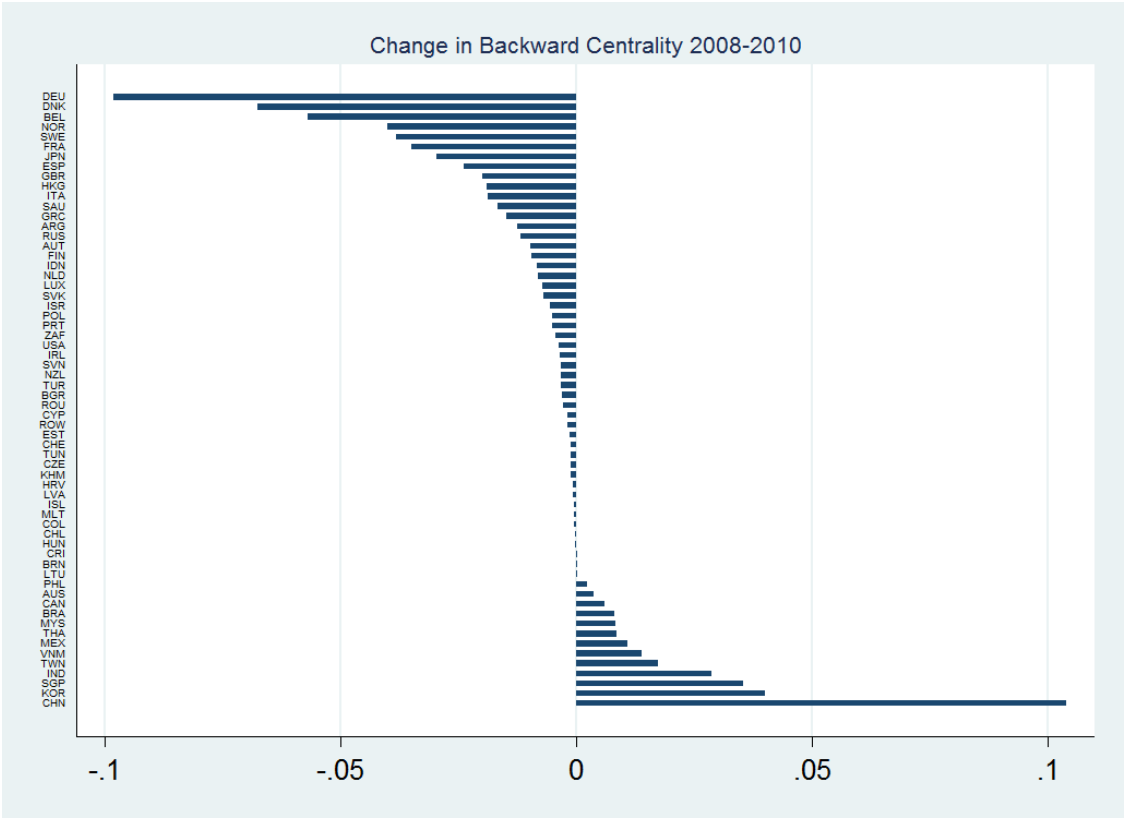


Figure A.31. Forward centrality in the T&S sector in 1995 and 2011

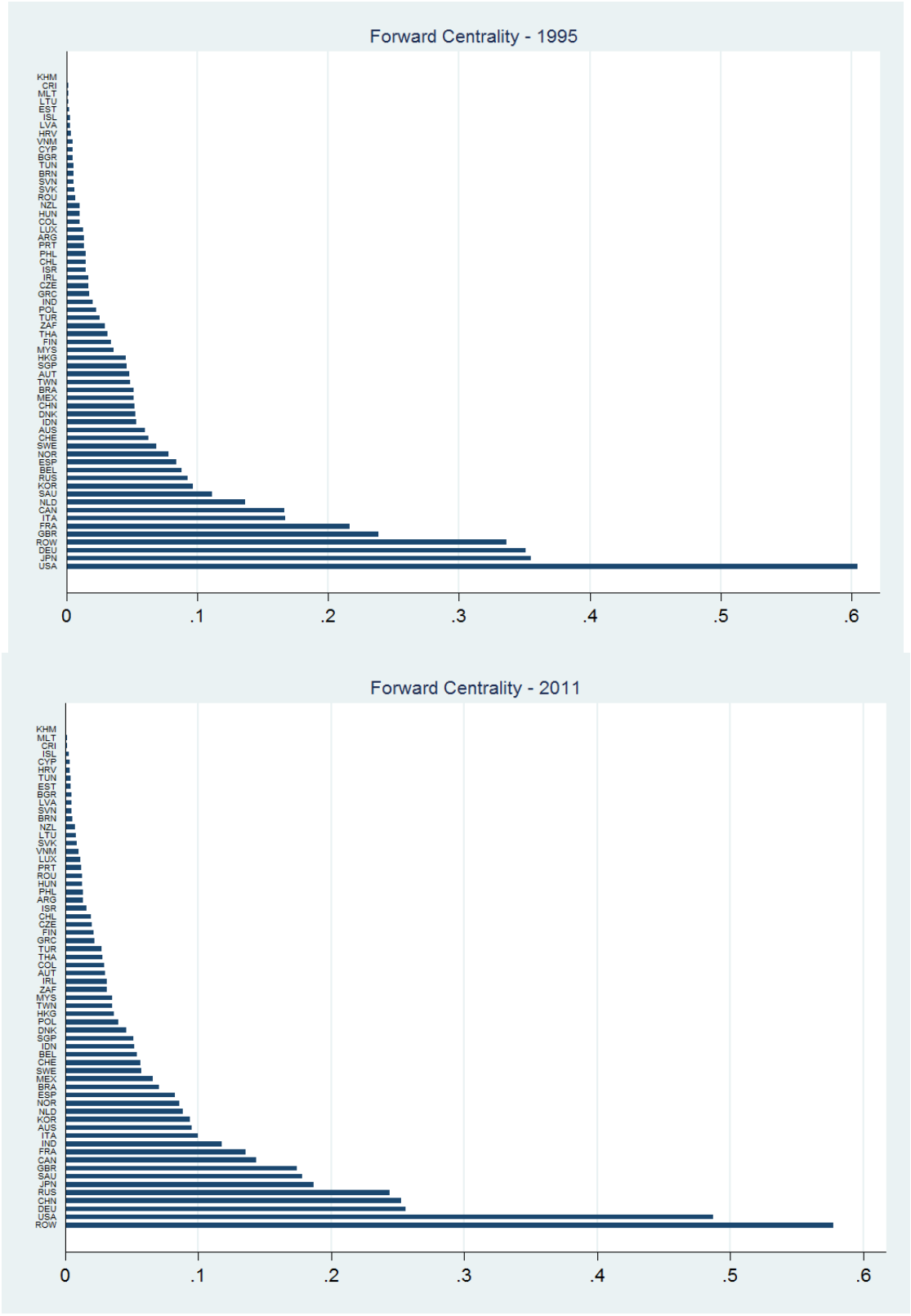


Figure A.32. Change in forward centrality in the T&S sector

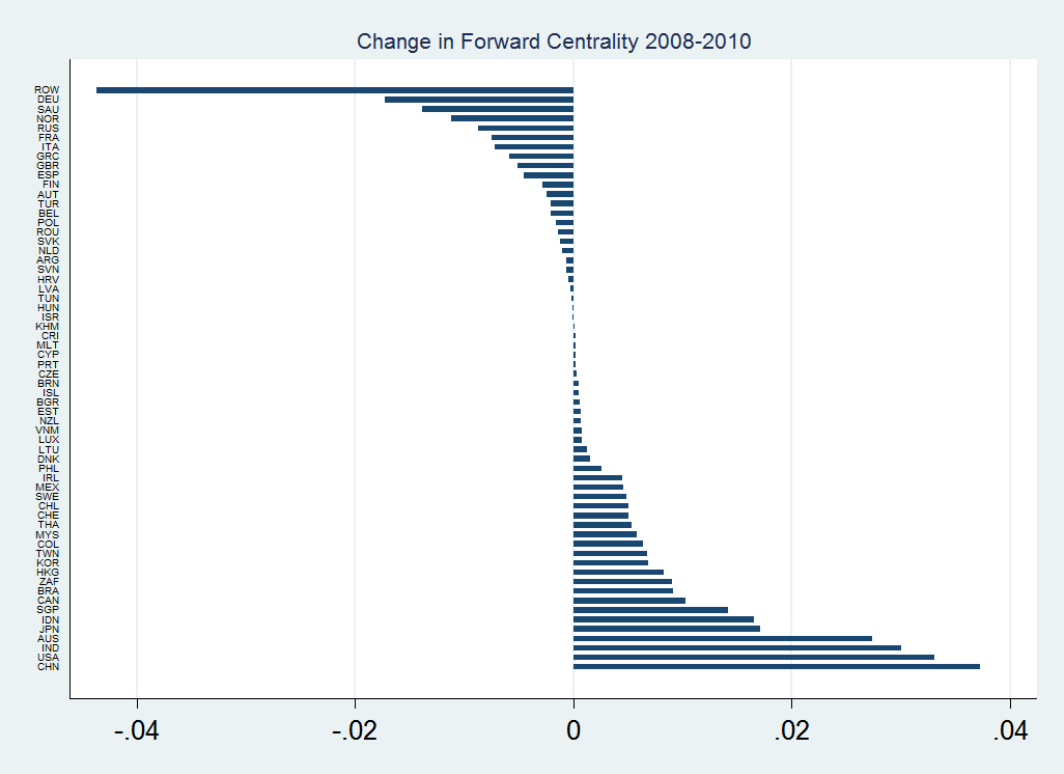


Figure A.33. Product complexity in the M&Q sector

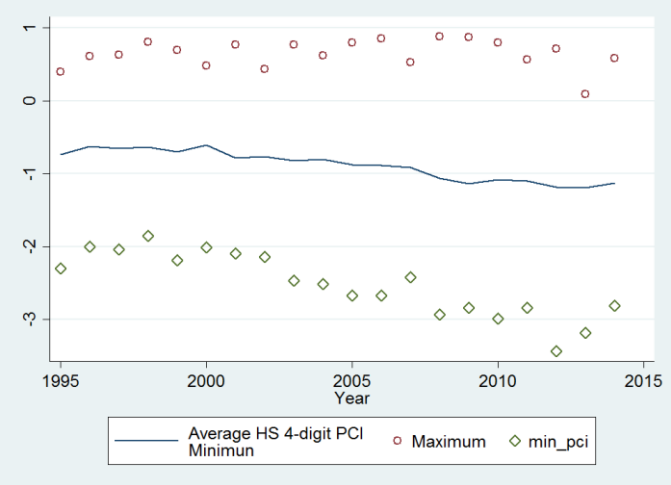
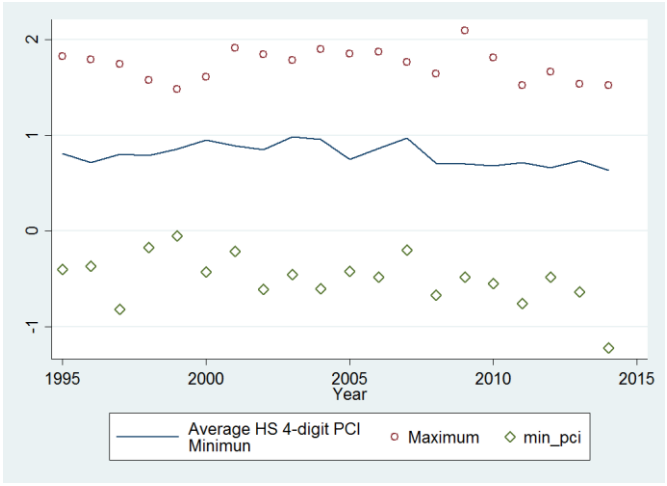


Figure A.34. Product complexity in the MV&T sector



Annex B.

Tables

Table B.1. Correlation between weighted average product complexity and DVA

	(1)	(2)
	OLS - All TiVA year	OLS - no 2008
Dep Var:	Ln(DVA)	Ln(DVA)
Ln(PCI)	-0.002**	-0.003***
	(0.001)	(0.001)
Ln(Gross Exports)	1.010***	1.012***
	(0.009)	(0.010)
Constant	-0.075	-0.159
	(0.101)	(0.114)
Country Fixed Effect	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	397	339

Notes: Standard deviation values in parentheses, ***, ** and * respectively indicates significance at the 1%, 5% and 10% levels. Robust standard errors are clustered at the year level.

Table B.2. Controlled correlation between various GVC indicators and product complexity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ln(DVA)			Ln(Weighted PCI of exports)			Ln(Weighted PCI of exports)		
	1995-2011	pre-2008	from 2008	1995-2011	pre-2008	from 2008	1995-2011	pre-2008	from 2008
Ln(Weighted PCI of exports)	-0.119	-0.804***	-0.001						
	(0.099)	(0.299)	(0.102)						
Ln(Gross Exports)	0.986***	0.993***	0.986***						
	(0.016)	(0.023)	(0.025)						
Ln (Backward centrality)				0.007	0.010**	-0.039			
				(0.007)	(0.002)	(0.026)			
Ln (Forward centrality)							0.010	0.030**	-0.100
							(0.012)	(0.006)	(0.122)
Constant	-0.313	-0.638***	-0.171	0.441***	0.469***	-0.407***	0.245	0.640***	-1.092
	(0.217)	(0.071)	(0.298)	(0.028)	(0.030)	(0.044)	(0.131)	(0.061)	(0.874)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	405	169	236	406	170	236	406	170	236

Notes: Standard deviation values in parentheses, ***, ** and * respectively indicates significance at the 1%, 5% and 10% levels. Robust standard errors are clustered at the year level.

Table B.3. Maritime features and centrality in T&S value chain over 2005-2011

	(1)	(2)	(3)	(4)
Dep Var	Out_degree	In_degree	Forward centrality	Backward centrality
LnGDPpc	0.971***	0.865***	0.543***	0.895***
	(0.116)	(0.152)	(0.087)	(0.046)
LnPoP	0.905***	0.794***	0.533***	0.811***
	(0.112)	(0.120)	(0.066)	(0.042)
LnDistance	-1.395***	-0.905**	-0.636***	-0.477***
	(0.322)	(0.380)	(0.230)	(0.172)
Lnlinership	0.208	0.487**	0.487***	0.053
	(0.150)	(0.191)	(0.121)	(0.064)
AVE CEPII	-0.724***	-1.003***	-0.700***	-0.315***
in Water Transport	(0.158)	(0.193)	(0.121)	(0.059)
Year Fixed Effect	Yes	Yes	Yes	Yes
Observations	126	126	126	126
R-squared	0.77	0.69	0.78	0.93

Notes: Standard deviation values in parentheses, ***, ** and * respectively indicates significance at the 1%, 5% and 10% levels.

In those estimations, two interest variables are used, the share VA from the country of origin sector embodied in the partner's exports of destination sector (forward) and the foreign VA for origin sector embodied in the country's export of destination sector (backward). Columns show result on bilateral trade in value added for total destination sectors from different origin sectors and attest the relevance of this bilateral VA gravity exercise since all gravity variables have expected sign as for trade policy variables (FTA). The UNCTAD LSBCI (Index) shows strong positive impact. The restriction on maritime transports services (AVE CEPII) is the one in the country in case of backward estimation and the index of the partner in case of forward estimations.

Table B.4. Impact of maritime transport restrictions and maritime connectivity on forward and backward integration for all sectors

Origin Sector Destination Sector	Originating: Total Destination: Total		Originating: Total Destination: T&S		Originating: T&S Destination: Total		Originating: T&S Destination: M&Q		Originating: T&S Destination: MV&T	
	(1)	(2)	(3)	(4)	(5)	(6)	(5)	(6)	(5)	(6)
Variable	Forward	Backward	Forward	Backward	Forward	Backward	Forward	Backward	Forward	Backward
Distance	-0.892***	-0.893***	-0.956***	-0.979***	-0.841***	-0.857***	-0.855***	-0.912***	-0.769***	-0.785***
	(0.030)	(0.032)	(0.034)	(0.035)	(0.034)	(0.033)	(0.039)	(0.038)	(0.031)	(0.028)
Comnon Border	0.212**	0.207*	0.288**	0.243**	0.351***	0.294**	0.424***	0.337***	0.328***	0.266***
	(0.107)	(0.114)	(0.116)	(0.122)	(0.114)	(0.118)	(0.115)	(0.122)	(0.096)	(0.100)
Colonial ties	0.512***	0.535***	0.372*	0.390*	0.522***	0.504**	0.440**	0.359	0.336**	0.373**
	(0.174)	(0.181)	(0.192)	(0.200)	(0.199)	(0.202)	(0.215)	(0.220)	(0.148)	(0.147)
Common language	0.132	0.096	0.161	0.176	0.232**	0.284***	0.289**	0.345***	0.169*	0.216***
	(0.088)	(0.109)	(0.107)	(0.114)	(0.098)	(0.093)	(0.117)	(0.112)	(0.086)	(0.078)
Common colonizer	0.427**	0.270	0.292	0.097	0.337	0.216	0.264	0.153	0.223	0.251
	(0.213)	(0.228)	(0.237)	(0.251)	(0.233)	(0.238)	(0.269)	(0.257)	(0.237)	(0.212)
Common ethnicity	0.145*	0.123	0.094	0.042	0.047	-0.002	0.041	-0.048	0.066	0.013
	(0.083)	(0.108)	(0.101)	(0.110)	(0.089)	(0.081)	(0.103)	(0.097)	(0.079)	(0.069)
RTA	0.194***	0.211***	0.145***	0.178***	0.181***	0.151***	0.151***	0.105*	0.195***	0.200***
	(0.041)	(0.044)	(0.047)	(0.049)	(0.048)	(0.047)	(0.056)	(0.054)	(0.041)	(0.039)

Table B.5. Impact of maritime transport restrictions and maritime connectivity on forward and backward integration for all sectors (continued)

AVE_CEPII										
Developing_i - Developing_j	-0.844***	-1.121***	-0.726***	-1.492***	-1.032***	-1.252***	-0.302***	-0.382***	-0.616***	-0.028
	(0.066)	(0.062)	(0.074)	(0.071)	(0.073)	(0.070)	(0.050)	(0.071)	(0.042)	(0.049)
Developed_i - Developing_j	-0.947***	-0.737***	-0.830***	-0.949***	-1.115***	-0.747***	-0.354***	0.083	-0.671***	0.115*
	(0.094)	(0.053)	(0.104)	(0.063)	(0.104)	(0.056)	(0.057)	(0.109)	(0.047)	(0.060)
Developing_i - Developed_j	-0.279***	-1.343***	0.053	-1.708***	-0.428***	-1.501***	-0.050	-0.566***	-0.471***	-0.217***
	(0.055)	(0.092)	(0.062)	(0.104)	(0.063)	(0.106)	(0.066)	(0.075)	(0.058)	(0.056)
Developed_i - Developed_j	-0.375***	-0.912***	-0.113	-1.163***	-0.513***	-0.970***	-0.112	-0.089	-0.518***	-0.055
	(0.078)	(0.079)	(0.089)	(0.092)	(0.090)	(0.086)	(0.070)	(0.104)	(0.059)	(0.065)
LSCI_UNCTAD										
Developing_i - Developing_j	3.601***	3.059***	4.152***	3.527***	3.656***	2.980***	3.880***	3.345***	3.069***	2.139***
	(0.458)	(0.482)	(0.510)	(0.523)	(0.484)	(0.481)	(0.550)	(0.538)	(0.439)	(0.405)
Developed_i - Developing_j	1.816***	1.299***	1.439***	0.977**	1.649***	1.193***	1.534***	0.945**	1.646***	0.826***
	(0.353)	(0.361)	(0.393)	(0.401)	(0.380)	(0.365)	(0.406)	(0.412)	(0.323)	(0.300)
Developing_i - Developed_j	1.781***	1.992***	1.512***	1.913***	1.481***	1.660***	2.335***	2.355***	1.759***	1.236***
	(0.327)	(0.357)	(0.367)	(0.396)	(0.375)	(0.386)	(0.433)	(0.441)	(0.327)	(0.316)
Developed_i - Developed_j	0.403	0.128	0.101	-0.105	0.031	-0.060	0.383	0.076	0.539**	-0.007
	(0.272)	(0.283)	(0.294)	(0.310)	(0.296)	(0.295)	(0.327)	(0.332)	(0.270)	(0.242)
Importer*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,396	6,396	6,396	6,396	6,396	6,396	5,984	6,107	5,920	6,275
R-squared	0.92	0.92	0.89	0.90	0.89	0.90	0.92	0.87	0.96	0.93

Notes: Standard deviation values in parentheses, ***, ** and * respectively indicates significance at the 1%, 5% and 10% levels.

Annex C.

Using network analysis in trade in value added to better understand the position of sectors and Countries In The Value Chain: The Backward And Forward Centrality

Social Network Analysis is a methodology particularly suited for GVC analysis.[60] In order to better understand the relative position of various sectors and countries in GVCs, it is interesting to understand centrality both as a seller and a buyer of value added, either as a sector compared to other sectors in the economy, or between countries for the same sector. Therefore two eigenvectors are computed. The following explains the intuition behind those, using the case of sector centrality.

The first set of indicators aims at capturing the centrality of a sector as a buyer of value added by looking at how many supplying sectors are selling to that sector for the production of exports. The importance of this connection is weighted by the share of the value added provided by the supplying sector over the sum of all the supplying sector's exports in value added. In other words, it is weighted by the importance of the sector of interest as a buyer of value added by supplying sector. This provides the centrality of the sector as a buyer of value added. By analogy to other GVC indicators, the resulting vector is referred to as the backward centrality.

The second gives information about the importance of a sector of interest as a seller of value added to other sectors (countries) for the production of exports. This time it focuses on the amount of time a sector is pointing to other sectors, weighted by the share of the value added sold by the sector compared to the total amount of value added used by the sector it supplies for the production of its exports. The resulting vector is called the forward centrality.

The use of shares as weight has important features. The first is that, while the importance of value added exchanged in size still matters, it does not uniquely define the centrality of a sector (or a country). Using raw flows would indeed result in a focus on large trading sectors or economies. While it is undeniable that those are an important feature of the network, small sectors or economies might still be very well connected to international trade networks.

The second feature relates to interpretation. The use of the eigenvector centrality presents results slightly different from the traditional TiVA indicators, as it relies on social network analysis. In particular, one of the interesting features of computing an eigenvector of a network is for the analysis of resilience to shocks. In social network analysis, the centrality of a node, in our case a sector or a country is based on a random walk model. A random walk starts at a node *i*, randomly chooses a neighbour *j* of *i*, moves to *j* and repeats the process from there. Each step, assuming that each node has more than one neighbour, increases the choices of random walks. After a few steps, various paths might have been taken, each of them leading to a node with a probability determined by the characteristics of the network. In more tangible terms, consider a dollar is injected in a network from a node *i*. After n steps, it is possible to get a probability distribution of where the dollar might be. This corresponds to a vector v (n) of which each coordinate is associated with a node, a sector or a country according to the network we choose to analyse, and represents the probability that the dollar arrived at that node.[61]

The eigenvector can be thought of as such a vector, computed by taking the limit of the random walk to infinity. As such it provides a tool for shock propagation as a long term phenomenon, explaining differences

60. According to Miura (2012), when an analysed network is directed, such as it is in the case of GVCs, the most common centrality measures are based on how often a vertex, in our case a sector or a country, is being pointed to and the importance of neighbours associated with the incoming edges.

61. Ranging between zero and one and respecting P i∈C v(k)i = 1

with traditional TiVA indicators. As presented by Shepherd and Archanskaia (2014), it is therefore possible to show that the eigenvector represents the economic value of an extra dollar of value added traded at a random point in the network analysed and allowed to flow through all possible nodes. This feature of the eigenvector can be used to analyse the resilience of the value chains.

In terms of economic development paths, two things need to be taken into account: first, the impact of short term shocks according to the position in the value chain, which are larger for higher levels of centrality; and second, and maybe more damaging, the potential longer run impact resulting from the potential reorganisation of the value chain after a shock. This second type of impact is likely to be sector specific and depends on the characteristics of the integration in the value chain.

The assumption tested in the following analysis is that, whilst the shock is higher for more central nodes in the short run, its consequences can actually be higher for peripheral nodes in the longer run because of the reorganisation of the value chain and potential production processes. In terms of interpretation of the indicator, the higher the centrality of a sector or a country in the trade in value added network, the higher the sensitivity to both positive and negative shocks. The eigenvector is an indicator of the situation of a network at a certain point in time and it provides an indication of the likely impact of a shock at that exact time. It does not give any information about how the network might reorganise for the period following the shock. It is however possible to monitor the evolution of the eigenvector over time and see its evolution according to exogenous parameter and shocks.

Annex D.

Using network analysis and the product complexity index to test the relationship between the use of foreign value added and sophistication in the economy

Hidalgo and Hausmann (2009) use social network analysis to develop a set of indexes based on the idea that economic development is a process of learning how to produce (and export) more complex products.

The main assumption is related to the idea that the capacity of a country to accumulate *capabilities* required to produce varied and, in particular, more sophisticated goods, determines its development path. *Capabilities* in this framework of analysis are indirectly inferred, based on country-product exports relationships analysed through SNA methods.

Economic transformation has long been associated with an increase in economic diversification, and in particular export diversification. Hausmann, Hwang, and Rodik (2007) provide a framework behind this relationship. Their analysis highlights the heterogeneous relationship between exports of certain products and economic development. In particular, what matters is the extent to which the capabilities associated with the production of certain products can be redeployed into the production and export of others, while other products embody capabilities that re cannot really be used for the production of other goods. As summarized by the World Bank (2012) capabilities are considered to encompass set of human and physical capital, the legal system, institutions, etc. that are needed to produce a specific product. According to Abdon et al. (2010) at the firm level, they also more specifically integrate the "know-how" or working practices held collectively by the group of individuals comprising the firm.

More specifically, aggregate figures about human and physical capital are not useful when considering the heterogeneity of sets of skills and other features characterising production in different sectors. The process of economic transformation through increased economic complexity relies on the acquisition of more complex sets of capabilities allowing a country to move towards new activities associated with higher levels of productivity.

The economic complexity indicators are based on analysis of country-product associations using international trade data and provided at the HS 4-digit level. The relationship between products and countries is used to produce an indicator, considered to link exports of a product with a country's capacity to produce it. It is based on three principles. First a matrix of one and zeros is build according to the Revealed Comparative Advantage of a country *c* in a product *p*. In other words, the relationship between *c* and *p* is entered as a one in the matrix if the share of *p* in the export basket of *c* is higher than the importance of that product in world trade. In the same kind of mathematical approach used to calculate the backward and forward centrality, this matrix is used to calculate the eigenvector, with weights corresponding to the observed levels of diversification of a country, defined as the number of products exported by that country, and the ubiquity of a product, defined as the number of countries exporting that product. The principle is therefore the same as the previous centrality measures of trade in value added with the measure of the probability that a random walker that started at a given node ends up at another node after N steps, with N tending to infinity.

Looking at the position of countries according to their level of diversity and ubiquity, Hidalgo and Hausmann (2009) identify a strong relationship, highlighting that diversified countries tend to export less ubiquitous products. However, even if two countries share the same level of participation, the products they export might be of a very different nature. Comparing Malaysia and Pakistan, the author highlights that if they share a similar level of diversification, the products exported by Malaysia are also exported by more diversified countries than the ones exported by Pakistan suggesting, according to their analysis, that the productive structure in Malaysia is more complex than in Pakistan. The relative position of a country according to those parameters is then considered as informative about their *capabilities*. Countries with many capabilities can produce a wider range of products as they can produce goods requiring more complex sets of

capabilities, set that only few other countries have. Therefore, diversified countries are able to make less ubiquitous (or more sophisticated) products.

The level of c*apabilities* is therefore providing information about the level of complexity of the economy. The position of the exports in which a country has a revealed comparative advantage, in the periphery or in a denser part of the product space, provides information about the relative ease with which that country can transforms its economic structure.

The variable of interest for the following sector analysis, the PCI (the ranking of products according to the capabilities necessary to manufacture them), is derived from countries ECI.

Tables D.1. Average PCI per TiVA sector - weighted by the number of HS 6-digit products per HS 4-digit lines in the TiVA sector

Average PCI per TiVA sector - 2011			Average PCI per TiVA sector - 2011		
PCI		Sector	PCI		Sector
-1.19	C01T05	Agriculture, hunting, forestry and fishing	-1.15	C01T05	Agriculture, hunting, forestry and fishing
-0.87	C20	Wood and products of wood and cork	-1.09	C10T14	Mining and quarrying
-0.73	C10T14	Mining and quarrying	-0.70	C17T19	Textiles, textile products, leather and footwear
-0.70	C17T19	Textiles, textile products, leather and footwear	-0.61	C15T16	Food products, beverages and tobacco
-0.67	C15T16	Food products, beverages and tobacco	-0.54	C23	Coke, refined petroleum products and nuclear fuel
-0.20	C36T37	Manufacturing nec; recycling	-0.53	C20	Wood and products of wood and cork
-0.11	C23	Coke, refined petroleum products and nuclear fuel	0.00	C36T37	Manufacturing nec; recycling
0.22	C27	Basic metals	0.21	C27	Basic metals
0.32	C26	Other non-metallic mineral products	0.36	C26	Other non-metallic mineral products
0.43	C25	Rubber and plastics products	0.40	C25	Rubber and plastics products
0.44	C28	Fabricated metal products	0.41	C21T22	Pulp, paper, paper products, printing and publishing
0.47	C24	Chemicals and chemical products	0.44	C24	Chemicals and chemical products
0.51	C35	Other transport equipment	0.46	C28	Fabricated metal products
0.56	C21T22	Pulp, paper, paper products, printing and publishing	0.52	C35	Other transport equipment
0.75	C30T33	Computer, Electronic and optical equipment	0.72	C34	Motor vehicles, trailers and semi-trailers
0.78	C31	Electrical machinery and apparatus, nec	0.75	C31	Electrical machinery and apparatus, nec
0.81	C34	Motor vehicles, trailers and semi-trailers	0.90	C30T33	Computer, Electronic and optical equipment
1.15	C29	Machinery and equipment, nec	0.96	C29	Machinery and equipment, nec

Whilst based on a sound methodology, there are still some caveats about the use of this indicator. The first relates to the fact that it only relates to exports and not production, and it is possible that some products have a high ranking simply because they are only exported by highly complex economies, but do not have complex production processes.

The second relates to the fact that this indicator is based on gross exports which doesn't capture trade in tasks and does not control for imports of sophisticated intermediates for the production of exports. As a consequence, capacities of countries integrated in GVCs might be overstated or understated.[62] However, it is

62. Hausmann et al. (2011) explain that "*products such as chemicals and machinery are said to be highly complex because they require a sophisticated level of productive knowledge and typically emerge from large organizations*

still a good indicator about the capacity of a country to integrate value chains for more or less sophisticated products.

The case of the M&Q sector is particularly interesting as the economic activity is primarily determined by geology and not by *capacities*. Moreover, while the average PCI of the sector is low, the industry relies on sophisticated machineries and sets of skills. However, the production structure in the sector allows such inputs to be imported from other countries, and some industries in the sector can function as enclaves with minimum interaction with the rest of the economy. Therefore, the low ranking of the sector in terms of required capabilities for production still seem relevant.

All in all, the PCI has therefore to be taken with a grain of salt, but it is nonetheless a good indicator of relative position of countries and sectors and is used in this paper as an indicator for economic transformation and to test the relationship between GVC integration and in the share of domestic value added in exports with the level of sophistication of exports both in the M&Q and in the MV&T sectors

Finally, when looking at the evolution of the PCI over time, it is important to keep in mind that the position of a sector or a country is also relative to others. In other words, a change in complexity has to be interpreted as relative to other sectors or economies and not as a reduction in complexity per se.

where a number of highly skilled individuals interact. Whereas products, such as raw materials or simple agricultural products require only a basic level of know-how and can be produced by an individual or family-run business". Whilst this relationship holds perfectly well in a world where countries would need to build entire value chain in order to export, this is less the case in the world of GVCs where R&D can be conducted in one country and production is several others.

Annex E.

Specification of the bilateral gravity model

- $INTVAI_{ij}^{k} = f(geography\ \&\ culture_{ij}^{C}, FTA_{ij}, FE_{iy}, FE_{jy}, AVE_{i}^{k}, LSBCI_{ij}, \varepsilon_{ij}^{k})$

- $(INTVAI_{ij}^{k})$ denotes the share of imports of value added embodied in intermediate inputs (often T&S in this analysis) by using sector *k* in country *i* originating from country *j*—the "imports of intermediates" over the total value added used by country *i;*

- $(geography\ \&\ culture_{ij}^{c})$ is a set of *C* bilateral or unilateral indicators of geographical distance, contiguity, colonial relationship, common coloniser, or belonging to the same country in the past;

- (FTA_{ij}) is an indicator variable denoting the existence of a free trade agreement;

- (FE_{iy}, FE_{jy}) are exporter-year and importer-year specific effects.

- (AVE_{i}^{k}) is the Ad-valorem equivalent of protection in maritime transport services estimated by CEPII (Fontagné Mitaritonna and Signoret 2016), and

- $(LSBCI_{ij})$ the liner shipment connectivity index in bilateral, calculated by UNCTAD (Fugazza and Hoffman 2016),

- (ε_{ij}^{k}) and (ε_{i}^{k}) are error terms.