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Sébastien Miroudot, Charles Cadestin

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SERVICES IN GLOBAL VALUE CHAINS: TRADE PATTERNS AND GAINS FROM SPECIALISATION

Sébastien Miroudot and Charles Cadestin, OECD

Within global value chains (GVCs), services and manufacturing activities are intertwined. This report further investigates the role played by services in GVCs by looking at patterns of specialisation in 23 services industries over the period 2000-2014. Relying on the concept of revealed comparative advantage, it highlights that all countries have a comparative advantage in specific services industries, either in services within manufacturing value chains or in services exported as final products to consumers. A value-added approach is important to analyse the specialisation in services. In addition, there are tangible productivity gains out of this specialisation, as well as gains in terms of employment. Finally, empirical results suggest that services trade restrictiveness negatively affects bilateral flows of service value-added within GVCs. Both domestic reforms and the reduction of barriers in partner countries can benefit services sectors and the activities that rely on services inputs.

Keywords: Services, global value chains, servicification, trade in services, trade in value-added, revealed comparative advantage, productivity.

JEL Codes: F13, F14, F23, F68, L80.

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Executive Summary

Within global value chains (GVCs), services and manufacturing activities are intertwined. Understanding how countries specialise in services and the benefits they derive from their participation in international production requires new analytical tools and approaches. This report further investigates the role played by services in GVCs by looking at patterns of specialisation and gains in terms of productivity and employment. It also empirically tests to what extent regulations and barriers to trade in services impact this specialisation.

Using the information from the WIOD input-output tables over the period 2000-2014, the report relies on the concept of 'revealed comparative advantage' (RCA) to study the specialisation of OECD and key partner countries in services within value chains. Both manufacturing and services value chains are covered. Instead of calculating a traditional RCA index that indicates the relative strength of industries in exports as compared to the world average, the analysis is conducted with various value-added RCAs that look at the services contribution of countries from different angles (in terms of value-added originating from the services sector, total value-added derived from participation in services GVCs or service value-added derived from participation in manufacturing GVCs).

By definition, everybody has a revealed comparative advantage in some sector since the concept is based on the relative share of industries in exports. This report focuses on 23 services industries that matter for global value chains (out of a total of 56) and finds that all countries have at least 2 such industries exhibiting a RCA in value-added terms above 1, indicating the existence of a comparative advantage. As the service sector is very large, most countries have a comparative advantage in a variety of services industries and the general trend is for many countries to share the comparative advantage in those industries with relatively small RCA indices.

A value-added perspective is particularly important to understand the specialisation in services, as gross exports of services can be misleading when countries export services through their manufacturing activities.

The results of the analysis suggest that there are two types of specialisation in services in GVCs. First, some countries have specialised in the provision of specific service activities within value chains, particularly the manufacturing value chains. We can see evidence of such specialisation through indicators looking at the origin of value-added in exports and attributing this value-added to services even when it is embodied in a good. We can also see this specialisation within manufacturing firms through data on business functions.

Another type of specialisation consists of providing services more directly, as final products to consumers or as inputs to companies relying on foreign sourcing. This specialisation is more visible in services trade statistics as the services exported are not embodied in manufacturing goods or other services. But the GVC income perspective introduced in the report also allows a more comprehensive picture of this specialisation in services value chains by highlighting the fragmentation of the production process and the contribution of countries through different industries (including manufacturing industries).

From these findings, the first policy implication is that all countries, including emerging and developing economies, specialise in services. Therefore, services trade policy and market openness are a topic of importance and a potential driver of economic growth and employment for all countries.

The second policy implication is that trade in goods and services are intertwined, therefore barriers to both must be addressed in a coherent manner. Countries that specialise in services value chains are well placed to derive benefits from provisions found in the services chapters of trade agreements and sector-specific chapters dealing with final services. Countries exporting services mainly through goods, on the other hand, will have a greater propensity to gain from domestic reforms addressing the barriers they face.

In addition, higher levels of productivity are achieved through GVCs. The report provides new evidence on the gains from GVCs by introducing the concept of GVC productivity, thereby providing insights which are not always clear when looking at traditional productivity measures. The report also highlights that there is a positive correlation between specialisation in services and productivity growth and job creation.

Although, on average, the productivity gains observed in the manufacturing GVCs are higher, a large part of this productivity is coming from the services inputs they rely on. Services productivity is not lagging behind manufacturing activities. As such, there is no reason to believe in any kind of 'Baumol disease' that would make specialisation in services a threat to future productivity. The fact that services and manufacturing are so intertwined means that the choice between the two types of activities is irrelevant. If there is a choice, it is between exporting final services or final goods, but both rely on services value-added and a specialisation in services activities.

Services value chains contribute more to the expansion of employment than manufacturing value chains, according to the evidence reviewed in the report. Labour productivity gains observed in services GVCs are positive and high in absolute terms, but relatively lower than manufacturing value chains. The fact that productivity has also increased for services indicates that the expansion of employment was not detrimental to economic efficiency and GDP growth.

Evidence that the manufacturing sector becomes more competitive through services is relevant for policy-makers pursuing strategies aimed at re-industrialising and reinvigorating manufacturing employment. The impact of such strategies will benefit from an approach that integrates the servicification considerations. On the other hand, reversing or undermining the servicification process would be detrimental.

Domestic services reforms can bring important gains for countries specialising in services. The report introduces additional evidence on the role of trade barriers in shaping patterns of specialisation. The OECD STRI, identified in previous empirical work as a reliable proxy for services regulations affecting trade, is also a significant variable when trying to explain bilateral flows of service value-added within GVCs. The higher the STRI, the lower are the bilateral flows.

In some sectors, the results suggest that domestic reforms may have an even greater impact on exports of value-added than the reduction of barriers in partner countries. But at the aggregate level, both the STRI of the exporting and importing economies are affecting negatively services value-added trade flows. Therefore, there are further benefits from reducing bilateral trade barriers and addressing obstacles in partner countries. Going forward, the nature of trade within GVCs (with services embodied in goods or bundled with goods) requires new thinking in terms of how to best address such barriers.

Introduction

As knowledge on global value chains (GVCs) accumulates, there is a growing awareness that services play an important role in explaining how production networks are organised and the profile of companies creating or capturing value within these networks. The GVC framework demonstrates that services and manufacturing are intertwined, as the production of any good starts with R&D and design services. At the other end of the value chain, services allow the product to reach consumers (marketing, distribution and after-sale services).

The first report of the OECD project on services in global value chains (Miroudot and Cadestin, 2017) has provided new quantitative evidence on how important services activities are within GVCs. In this second report, the focus is on patterns of specialisation across countries, the gains from specialisation in services and the role of services trade policy in shaping GVCs.

The first part of the report summarises the findings of previous work and sets the stage for the analysis of patterns of specialisation in services within GVCs by defining comparative advantage and how it operates for services in value chains. The second part provides an empirical analysis of these patterns based on the WIOD 2016 input-output tables and the database of employment by business function developed for the project. The third part deals with gains from specialisation in terms of productivity and employment. Part four provides some econometric analysis of the role played by restrictions on trade in services in specialisation patterns, taking advantage of the OECD STRI. The last part concludes and draws some policy implications.

1. Services in the age of global value chains

As emphasised in several reports[1], the role of services in GVCs is multi-faceted. First, services link manufacturing activities across countries. There are GVCs because companies can split production internationally and use transport, communication, logistics and a variety of other services to coordinate and manage activities that are geographically fragmented. But services are not just the 'glue' in value chains, they are also essential inputs in key stages of the production process, starting with design and engineering at the beginning of the value chain and finishing with marketing, distribution, sales and after-sales services at the end.

While services inputs can be outsourced and provided by independent companies, they are also produced in-house. It is often the case for research and development or IT activities. Firms tend to produce in-house services that correspond to core strategic functions for which they are interested in investing in the human skills and training that will contribute to the productivity of the firm and guarantee that it remains more competitive than other firms. On the contrary, activities that are too costly to maintain in-house, are more efficiently carried out by external providers and are not part of the core functions of the firm, are outsourced.

But services are not just inputs; they are also the output of value chains. First, the fragmentation of production is not limited to manufacturing. While supply chains are generally shorter for services (De Backer and Miroudot, 2013), there is also a fragmentation and internationalisation of production for services. Some service industries such as transport, telecoms and financial services tend also to have sophisticated global value chains. Even haircuts -the textbook example of a non-tradable service- are nowadays the product of an international industry with some large companies managing hair salons in multiple countries, and organising the training of hairdressers and the supply of equipment and consumables at a global level.

In addition to the fragmentation of production in traditional services industries, the other important trend is for goods and services to be sold together as bundles. A large share of services exports now originates from the manufacturing sector, with companies no longer selling a product but providing their customers with

1. In particular, Low (2013), Lanz and Maurer (2015), De Backer et al. (2015) and Miroudot and Cadestin (2017).

solutions and integrated systems. This phenomenon, known as 'servitisation' (Vandermerwe and Rada, 1988) allows firms to add more value and to create a long-term relationship with customers that will generate income not only when the good is sold but all along its life until it is replaced. Consumers also benefit by not having to deal with multiple companies and avoiding the hassle of getting all the needed services separately over time.

But the story would not be complete without also emphasising that the servicification of manufacturing goes together with digitalisation and the innovation of new business models where companies push customer service to new levels. The consumer herself can become associated with the production process through a community or through tailored solutions. As such, the servicification is not just the result of more people working in services or a higher share of value-added originating in the service sector. It is a shift towards more productive and more customer-centric production models where value can be seen as co-created with consumers (Cinquini et al., 2013).

This servicification is therefore not limited to manufacturing sectors. The way services industries operate has also changed in the recent period. In the financial, transport, telecoms, distribution or other business services sectors, companies have broadened the range of services they provide and created new types of relationships with customers. For example, banks offer a variety of services through 'packages' that combine insurance services, payment services, legal services, access to advice or investment tools, etc. Telecom operators provide 'triple play' or 'quad play' services that combine fixed telephony, mobile services, access to Internet, television and additional digital content -in some cases through third-parties-, while also renting the required hardware. Services companies themselves provide more services and solutions closer to consumers' needs.

As a consequence, what we call "trade in services" today is not only more important from a quantitative point of view, in terms of value-added traded, but also it is qualitatively different. It explains the challenges in measuring trade, output, growth and productivity in a world where it becomes more and more difficult to distinguish the contribution of manufacturing industries from services industries. Defining comparative advantage in services and identifying how countries perform in different types of services within value chains requires new tools and new types of data.

i. What is comparative advantage in services?

The concept of comparative advantage comes from David Ricardo (1817),[2] the main insight being that gains from trade are not derived from absolute differences in productivity across countries but rather from relative differences *within* countries. It is based on the concept of opportunity cost, i.e. the resources that have to be used to produce a good at home as opposed to the resources needed to obtain the same good from abroad through trade (while producing something else at home that will be exchanged). In the classic example involving wine from Portugal and cloth from Britain, Portugal is more productive in the production of both wine and cloth. But in order to get more clothes, it has to renounce to the consumption of more bottles of wine when it produces clothes domestically as opposed to a situation where it can trade wine for clothes with Britain.

While developed having in mind trade in goods, the theory of comparative advantage is not different when it comes to services. Already in the 19th century, trade was presented as an "exchange of services" (Bastiat, 1848), emphasising that the argument made for commodities or goods is the same for immaterial goods or amounts of money. When Grossman and Rossi-Hansberg (2008) indicate that "it's not wine for cloth anymore", their point is that countries increasingly trade "tasks" rather than goods in the context of offshoring. The benefit of such trade does not depart from the initial wine and cloth argument. What is traded, however, is more like a service or a task and no longer a good.

2. And can be traced back as far as 1701 in *Considerations upon the East-India Trade*, attributed to Henry Martin (Irwin, 1998).

The theory of comparative advantage is still the basis for most trade analysis. The gains it describes were never questioned, except when looking at the evolution of comparative advantage over time (Samuelson, 2005). But it is because in addition to Ricardo, one has to refer to Adam Smith as well to understand the benefits of trade. For a long time, Smith and the theory of absolute advantage were seen to be in contradiction with Ricardo's comparative advantage. It is however less of a contradiction when interpreting Smith as the dynamic version of Ricardo's argument (Morales-Meoqui, 2014). Both Ricardo and Smith agree when it comes to the role of market extension in dynamic productivity gains. Economies of scale related to specialisation are the other source of economic gains related to trade, as modelled in the new trade theory with increasing returns (Krugman, 1980). Specialisation of countries in services is also expected to yield productivity gains over time, due to the fact that companies serve larger markets.

However, the challenge in the context of global value chains is that comparative advantage is no longer something fully determined by a country's characteristics, such as its technologies or factor endowments. When producers have access to inputs from other countries, what a country produces is not only determined by domestic characteristics but also by the costs of inputs abroad and the trade costs involved for sourcing these inputs from abroad. It is a more complex set of relative costs along the value chain that determines comparative advantage and that explains the task in which each country specialises in. Dealing with comparative advantage in services requires an approach that can take into account this type of specialisation, as most services are traded within value chains and are inputs in the production process rather than final products.

By relying on the neo-Ricardian trade model (Shiozawa, 2012), Escaith and Miroudot (2016) highlight that the international input-output model offers a consistent framework to track value-added across countries and account for trade costs in the context of global value chains. The approach in this report is hence to look at revealed comparative advantage in services on the basis of value-added trade within GVCs.

ii. The determinants of comparative advantage in services

As explained in the previous section, comparative advantage might involve more external determinants in the context of global value chains, as not only costs within the domestic economy matter but also how these costs are impacted by access to foreign inputs.

Nevertheless, some country characteristics also explain the specific role of an economy in global value chains and the services at which it is relatively more productive. The traditional determinants identified in the literature on trade in goods and in the context of a fully domestic production remain relevant because comparative advantage will still come from differences in productivity across sectors. These differences result from various factors such as technologies, factor endowments, infrastructure, geography, history or institutions. Technology itself can be seen as a primary determinant explained by secondary sources to be found in the interplay between factor endowments, infrastructure, geography, history and institutions.

The literature on sources of comparative advantage for services is scarce. In one of the rare attempts at quantifying the importance of different types of determinants for comparative advantage in services, Van der Marel (2012) finds that the three main determinants are the stock of high-skilled and medium-skilled labour, the level of trust received from importers and the quality of regulatory governance.

It is generally assumed that human capital plays a more important role in the case of services due to the nature of their production (e.g. co-creation with the customer) and the importance of skills. One specificity in the case of services, perhaps, is that human capital itself (the determinant of comparative advantage) is developed through services such as R&D services, education or health services (Hoekman and Mattoo, 2008). Therefore, it is not surprising to see the stock of high-skilled and medium-skilled workers as an important empirical determinant of comparative advantage in services.

When it comes to offshoring, the literature has emphasised in the context of global value chains, determinants such as the language spoken by the workforce, the compatibility between cultures or favourable time-zone differentials, in addition to lower labour costs. For example, the success of the Philippines in call centre services for the United States can be explained by the large number of English speakers, the time-zone

difference (that does not involve night work that would be more costly) and a culture compatible with American clients (Gereffi and Fernandez-Stark, 2010).

More than with goods, one can believe that institutions and policies then play an important role for comparative advantage in services. Due to their complexity and the presence of externalities in service sectors (such as network effects), services regulations are more likely to create productivity differences between sectors. Some regulations intentionally limit the provision of the service by foreign companies in some sectors (e.g. through foreign equity limits or nationality requirements). The fact that such policies focus on specific sectors can be a determinant of comparative advantage in others. For example, the strong comparative advantage of India in computer services can be explained by the fact that other services sectors in India and the manufacturing sector in general are more regulated (Eichengreen and Gupta, 2013).

Many services regulations are, however, not intended to have an impact on trade and address a different set of issues such as the protection of consumers, the enforcement of competition or the avoidance of a disruption of the economy (e.g. prudential regulations in financial services). Still these policies can have an indirect impact on trade when they create some heterogeneity across services sectors leading to comparative advantage. This is why Part III of the report focuses on the role of regulations in explaining patterns of specialisation in services.

iii. Revealed comparative advantage in services

In this report, we rely on the concept of "revealed comparative advantage" (RCA). The concept was discussed by Alan Deardorff in a presentation made at the 2010 OECD Global Forum on Trade. In a world without any trade distortion, the RCA would be a good proxy for what economists define as comparative advantage. However, when various policies and trade barriers distort trade, the RCA does not just reflect comparative advantage. It includes the incidence of such policies. But it remains a useful tool to look at trade patterns and identify sectors that gain or lose.

The RCA is an index that was first introduced by Béla Balassa (1965). It is calculated as the share of a country's exports of product *i* in total exports divided by the share of world exports of *i* in total world exports. For a given service, the RCA is the share of this service in total exports of the country divided by the share of this service in world exports.

To take into account global value chains, the RCA is first calculated in value-added terms. Instead of looking only at the value of exports of services, the RCA is calculated in terms of all the value-added originating in services sectors embodied in any type of export (goods or services). For example, if a country exports manufacturing goods with value-added from the business services sector (i.e. a good produced with inputs purchased from the business services industry), this value-added will contribute to the definition of the revealed comparative advantage in business services together with direct exports of business services. With the gross trade RCA, these business services would contribute to a comparative advantage in the manufacturing sector.

The value-added RCA is defined as the share of value-added originating from a given service sector in a country's exports divided by the share of value-added originating from this service sector in world exports. As with the traditional RCA, a country has a comparative advantage in a service industry when this share is above 1, i.e. when the value-added coming from this service sector represents a higher share for this country as compared to the world average.

In addition, we calculate an additional indicator, similar in approach but of a different type: the RCA in terms of GVC income (Timmer et al., 2013). Instead of looking at value-added in exports, the RCA relies on all the income generated by a given value-chain. For example, for all IT products consumed in the world, it looks at the share of value-added from a given country as compared to the average share contributed by all economies. Even if these IT products are goods, the calculation includes the value-added provided by services industries as part of this 'GVC income'. But the RCA can also be calculated for a service industry, such as the accommodation and food service value chain. In this case, both goods and services used as inputs in the value chain are part of the GVC income and the indicator looks at the strength of a given country in its contributions

from different industries going into the final products of the accommodation and food service industry. When the value is above 1, it indicates that the country has a comparative advantage in this global value chain.

Finally, to come even closer to the concept of trade in tasks, the RCA analysis is also conducted with a dataset where the value-added is split according to specific business functions. If we refer to the 'TOSP' framework suggested by Baldwin (2012) -TOSP meaning Tasks, Occupations and Stages of Production-, the task is the most disaggregated level at which production takes place. Tasks correspond to activities of workers within a given occupation. Above occupations (sets of tasks) are production stages (sets of occupations). The business function is a unit similar to the production stage in the TOSP framework in the sense that it involves a group of workers with similar or complementary occupations. We prefer to use business functions because it is the concept coming from the analysis of the value chain by Michael Porter (1985). Moreover, it is the unit seen as relevant to develop new statistics on global value chains (Sturgeon et al., 2013).

The first business function corresponds to the core activity of the firm, the production of the good(s) or service(s) it sells. There are then six types of support service functions: transport, logistics and distribution; marketing, sales and after-sales services; IT services and software support; management, administration and back-office; R&D, engineering and related technical services; other business functions (that include in particular activities related to maintenance, repair, security, education and training). The idea is to look at whether some countries specialise in business functions rather than specific industries, consistent with the trade in tasks paradigm (Grossman and Rossi-Hansberg, 2008).

2. Specialisation patterns in services within GVCs

Against this backdrop, results are presented in this section for OECD countries and key partners covered in the WIOD 2016 dataset (a total of 36 countries).[3] More details on the calculation of the different indicators used can be found in the technical appendix (Annex A).

i. Revealed comparative advantage in value-added terms

The RCA in value-added terms first reveals some interesting patterns across countries. Figure 1 summarises results for all countries and industries by showing the set of services where a comparative advantage was identified (i.e. values above 1)[4]. Countries are in rows and industries in columns. The size of the 'bubble' at the intersection is proportional to the value of the RCA.

All countries have a comparative advantage in at least one service industry. The minimum observed is 2 for Mexico and Norway. Countries that specialise in manufacturing industries, such as Mexico and the People's Republic of China (hereafter "China"), have fewer RCAs above 1 when looking at service industries. China has nonetheless a comparative advantage in four service sectors. In the case of Norway, exports are very concentrated in the 'mining and quarrying' sector (that includes the oil and gas industry), even in value-added terms. There is therefore less room for a comparative advantage in other industries.

At the opposite end of the spectrum, there are countries for which most of their industries have a comparative advantage in the service sector. In particular, the United Kingdom has a RCA above 1 in 16 of the 23 industries included in Figure 1. The United States and Italy have 12. It means that in all these industries, these countries tend to export more value-added than the average observed for the world. This indicates a strong specialisation in services spread out across very different sectors. Another group of services exporters has a RCA above 1 in fewer industries but stronger values for the RCAs where they are specialised.

3. Four OECD countries are not covered in the WIOD database: Chile, Iceland, Israel and New Zealand.

4. An additional criterion is applied to provide clearer results on the figure: only industries representing more than 1 percent of total services exports are included. This additional filter removes very small sectors where a RCA could be found but that account for a negligible share of exports.

It is the case for example of Greece with the highest RCA calculated in the dataset (24.3) in 'water transport' and Luxembourg with a very high RCA (18.8) in 'activities auxiliary to financial services'.

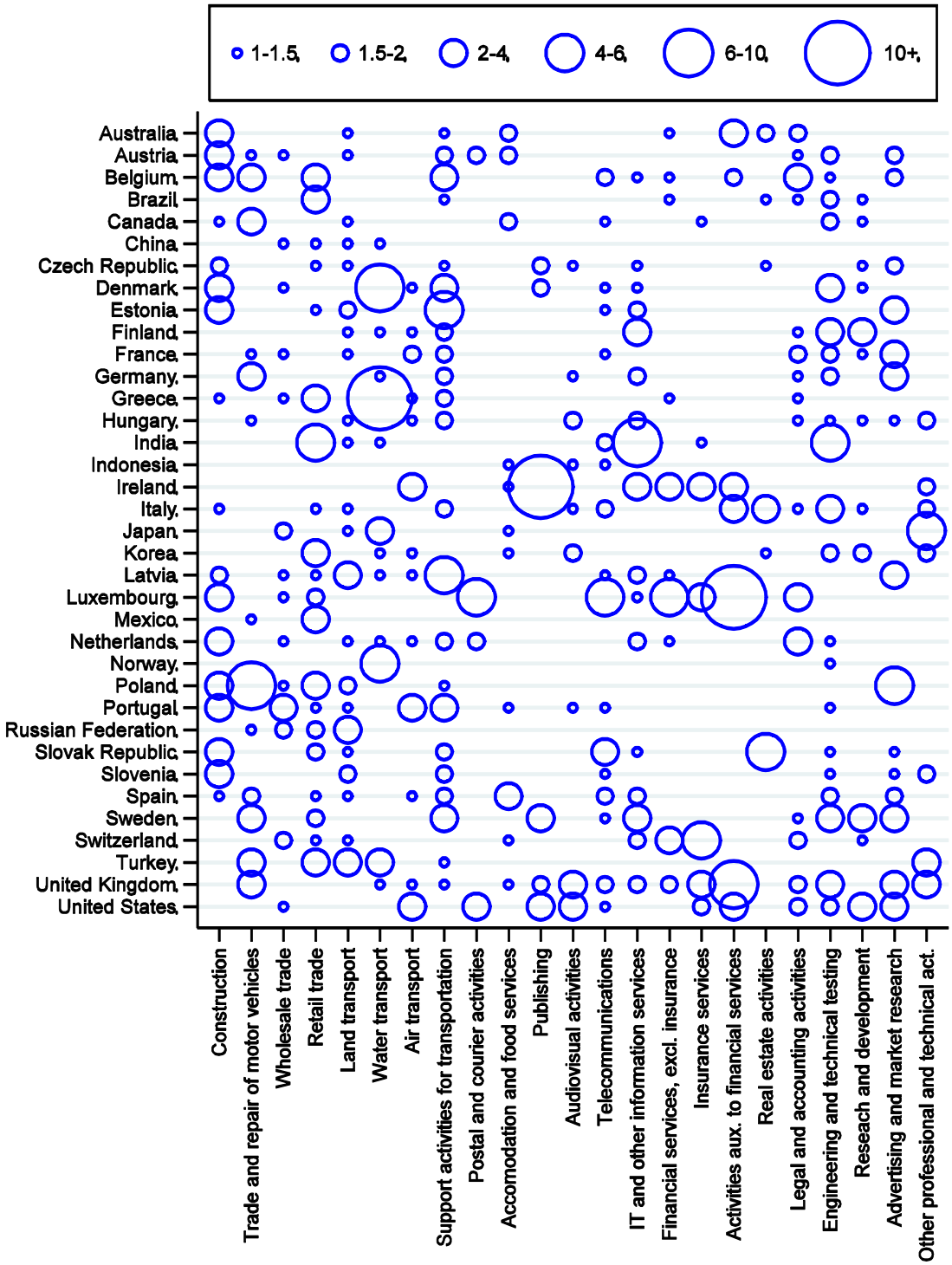
Figure 1 can also be read across columns to see which countries are most specialised in the services industries reported. For example, in the case of 'water transport', a few countries stand out: Greece, Denmark and Norway. Another industry where a few countries account for most of the specialisation in exports of value-added is 'publishing' with Ireland and to a lesser extent the US and Sweden having the strongest revealed comparative advantage. There are also industries for which many countries have a comparative advantage, with smaller RCAs spread out across a higher number of countries, such as 'support activities for transportation', 'engineering and technical testing' or 'IT and other information services'. But not all countries are on Figure 1. In the case of these industries the countries not included (and in particular the 'rest of the world' in the WIOD dataset) are the ones exporting relatively less value-added, explaining that most countries on Figure 1 are above-the-average exporters.

The difference between the RCA in value-added terms and in gross terms (the traditional way to calculate it) has already been highlighted in previous reports (OECD, 2013). As an illustration, Figure 2 provides some of the most extreme examples found in the dataset with a difference between the two RCAs higher than 1. By looking at gross exports only, Turkey for example would not have any comparative advantage in 'other professional and technical activities'. With the value-added figures, the sector is on the contrary one of the most competitive in Turkey.

There are two reasons why RCAs in gross terms and value-added terms differ. The first one is related to the domestic content of exports. As services are produced with fewer foreign inputs, they generally account for a higher share of exports in value-added terms and it is reflected in the RCA with more weight given to services as opposed to manufacturing goods once the value of foreign intermediate inputs is removed. The second reason is related to indirect exports and the fact that services are exported embodied in goods. The value-added calculation identifies services activities within manufacturing goods while gross exports allocate all these embodied services to the manufacturing sector. This is why Turkey in the above example has a very low RCA in gross terms but a high one in value-added terms. Most of professional and technical activities are exported embodied in goods, thus leading to an important discrepancy in the two types of RCAs.

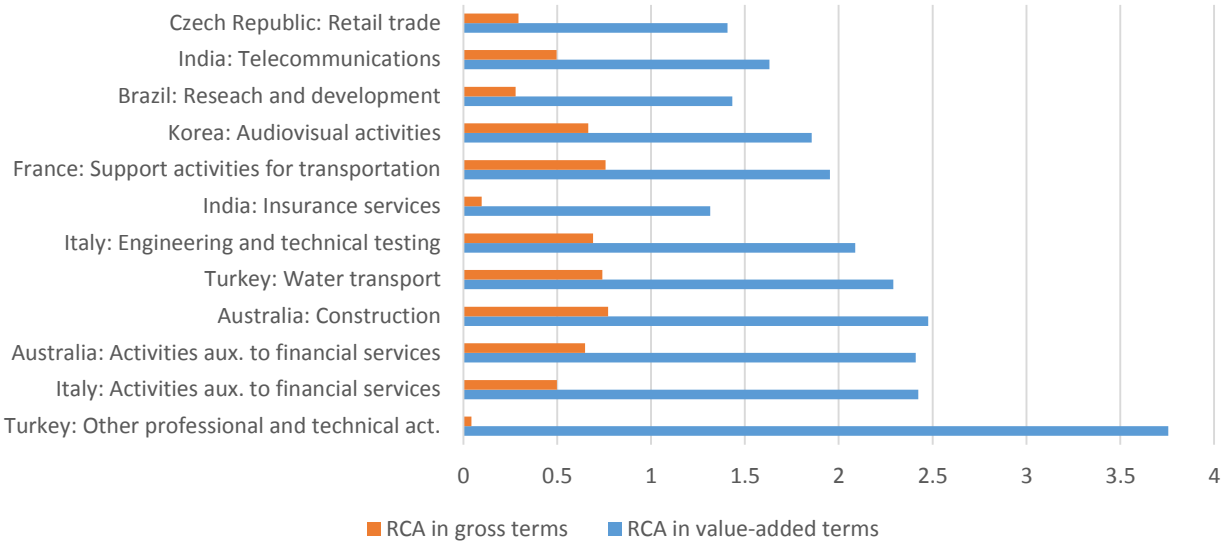
From a policy perspective, the RCA in value-added terms is more relevant for the purpose of identifying the true contribution of services to trade and the companies that are important for exports. In Figure 2, there are several examples of services that seem key for manufacturing exports, such as insurance services, support activities for transportation or transport services. For the countries that are more specialised in exports of manufactured goods, a revealed comparative advantage in these activities would not appear if the analysis was limited to RCAs in gross terms. But these countries actually create relatively more value-added in these services industries as compared to other countries.

Figure 1. Value-added export RCA in services, by country (2014)



Source: Authors' calculations based on WIOD 2016.

Figure 2. RCA in value-added terms and in gross terms, 2014, selected countries and industries



Source: Authors' calculations based on WIOD 2016.

ii. Revealed comparative advantage in terms of GVC income in services industries

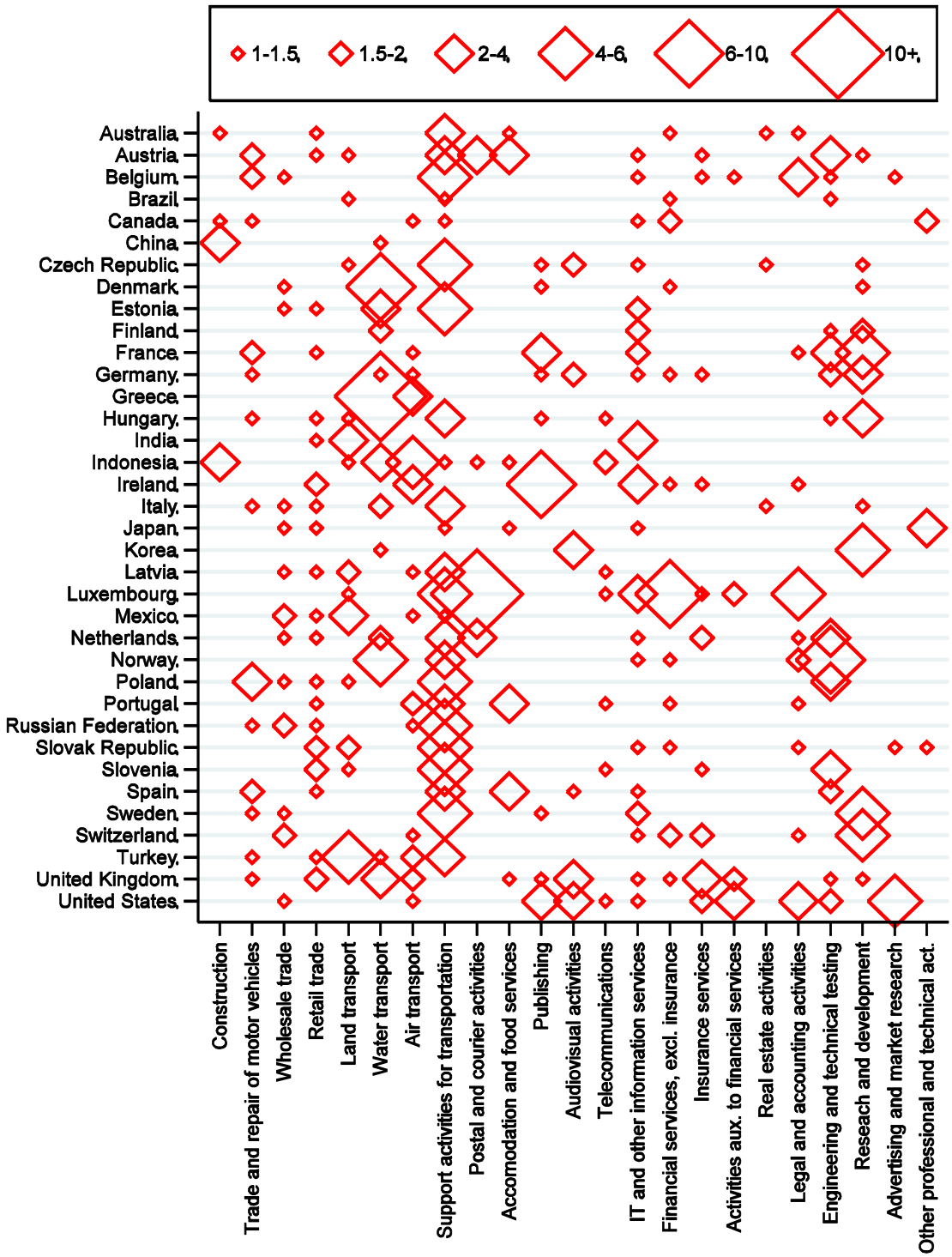
To further investigate the specialisation in services from a global value chain perspective, Figure 3 introduces a different type of RCA based on the concept of 'GVC income' (Timmer et al., 2013). This RCA also relies on a value-added calculation but this time from the point of view of final demand. For each service industry on Figure 3, the final consumption all over the world has been aggregated and the RCA identifies whether some countries account for a relatively higher share of the value-added generated by these services industries. This time, the analysis is about services value chains (i.e. value chains producing final services) and the contribution from each country (its 'GVC income') from all industries. It means that the value-added contributed by each country can originate from the same service sector, from another service sector (e.g. IT services used as inputs to produce financial services), or from an agricultural or manufacturing sector (e.g. food products used as inputs to produce accommodation and food services).

Figure 3 shares some similarities with Figure 1, especially when the value-added captured in the GVC income comes from the same sector and is an export in value-added terms from the same industry. But overall there is not a high correlation coefficient between the value-added export RCA and the GVC income RCA.[5]

If one looks at China for example, the GVC income RCA tells a different story. The construction sector was not an industry where China had a revealed comparative advantage in exports of value-added on Figure 1 but it has a strong RCA on Figure 3 because value-added from other industries ending up in final demand for Chinese construction services is now included. It is likely that inputs from the manufacturing sector, such as construction materials, are now making a significant contribution in terms of domestic value-added in addition to the value-added coming from the construction sector itself. Where China had an RCA above 1 for wholesale trade, retail trade and land transport on Figure 1, it has lost this comparative advantage in Figure 3. Some of these services were likely to be embodied in exports of goods in the value-added export RCA. They are no longer captured in Figure 3 since the perspective is the final consumption of such services (their value is now part of the GVC income in the manufacturing value chains they contribute to).

5. The correlation coefficient when pooling all years, countries and services industries is 0.45. It is lower than the correlation between the export RCA in gross terms and in value-added terms (0.71).

Figure 3. GVC income RCA in services, by country (2014)



Source: Authors' calculations based on WIOD 2016.

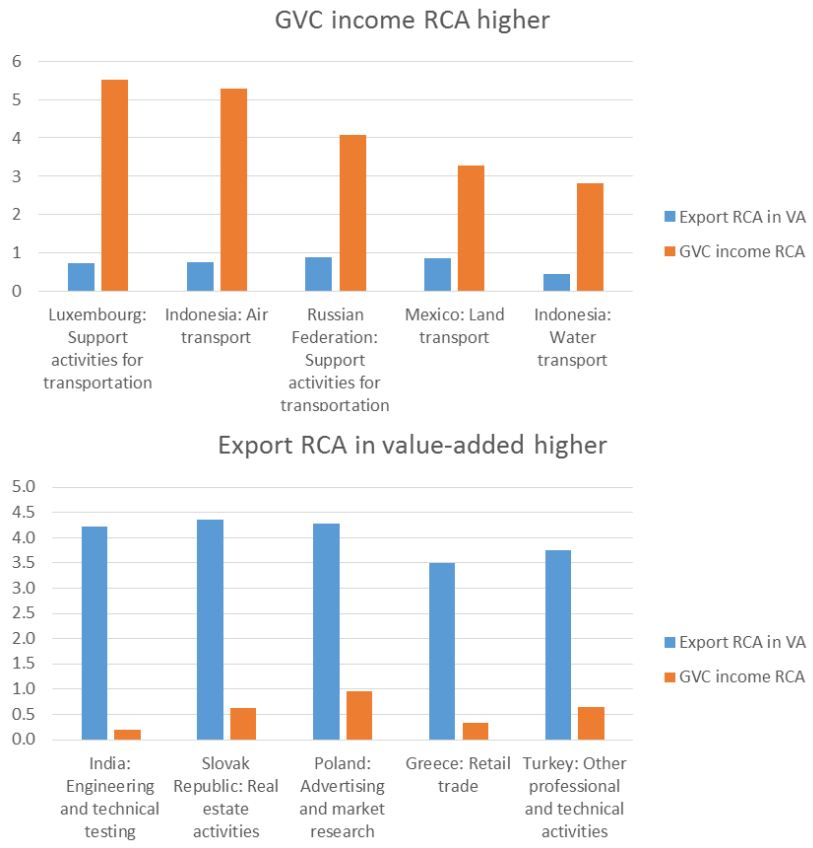
The analysis in Figure 3 thus answers a different question: what are the countries with a comparative advantage in the production of final services from a GVC perspective (i.e. when looking at the share of value-added from a country and from any industry of origin in world consumption of the service).

Other significant differences between the GVC income RCA and the export RCA in value-added terms are listed on Figure 4. The top panel includes cases where the GVC income RCA is much higher than the export RCA. It suggests activities where there is an important indirect contribution from other industries so that the overall contribution of the country to the service is higher. For example, Luxembourg might not be a strong exporter of 'support activities for transportation' but accounts for a high share of final production of support activities for transportation through financial services and other supporting business services it provides in this value chain.

The bottom panel of Figure 4 has on the contrary countries and industries where a high value-added export RCA does not translate into a high GVC income RCA. The sectors that illustrate this case are generally intermediate inputs sectors, such as 'engineering and technical testing' or 'advertising and market research'. The final demand for such services is small as compared to their use as intermediate inputs and therefore the GVC income RCA is not a very good indicator of the strength of some countries as exporters, such as India in the case of 'engineering and technical testing'.

The GVC income RCA is therefore more interesting for services industries that have a significant output going to final demand, such as construction, accommodation and food services, insurance services or telecommunications. Since the final product is a service, there are also some policy implications in terms of barriers to services. The GVC income measured from the point of view of final demand is affected by barriers to trade in services in the countries of consumption.

Figure 3. GVC income RCA and export RCA in value-added terms, 2014, selected countries and industries

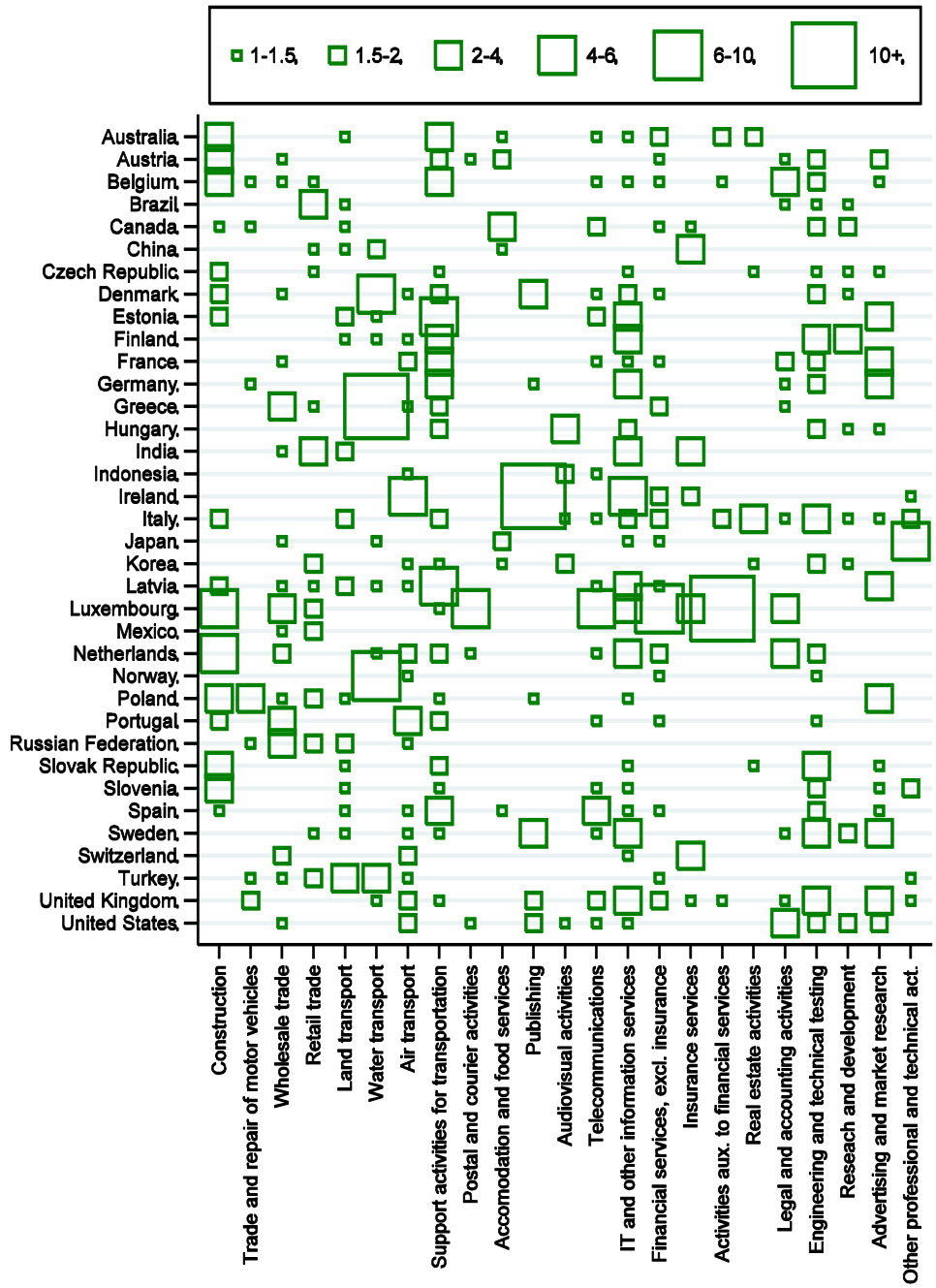


Source: Authors' calculations based on WIOD 2016.

iii. Revealed comparative advantage in terms of services in manufacturing GVC income

In the case of services mainly used as inputs in the manufacturing sector, a different calculation can help to identify countries with a revealed comparative advantage. The GVC income in manufacturing industries is simply all the value-added contributed by a given country to final demand for all manufacturing goods consumed in the world. Some of this VA comes from manufacturing industries but a significant share also comes from services sectors. By isolating this share, we can work with the service contribution of each country to manufacturing GVC income and calculate a RCA in terms of this service contribution.

Figure 5. RCA in services embodied in manufacturing GVC income, by country (2014)



Source: Authors' calculations based on WIOD 2016.

The results are on Figure 5. There is a higher correlation with the export RCA in value-added terms (Figure 1).[6] But still there is conceptually a difference since this RCA does not look at the value-added in exports but the value-added in manufacturing GVC income. It can be seen as the complement to the RCA in terms of GVC income in services industries, as it adds the dimension of services used as inputs by manufacturing firms (and therefore contributing to GVC income in manufacturing industries).

The focus on services as inputs rather than final products explains differences with Figure 3. Looking at China again, the revealed comparative advantage in construction disappears as this industry is mainly selling final services. And the RCA in retail trade and land transport comes back because these industries contribute to the manufacturing GVC income by providing inputs for manufacturers in their operations. Since there are only minor differences between Figures 1 and 5, it is however not so useful to focus on this type of RCA and the combined use of the export RCA in value-added terms and GVC income RCA in services industry might be enough to characterise the comparative advantage of each country in services industries.

iv. The evolution of comparative advantage in services over time

In the previous figures, we have looked at patterns of specialisation in 2014. The question is whether countries tend to preserve their comparative advantage over time or whether there are changes with some RCAs disappearing (the value becoming smaller than 1) and others being revealed (the value becoming higher than 1)

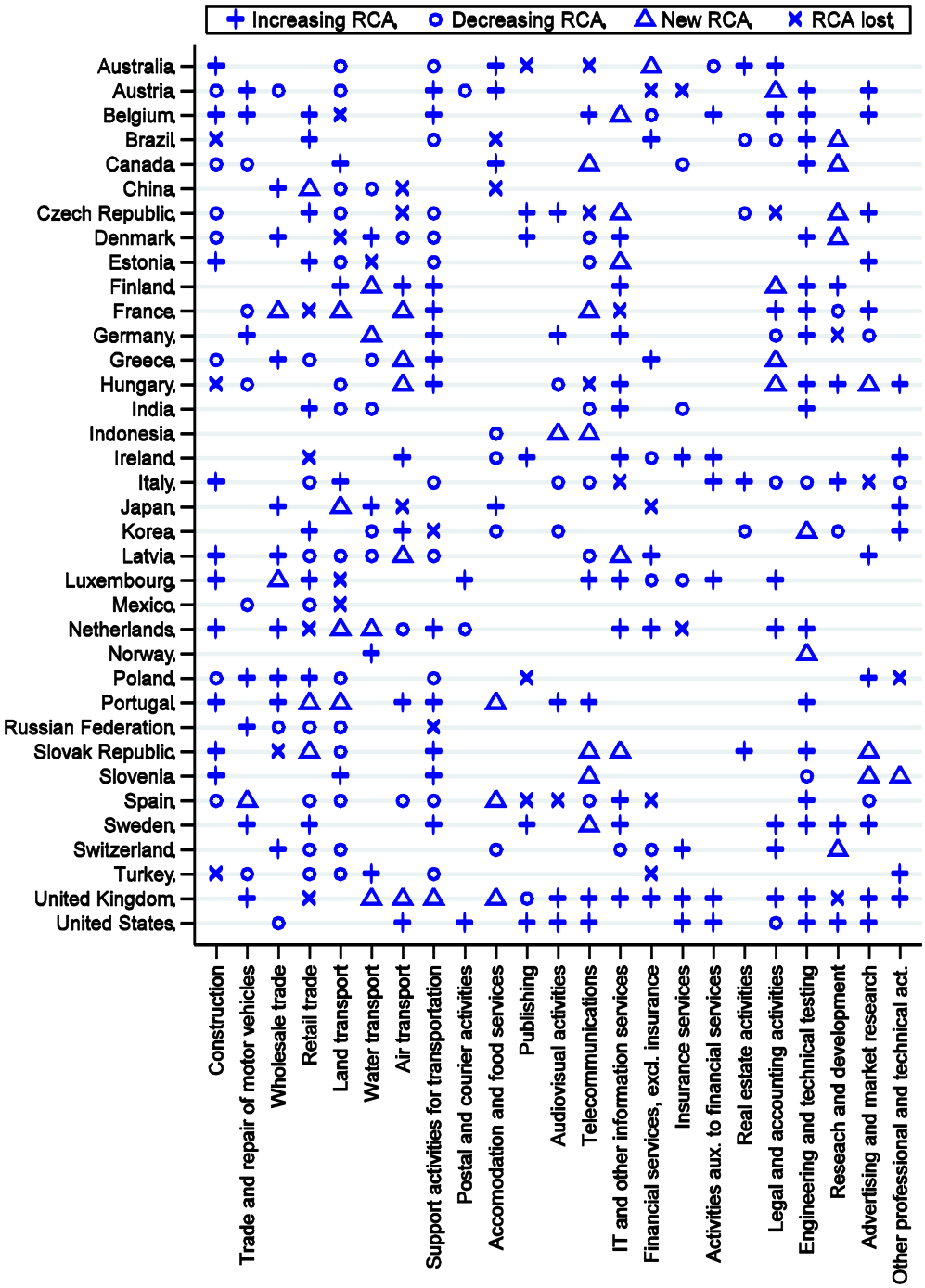
Figure 6 provides such analysis using the value-added export RCA (the one from Figure 1). Instead of markers proportional to the size of the RCA, four symbols describe the evolution of the RCA between 2000 and 2014. A "+" indicates that the value of the RCA, already above 1 in 2000, has increased over the period, while the "o" sign is used when the value has decreased (but there is still a comparative advantage at the end of the period). The marker is a triangle ("Δ") when there is a new comparative advantage, i.e. a RCA becoming higher than 1 during the period and a "x" when the comparative advantage has been lost (the value becoming smaller than 1).

A quick look at Figure 6 suggests that over 14 years, there is quite some change in patterns of specialisation and that, as mentioned in the introduction, the dynamic is important. The most common pattern, however, is an increase in comparative advantage (156 cases), followed by a decrease but with still an existing comparative advantage at the end of the period (94 cases). Therefore, whether through the deepening of the existing comparative advantage or some slow erosion of it, Figure 6 suggests that in almost three-quarters of the cases, countries could maintain their specialisation in the services industries where they had a comparative advantage in 2000. There are then 51 cases where a comparative advantage has appeared in a new service sector and only 40 cases where the comparative advantage has disappeared (a value decreasing below 1).

Some differences are also observed across countries. The United States for example are clearly increasing their specialisation in services over the period with the exception of 'wholesale trade' and 'legal and accounting activities' where there is a decrease in the RCA (but still a comparative advantage). Another country clearly moving towards services is Sweden with only RCAs increasing and a new sector with a comparative advantage ('telecommunications'). The same is observed for Portugal with even three new sectors with a comparative advantage ('wholesale trade', 'land transport' and 'accommodation and food services'). The Czech Republic shows interesting patterns, including a range of new sectors with a comparative advantage and other sectors where the comparative advantage is lost. The country is moving towards new activities more related to new technologies ('IT and information services', 'research and development').

6. For 2014, the correlation coefficient is 0.79.

Figure 4. Evolution of the value-added export RCA between 2000 and 2014, by country



Source: Authors' calculations based on WIOD 2016.

The 'IT and other information services' and 'telecommunications' sectors, more generally, are the ones where many changes are registered during the period. It is not surprising since they are the ones related to the digital economy. Interestingly, there are also many new entrants in terms of comparative advantage in the air transport sector, which is another sector impacted by new business models.

v. Is there a specialisation in specific business functions in the value chain?

The last type of evidence to be reviewed is related to business functions and trade in tasks. The analysis so far has taken into account services used as inputs in manufacturing value chains and looked at specialisation in industries. But as mentioned in the introduction, services activities are also within manufacturing firms and specialisation is believed to be more related to tasks than industries.

Figure 7 first presents some results based on the GVC income calculation for both manufacturing and commercial services GVCs, using employment data.[7] An RCA is calculated for each business function after pooling the employment figures from all industries and looking at the ratio of the share of employment of the country in this business function and the "world" share (in the absence of all countries, the "world" share is just the share across countries included in the dataset). Only RCAs above one are shown on the Figure and only for the top 10 countries when more than 10 countries have a RCA above 1.

For operations, only three countries have a relatively small comparative advantage: India, Turkey and Indonesia. These countries tend to focus on core production activities, including assembly. But the small values of the RCA (slightly over 1) suggest that they are not only doing such activities in value chains and are involved in other business functions as well.

With respect to transport, logistics and distribution, small RCAs are also observed. Countries with the highest RCAs are the ones that were previously identified as having a comparative advantage in the transport sector, such as Denmark in water transport, but also more generally countries with large MNEs involved in international operations that require a significant amount of transport, logistics and distribution activities. This is why countries such as Germany, the United States, the Netherlands or Korea are also in the list. A difference with Figure 5 and the GVC income RCA by industry is that with the business functions analysis, support activities within manufacturing firms contribute to the identification of the RCA. Previously, only outsourced services were taken into account for the specialisation in transport, logistics and distribution activities.

In the case of marketing, sales and after-sale services, there are also quite small RCAs. Interestingly, Indonesia has the strongest RCA, confirming that emerging economies are not relegated to assembly and core production. It means that the country plays a role in sales and since it did not have before a comparative advantage in the trade sector, it can be again related to activities of MNEs and domestic firms that are in the manufacturing sector but with a role in sales and customer services. Indonesia is then together with countries whose comparative advantage in the wholesale and retail trade sector was identified before, such as the Netherlands, Spain and Ireland in the European Union.

7. The WIOD 2016 update does not include socio-economic accounts with information on employment and wages. We have used data from the business functions dataset. To cover as many countries as possible, the analysis is done with the employment vector (as fewer countries have wage information).

Figure 5. GVC income RCA by business function, 2014, selected countries, manufacturing and services GVCs

Source: Authors' calculations based on WIOD 2016 and OECD business functions dataset.

With IT services and software support, much higher RCAs are observed, indicating that there is more of a specialisation in this type of activities. While all companies need transport, logistics, distribution, marketing, sales and after-sale services, the IT services are more outsourced or, if kept within firms, show more heterogeneity across countries in the share of employment devoted to them. Some countries known as technological leaders have the strongest RCAs, such as Korea, Finland and Sweden.

The management, administration and back-office support function captures some key headquarter activities and not surprisingly countries that have the headquarters of large MNEs have a higher RCA, such as Luxembourg, Japan or Switzerland. But this business function also includes some professional services (legal and accounting support services) and countries with the comparative advantage in such sectors on Figure 5 (e.g. Belgium) also have higher RCAs in this business function.

Finally, the R&D, engineering and technical testing business function is the one with the highest RCAs. As with IT services, part of these activities are outsourced but also another important part is kept in-house (because these functions are strategic). Since the business functions data capture both, the comparative advantage of some countries in these activities is even more emphasised on Figure 7, particularly for Finland, Sweden and Norway.

Results of the analysis by business function become more interesting when looking at specific GVCs. For example, Figure 8 shows the patterns of specialisation for the automotive industry ('Manufacture of motor vehicles, trailers and semi-trailers'). There are fewer markers and not all countries have a RCA above one because a threshold is applied so that countries with almost no output in this industry do not have large RCAs.

The automotive industry is interesting because unlike other manufacturing industries, the production of cars tends to remain local or regional rather than global, and fewer developing or emerging countries are involved (Sturgeon and Van Biesebroeck, 2011). It is the case when looking at Figure 8 and the RCA in operations which, unlike what was seen on Figure 7, is found above 1 for most of the developed economies. Is it the consequence of industry characteristics or of policies that have influenced localisation (as suggested by Sturgeon and Van Biesebroeck)? The RCA, as highlighted in the introduction, is affected by distortions introduced by policies. But from Figure 8 we cannot answer this question.

We can however confirm that operations are spread across a larger number of countries in the motor vehicles industry. But we see also in the case of EU countries the regional value chains, with Germany not having the comparative advantage in operations but countries around (such as Belgium, the Czech Republic, France, Poland or the Slovak Republic) having RCAs above 1. These countries host the main suppliers of parts and components for the German car industry. Germany has however the comparative advantage when it comes to transport and distribution, IT services and even more so, R&D and engineering. The German comparative advantage in the automotive sector is therefore mostly related to services. For R&D and engineering, this comparative advantage is however shared with other EU countries and particularly the ones involved in parts and components previously mentioned. It also confirms the results from the GVC literature about the increasing role of suppliers in providing integrated systems to car manufacturers rather than basic parts and components. Suppliers are increasingly involved in R&D activities.

Figure 6. GVC income RCA by business function, 2014, motor vehicles industry

Source: Authors' calculations based on WIOD 2016 and OECD business functions dataset.

More results for additional industries are included in Annex C. The conclusion is that we see indeed some specialisation according to these business functions. However, it is difficult to say that tasks have really replaced industries. Maybe patterns of specialisation remain clearer when looking at results such as on Figure 1 as compared to Figure 7. But the business function analysis offers a complementary perspective that can help to better understand the role of each country within industries participating in the same value chain.

3. Gains from specialisation

There are two types of economic gains that can be captured in our framework. A first approach is to look at the increase in value-added in sectors where a comparative advantage was developed (RCA in value-added above 1 at the end of the period). Since we also have data on employment in such sectors, the increase in productivity and job creation can be highlighted. This approach can only point to some correlation between specialisation and productivity; no causality is empirically tested.

A second approach is to look at productivity from a GVC angle. Following Dietzenbacher and Los (2012), a GVC labour productivity growth can be calculated, accounting for productivity all along the value chain from the point of view of final products (including labour productivity gains upstream). This approach can highlight how more efficient services inputs have benefitted not only countries producing these services but all countries relying on these inputs. In this calculation, we can also isolate the specific productivity gains related to the domestic segment of GVCs where countries have specialised. Here the productivity derived from GVCs is directly observed (and the analysis is not limited to sectors where a comparative advantage was developed, as all sectors participating in the value chain are included).

Results using the first approach are summarised in Table 1. For each variable, the numbers are ratios of the levels observed in 2014 and in 2000 (by subtracting 1 these ratios can be interpreted as the percentage change between 2000 and 2014). Since the WIOD database 2016 does not have socio-economic accounts with employment data, we are relying on our own data from labour force surveys (coming from the business functions database). Labour productivity is calculated as the value-added in volume divided by employment. The table has been split in two to look at manufacturing industries with a comparative advantage (RCA in value-added terms above 1 in 2014) and commercial services industries with a comparative advantage (the same industries analysed in previous sections). Two countries have no manufacturing industry with a comparative advantage (Australia –as mining is not included- and Luxembourg).

In almost all countries, there is a significant increase in the value-added of industries with a revealed comparative advantage in 2014, indicating that these industries have been expanding in the 14 years covered, despite the financial crisis in 2008-2009 and the fact that 2000 was a year with high levels of VA at the end of the cycle of rapid growth observed in the second part of the 1990s. With respect to labour productivity, there are also very few countries with a negative growth rate (ratios below 1). Countries have generally deepened their specialisation, in line with the rise of GVCs. The increase is on average stronger in services industries, but for some countries value-added has increased more in manufacturing industries with a comparative advantage.

The results are however different between the manufacturing and service sector when looking at employment. Despite only including the sectors with a RCA above 1, there is often a decrease in employment in the manufacturing sectors with a comparative advantage (ratios below 1). It is particularly the case for developed countries. The same is not observed for emerging economies such as Brazil, China, Mexico, the Russian Federation or Turkey. There are however developed countries with job creation in these manufacturing sectors, such as France, Norway, Spain and the United Kingdom, as well as some East European countries (the Czech Republic, Hungary, Poland and the Slovak Republic). But the increase in employment is generally stronger when looking at services industries.

Table 1 suggests that in terms of employment, the specialisation in services industries brings more benefits. And this higher employment is not always detrimental to productivity because there are also higher growth rates for value-added in some of these services industries. In 14 countries out of 28 for which the data are available, there is a higher growth rate in the productivity of services sectors with a comparative advantage as compared to manufacturing sectors. And the ratios for the 14 other countries also indicate strong productivity gains. Only three countries have a negative growth rate for productivity in services industries with a comparative advantage.

Table 1. Growth rates of employment, value-added and labour productivity in industries with a RCA above 1 in 2014 (ratios of levels for 2014 and 2000)

Country	Manufacturing			Commercial services		
	Growth in employment	Growth in VA	Growth in labour productivity	Growth in employment	Growth in VA	Growth in labour productivity
Australia				1.36	1.65	1.22
Austria	1.01	1.87	1.86	1.13	1.71	1.51
Belgium	0.84	1.74	2.07	1.12	1.92	1.70
Brazil	1.19	1.33	1.12	1.44	1.49	1.04
Canada	0.68	0.93	1.38	1.33	1.26	0.95
China	2.39	4.28	1.79	2.94	4.06	1.38
Czech Republic	1.20	4.10	3.42	1.02	2.26	2.21
Denmark	0.99	2.73	2.77	0.82	2.16	2.63
Estonia	0.92	5.33	5.78	1.17	7.33	6.25
Finland	0.76	1.56	2.05	1.16	1.66	1.43
France	1.88	1.81	0.96	1.26	1.76	1.40
Germany	1.02	1.87	1.83	1.32	1.82	1.38
Greece	0.94	2.73	2.90	0.94	3.40	3.63
Hungary	1.24	5.02	4.06	0.99	5.53	5.60
India	2.21	2.81	1.27	1.78	3.37	1.89
Indonesia	0.45	1.51	3.35	1.67	2.59	1.55
Ireland	0.80	1.96	2.44	1.30	4.64	3.58
Italy	0.80	1.28	1.61	1.31	1.47	1.12
Japan	0.87	1.25	1.44	0.91	1.28	1.40
Korea	0.92	2.32	2.52	1.33	1.83	1.38
Latvia	0.57	3.66	6.42	1.19	5.89	4.95
Luxembourg				1.84	2.36	1.28
Mexico	1.39	1.12	0.81	1.35	1.31	0.97
Netherlands	0.88	1.59	1.81	1.05	1.74	1.66
Norway	1.27	2.13	1.67	1.28	1.69	1.32
Poland	1.20	4.47	3.74	1.16	5.31	4.57
Portugal	0.69	1.32	1.92	1.02	1.59	1.56
Russian Federation	1.88	1.77	0.94	2.18	2.06	0.94
Slovak Republic	1.30	7.03	5.39	1.27	8.78	6.94
Slovenia	0.96	3.19	3.32	1.03	3.98	3.88
Spain	1.23	1.68	1.37	1.21	2.06	1.70
Sweden	0.72	1.53	2.11	1.24	1.87	1.50
Switzerland	0.76	1.42	1.87	0.95	1.28	1.34
Turkey	1.40	1.65	1.18	1.18	1.86	1.58
United Kingdom	1.26	1.15	0.91	1.08	1.61	1.48
United States	0.80	1.67	2.08	1.18	1.41	1.19

Source: Authors' calculations based on WIOD 2016 and labour force surveys data. Deflators from EUKlems, WorldKlems and UN database. VA and employment data for industries with a RCA above 1 in 2014 are summed for each country to obtain the average growth in employment, VA and productivity. Manufacturing does not include mining and utilities.

It should be noted that the productivity measured in Table 1 is the apparent labour productivity, based on the level of value-added and employment in each industry. It does not account fully for efficiency as it would be the case with measures of multi-factor productivity. Table 1 highlights the correlation between comparative advantage and higher levels of employment and income.

To complement Table 1, additional measures of productivity are calculated in Table 2 based on a GVC approach. The idea is to capture broader gains beyond the specific sectors where specialisation takes place, in terms of more productive value chains (including abroad) that improve the production of all the final goods and services manufactured in the economy. Such calculation was introduced by Dietzenbacher and Los (2012). The GVC productivity is a measure of labour productivity that takes into account the amounts of labour required for a dollar of final output in a given industry, by aggregating labour requirements over all industries and all countries that participate in the value chain (i.e. countries producing raw materials, intermediate inputs as well as the final product).

As with Table 1, the productivity measures are proposed both for manufacturing and services sectors. But in the case of Table 2, the GVC productivity in the manufacturing sector takes into account all the services inputs used. There are several interesting findings in Table 2. The first one is that the growth in GVC productivity is almost always lower than the growth in domestic GVC productivity (the only exceptions being the Russian Federation in manufacturing industries and Turkey in services industries when omitting cases where the two ratios are roughly equal). It means that offshoring takes place in segments of the value chain that have a relatively lower productivity, confirming the insight from the business management literature that firms focus on their core competencies where they are more productive. It is also consistent with the idea that offshoring is a strategy that creates productivity at home rather than a defensive strategy in industries that would be in decline (and where companies would seek more productive factors of production abroad).

The second finding is that domestic GVC productivity is generally higher than the traditional labour productivity. There are also exceptions to this rule (China, Greece, Indonesia, the Russian Federation and Switzerland in the case of manufacturing industries, and Greece and Ireland in the case of services industries – omitting small differences). But still the results are quite clearly in favour of the domestic GVC productivity. It means that through GVCs and particularly their 'domestic leg', higher levels of productivity are achieved as compared to the productivity directly measured in the industry of production of the final good or service. In about half of the cases, the total GVC productivity (including stages of production taking place abroad) is also higher than the traditional labour productivity.

Table 2 thus provides evidence of the productivity gains associated with GVCs and the fact that they benefit first and foremost the domestic part of the value chain. Unlike Table 1, the calculation of GVC productivity itself incorporates the value chain and figures can be directly interpreted as the impact of these value chains on productivity. These productivity gains are strong in services GVCs. With the exception of the Russian Federation, positive growth rates are found everywhere and are quite high for transition economies that joined the European Union during the period, such as Estonia, Hungary, Poland, the Slovak Republic or Slovenia.

Positive GVC productivity gains are also found in all manufacturing industries, with the exception of the Russian Federation, even when the traditional labour productivity is declining. For countries like Australia, Brazil or Mexico, where labour productivity at the industry level has only slightly increased in manufacturing, there is a bigger increase with the GVC productivity measure because it accounts for the services inputs that have improved the productivity upstream. At the end, this GVC measure of productivity is more accurate as it reflects what consumers will gain. And the stronger domestic segment shows that this gain for consumers is not a trade-off where the domestic economy would lose on the production side. On the contrary, it is achieved through higher domestic GVC productivity.

Table 2. GVC productivity growth rates, all manufacturing and commercial services (ratios of levels for 2014 and 2000)

Country	Manufacturing			Commercial services		
	Growth in GVC productivity	Growth in domestic GVC productivity	Growth in labour productivity	Growth in GVC productivity	Growth in domestic GVC productivity	Growth in labour productivity
Australia	1.22	1.21	1.06	1.20	1.17	1.18
Austria	1.81	2.29	2.09	1.67	1.75	1.54
Belgium	1.47	2.23	2.10	1.59	1.89	1.66
Brazil	1.23	1.25	1.04	1.11	1.11	1.06
Canada	1.22	1.20	1.23	1.16	1.15	1.05
China	1.51	1.52	1.82	1.65	1.64	1.28
Czech Republic	3.65	5.26	3.24	3.16	3.50	2.37
Denmark	1.96	2.80	2.30	2.27	2.79	2.26
Estonia	8.14	13.12	6.97	5.81	6.68	5.78
Finland	1.63	2.22	2.01	1.81	2.11	1.65
France	1.65	2.06	1.87	1.54	1.74	1.47
Germany	1.59	1.83	1.83	1.53	1.62	1.48
Greece	2.51	2.90	3.19	2.05	2.18	2.69
Hungary	3.82	5.28	4.76	4.76	5.41	5.38
India	2.12	2.17	1.72	2.18	2.19	1.85
Indonesia	2.30	2.35	3.26	5.55	5.64	2.25
Ireland	1.76	3.63	2.44	1.86	2.76	2.98
Italy	1.41	1.58	1.40	1.37	1.41	1.31
Japan	1.48	1.91	1.44	1.27	1.35	1.32
Korea	1.69	1.95	2.39	1.33	1.38	1.28
Latvia	5.25	7.11	5.08	4.35	4.69	4.48
Luxembourg	1.38	4.75	1.46	1.30	2.59	1.69
Mexico	1.09	1.09	1.01	1.40	1.43	0.94
Netherlands	1.37	2.84	1.86	1.50	1.95	1.61
Norway	1.96	2.49	1.79	1.95	2.22	1.58
Poland	4.11	4.99	4.17	4.50	4.87	4.62
Portugal	1.83	2.10	1.97	1.65	1.67	1.69
Russian Federation	0.97	0.87	0.95	0.94	0.92	0.83
Slovak Republic	4.85	7.34	5.45	5.62	6.20	5.80
Slovenia	2.93	3.96	3.48	3.35	3.96	3.68
Spain	1.62	1.98	1.79	1.68	1.69	1.68
Sweden	1.70	2.14	2.11	1.91	2.10	1.56
Switzerland	1.52	1.63	1.77	1.40	1.46	1.35
Turkey	1.43	1.68	1.17	1.48	1.47	1.34
United Kingdom	1.50	1.71	1.46	1.54	1.59	1.45
United States	1.57	1.86	1.75	1.77	1.89	1.31

Source: Authors' calculations based on WIOD 2016 and labour force surveys data. Deflators from EUKlems, WorldKlems and UN database.

4. What is the role of trade barriers in explaining specialisation patterns?

The previous sections have highlighted the diversity in patterns of specialisation in services across countries, as well as the gains from specialisation. But so far, little has been said about the reasons why some countries have a comparative advantage in specific services sectors, while others do not. As previously highlighted, there are several determinants explaining comparative advantage in services, mostly related to countries' characteristics in terms of labour endowments, skills and technology.

In this section, we investigate the role of trade barriers in explaining specialisation patterns. On the one hand, barriers to trade in the country producing a specific service have an impact on how competitive services markets are. Domestic services protected by high barriers to trade are likely to be less efficient and even if their productivity is not lower than abroad they will not have the necessary international focus to answer the needs of foreign consumers. We therefore expect a negative relationship between the level of barriers to trade and the export capacity of services industries, even if these barriers only affect imports.

On the other hand, barriers to services trade abroad prevent efficient domestic service providers from accessing foreign markets. These barriers should also limit the ability of domestic industries to expand and become more competitive through scale economies.

The rest of this section tests such relationships in the context of global value chains by looking at value-added trade flows in services with regressions introducing both the OECD Services Trade Restrictiveness Index (STRI) of the exporter of services inputs and of the producer of manufacturing goods or services that rely on such inputs. Table 3 below shows the main result from the empirical analysis. Coefficients are reported for the STRI of the country that has exported services inputs (STRI_origin) and for the STRI of the country using these inputs (STRI_destination), i.e. manufacturing or services firms producing final products with the help of these services inputs. Technical details are available in Annex B together with additional results that emphasise the robustness of the relationships. A separate STRI value is used for each of the 18 industries providing services inputs (see Table A4 in the Annex).

Table 3. The impact of services barriers on bilateral exports of service value-added in GVCs

Dependent variable: bilateral exports of services value-added	**All GVCs**	**Manufacturing GVCs**	**Services GVCs**
STRI_origin	-0.681***	-0.831***	-0.551***
	(0.079)	(0.090)	(0.077)
STRI_destination	-0.492***	-0.652***	-0.337***
	(0.095)	(0.108)	(0.089)
Fixed effects	Pair and industry fixed effects	Pair and industry fixed effects	Pair and industry fixed effects
Number of observations	885,780	400,710	485,070
R-squared	0.284	0.255	0.322

Note: Clustered standard errors are in parenthesis. Coefficients for the constant and fixed effects not reported. The stars denote the statistical significance percentage level: .01 - ***; .05 - **; .1 - *.

There are 3 columns in Table 3. First, a regression is carried out with all the observations in the dataset, i.e. all the bilateral flows of services value-added in the context of manufacturing and services GVCs. Services GVCs are defined as in previous sections of the report as the ones providing commercial services (from construction -F- to professional, scientific and technical activities -M- in the ISIC Rev. 4 classification). Primary sectors (agriculture and mining) as well as public administration, education, health and social services are not included. The two other columns in Table 3 provide separate results for the manufacturing and services GVCs.

In all these pooled regressions, both the STRI of the exporter of service value-added and of the 'importer' (here importer means the country using the services inputs for final production) have statistically significant negative coefficients. It means that barriers to trade in services, as measured in the STRI, prevent final producers from using imported services inputs. It confirms that trade barriers play a role in the specialisation of countries in the production of services used in global value chains.

An interesting result from Table 3 is that in the three regressions the coefficient for STRI_origin tends to be higher than the coefficient for STRI_destination. However, the two coefficients are not strictly statistically different when taking into account the standard errors in Table 3.[8] Other empirical studies comparing the impact of the STRI of the exporter and importer of services (Nordås and Rouzet, 2015) have also found that domestic reforms in services sectors matter even more than trade liberalisation by export partners.

The other interesting finding is that coefficients are higher (and statistically different)) for manufacturing GVCs as compared to services GVCs. It may appear as a paradox that barriers to trade in services affect manufacturing GVCs more than services GVCs - - but this makes sense when the role of services in manufacturing value chains is taken into account. A large share of manufacturing value-added is made of services (Miroudot and Cadestin, 2017).

It may also be related to the fact that when goods manufacturers have to use services, these services have to be provided in the specific locations where the physical production takes place with modes of supply more related to a commercial presence (Mode 3) or the movement of people (Mode 4), while immaterial services inputs going into the production of other services can be provided more through Mode 1 (the cross-border provision) where there are fewer barriers to trade. It should be kept in mind that the value-added trade data used here are not always corresponding to pure cross-border trade as a service input can be embodied in another input before reaching the final producer.

In Table 4, results are disaggregated across broad ISIC sectors. With fewer observations and value-added trade flows that are less reliable when using more disaggregated input-output information, there is more heterogeneity in these sectoral results.

The results from Table 3 are confirmed for two sectors, 'transportation and storage' and 'information and communication' with a negative and significant coefficient for the two STRI indices (with a lower significance in the case of the STRI of destination for 'information and communication' services). For 'construction' and 'wholesale & retail trade', only the STRI of the country of origin is significant, while no significant coefficients are found for 'financial and insurance activities'. In the case, of professional, scientific and technical activities, the STRI of the country of destination has the opposite sign, suggesting that barriers to imports of services are associated with higher value-added flows within the value chain.

8 . Additional econometric results are included in Annex B highlighting higher and statistically different coefficients for STRI_origin as compared to STRI_destination.

Table 4. The impact of services barriers on bilateral exports of service value-added in GVCs, results by sector of origin

Dependent variable: bilateral exports of services value-added	Construction	Wholesale & retail trade	Transportation and storage	Information and communication	Financial and insurance activities	Professional, scientific and technical activities
STRI_origin	-0.793***	-0.148**	-0.442***	-0.705***	-0.120	0.149
	(0.140)	(0.065)	(0.109)	(0.108)	(0.105)	(0.149)
STRI_destination	-0.151	0.056	-0.542***	-0.139*	0.062	0.660***
	(0.260)	(0.087)	(0.082)	(0.084)	(0.087)	(0.153)
Fixed effects	Pair and industry fixed effects	Pair and industry fixed effects	Pair and industry fixed effects	Pair and industry fixed effects	Pair and industry fixed effects	Pair and industry fixed effects
Number of observations	55,944	111,888	262,836	167,832	111,888	279,720
R-squared	0.196	0.379	0.281	0.358	0.308	0.188

Note: Clustered standard errors are in parenthesis. Coefficients for the constant and fixed effects not reported. The stars denote the statistical significance percentage level: .01 - ***; .05 - **; .1 - *.

Again, one should not over-interpret these sectoral results, as fixed effects are less robust and selecting the type of services imported introduces a bias since it does not account for alternative activities and complementary relationships. But Table 4 provides additional evidence that services regulations in the country of origin have a higher impact on value-added trade flows than regulations in the destination economy, at least for construction, wholesale & retail trade and information and communication services where coefficients are significantly different.

5. Concluding remarks and main policy implications

This report has provided evidence on patterns of specialisation in exports of services, focusing on their contribution to manufacturing and services global value chains. The main findings are the following:

- By construction, everybody has a revealed comparative advantage in some type of industry since the concept is based on the relative share of industries in exports. But the report has focused on 23 industries that can be described as "commercial services" out of a total of 56. The fact that all countries are found with at least 2 such industries exhibiting a RCA in value-added terms above 1 is a non-trivial result. It indicates that all countries participate in global value chains in services and that specialisation has taken place over the last 15 years.
- Another relevant finding is that, over time, most countries have maintained their comparative advantage in services and have often increased it, in line with the idea of dynamic specialisation gains where the more countries specialise, the more productive they are and the more they have a comparative advantage.
- But this specialisation does not mean that countries are dependent on exports in a few sectors. The results also show the diversity in patterns of specialisation. The service sector is so large that countries are generally involved in many types of exports in a variety of sectors. The high number of RCAs with rather small values above 1 suggests that many countries benefit from trade in services. Rather than a fierce competition in a zero-sum game environment where only a few companies and countries dominate global markets, the results emphasise the diversity of services activities with many countries finding their place within services in value chains.

- A value-added perspective is particularly important to understand the specialisation in services, as gross exports of services do not make it clear that countries export services when they do it through their manufacturing activities. The report has introduced several types of value-added revealed comparative advantage indicators that allow one to uncover the specialisation of some countries in services in ways not seen before with the traditional RCAs or trade statistics.
- There are two types of specialisation in services in GVCs. First, some countries have specialised in the provision of specific service activities within value chains, particularly the manufacturing value chains. We can see evidence of such specialisation through indicators looking at the origin of value-added in exports and attributing this value-added to services even when it is embodied in a final good. We can also see this specialisation within the manufacturing firms through the data on employment by business function.
- Another type of specialisation consists of providing services more directly, as final services to their consumers or as inputs to companies that have decided to rely on some offshore supply. This specialisation is more visible in services trade statistics as countries directly export the services – it is not embodied in manufacturing goods or other services. But the GVC income perspective introduced in the report also allows us to have a more comprehensive picture of this specialisation in services value chains by highlighting the fragmentation of the production process in services industries and the contribution of countries through different industries (including manufacturing industries) that allow them to be strong exporter of services.

From these findings, the first policy implication is that all countries have an interest in services, and therefore would benefit from a strategy for trade policy in services. The topic is not of importance only for a handful of more advanced economies that have specialised in services. All countries, including emerging and developing economies, are now specialised in services.

The second policy implication, already made in previous reports, is that trade in goods and services are so intertwined that addressing one cannot be done without looking at barriers affecting the other. Countries involved in the second type of specialisation mentioned above (the specialisation in services value chains) should be particularly interested in services trade policy focusing on provisions found in the services chapters of trade agreements and sector-specific chapters dealing with some identified final services. But for countries involved in the first type of specialisation and that are exporting services mainly through goods, the domestic regulation of services is of pronounced importance.

In addition, the report has provided new evidence on the gains from specialisation in services. By introducing the value-added perspective and the concept of GVC productivity, it has highlighted that there is a correlation between higher levels of labour productivity and specialisation in services but also that productivity growth is stronger within GVCs and their domestic segment as a consequence of services used upstream.

Services are not lagging behind manufacturing activities when it comes to productivity. It is true that on average the productivity gains observed in the manufacturing GVCs are higher; but a large part of this productivity is coming from the services inputs they rely on. Therefore, there is no reason to believe in any kind of 'Baumol disease' that would make specialisation in services a threat to future productivity. The fact that services and manufacturing are so intertwined is even making irrelevant the question of a choice between the two types of activities. If there is a choice, it is between exporting final services or final goods, but both rely on services value-added and a specialisation in services activities.

The relatively lower productivity gains observed in services GVCs (albeit positive and high in absolute terms) are even an advantage when it comes to employment. The services value chains have contributed more to the expansion of employment than the manufacturing value chains according to the evidence reviewed in the report.

Such finding is relevant for policy-makers pursuing strategies aimed at re-industrialising and reinvigorating manufacturing employment. The impact of such strategies will benefit from an approach that

integrates the servicification considerations. On the other hand, it would be detrimental if such strategies try to reverse the process of servicification.

Lastly, the report has introduced additional evidence on the role of trade barriers in shaping patterns of specialisation. The OECD STRI, previously found as a reliable proxy for services regulations affecting trade, is also a significant variable when trying to explain bilateral flows of services value-added within GVCs. The higher the STRI, the lower are the bilateral flows. In addition, in several sectors the impact of regulations of the country producing services and exporting them (embodied in goods or not) is more important than regulations of the country where these services are used in final production. It suggests that an agenda for domestic services reforms can bring important gains for countries specialising in these services.

But since the STRI of the country importing services also negatively affects the activities of producers relying on these services inputs (and there is no statistical difference at the aggregate level between the two indices), the results do not draw into question efforts to reduce bilateral trade barriers and address obstacles in partner countries. The nature of "trade" within these GVCs (with services embodied in goods or bundled with goods) still requires new thinking in terms of how best addressing the barriers to such trade.

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Annex A.

Data and methodology

Three sets of data are used in this report and described in this Annex. To measure services trade and value-added within global value chains, the analysis relies on the World Input-Output Database (WIOD), updated in November 2016. The database is described in Timmer et al. (2015) and information on the update can be found in Timmer et al. (2016). The data are combined with some information on business functions coming from labour force surveys. A description of these data can be found in Miroudot and Cadestin (2017). Finally, to assess barriers to services at the country and industry level, the report uses the Services Trade Restrictiveness Indexes (STRI) database from the OECD.

The World Input-Output Database, 2016 release

The 2016 release of WIOD consists in a set of world input-output tables covering 43 countries and a model for the rest of the world for the period 2000-2014. Detail is available for 56 industries in the ISIC Rev. 4 classification. The tables are built according to the 2008 version of the System of National Accounts. Four OECD countries are not included in the WIOD dataset: Chile, Iceland, Israel and New Zealand. They are covered in the OECD Trade in Value-Added (TiVA) input-output tables but the sectoral coverage is not as detailed as in WIOD and they could not be included in this report.

We extract several types of data from the WIOD tables. First, the tables provide a comprehensive matrix of bilateral trade in services. As opposed to the data found in balance of payments (BOP), these trade flows are by industry and consistent with output and GDP. No flow is missing, which is an improvement as compared to BOP data, but at the cost of including some estimates departing from official trade statistics. These estimates are however coming from a consistent national account framework. Only the allocation across partners is subject to the assumptions made in the construction of the world input-output tables. Gross trade flows in services are used in the report to calculate traditional Revealed Comparative Advantage (RCAs) indicators.

In addition, the WIOD tables allow us to look at trade in value-added terms. The conceptual and theoretical background was first explained in a joint note by the OECD and WTO in 2012.[9] Several academic papers also provide more details on how trade can be estimated in value-added terms by using an international input-output framework (Johnson and Noguera, 2012; Koopman et al., 2014; Los et al., 2016).

For the calculation of RCAs in value-added terms, we apply to the WIOD dataset the same type of formulas developed in the course of the TiVA project at OECD.[10] We first decompose gross exports and look at the contribution of domestic services industries to the value-added in exports. It allows us to calculate RCAs in value-added terms (see the next section for the formulas). We also decompose final demand to look at the origin of value-added in goods and services consumed in each country, identifying again the contribution of services industries. This final demand decomposition is used to calculate a RCA in terms of "GVC income". Lastly, we also rely on a final *output* decomposition to address the question of the use of services inputs by manufacturers of final products (independently of whether they are consumed in the domestic economy or exported).

9. www.oecd.org/sti/ind/49894138.pdf.

10. www.oecd.org/sti/ind/tiva/tivasourcesandmethods.htm.

There are initially 28 services industries in the WIOD dataset (excluding activities of households as employers and activities of extraterritorial organisations). When combining the WIOD data with information on business functions or STRI indices, a smaller set of industries is used. The choice is also to focus on the "commercial" services that are inputs in global value chains rather than on administrative and social services. This is why results are presented in this report for the industries described in Table A1.

Table A1. Classification of industries

Isic code	WIOD services industries	Industries covered in the analysis of patterns of specialisation (commercial services)	Industries covered in the analysis of services barriers (STRI)
F	Construction	X	X
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	X	
G46	Wholesale trade, except of motor vehicles and motorcycles	X	X
G47	Retail trade, except of motor vehicles and motorcycles	X	X
H49	Land transport and transport via pipelines	X	X
H50	Water transport	X	X
H51	Air transport	X	X
H52	Warehousing and support activities for transportation	X	X
H53	Postal and courier activities	X	X
I	Accommodation and food service activities	X	
J58	Publishing activities	X	
J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	X	X
J61	Telecommunications	X	X
J62_J63	Computer programming, consultancy and related activities; information service activities	X	X
K64	Financial service activities, except insurance and pension funding	X	X
K65	Insurance, reinsurance and pension funding, except compulsory social security	X	X
K66	Activities auxiliary to financial services and insurance activities	X	
L68	Real estate activities	X	
M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities	X	X
M71	Architectural and engineering activities; technical testing and analysis	X	X
M72	Scientific research and development	X	X
M73	Advertising and market research	X	X
M74_M75	Other professional, scientific and technical activities; veterinary activities	X	X
N	Administrative and support service activities		
O84	Public administration and defence; compulsory social security		
P85	Education		
Q	Human health and social work activities		
R_S	Other service activities		

The OECD dataset on employment (and wages) by industry and business function

The business function is a new statistical unit of analysis proposed in the GVC literature to better characterise the activities of workers within firms and industries (Sturgeon et al., 2013). It builds on the value chain as described by Michael Porter (1985) and the distinction between the primary or core activity of the firm (its operations) and a number of intangible support functions such as R&D, sales, marketing or IT services. These functions are services inputs when outsourced by firms.

Table A2. Typology of business functions

No.	Business function	Definition	Examples of occupations (ISCO 2008)
1	Operations/Core business functions	The core/primary business function of the firm. Generally the production of goods or services intended for the market or third-parties.	Food processing and related trades workers; Wood processing and papermaking plant operators; Assemblers; Garment and related trades workers.
2	Transport, logistics and distribution support functions	A support function that includes activities related to procurement, transportation, warehousing and the delivery of goods and services to customers.	Material-recording and transport clerks; Heavy truck and bus drivers; Transport and storage labourers.
3	Marketing, sales, after sales service support function	A support function focusing on market analysis, advertising, selling, retail management, as well as customer services (including help desks and call centres).	Sales, marketing and development managers; Sales, marketing and public relations professionals; Cashiers and ticket clerks; Client information workers.
4	IT services and software support functions	Activities related to data processing, software development and the provision of ICT services.	Software and applications developers and analysts; Database and network professionals; Information and communications technology technicians.
5	Management, administration, and back-office support functions	Activities associated with the administration of the firm, including legal, finance, accounting and human resources management.	Managing directors and chief executives; General office clerks; Administrative and specialised secretaries.
6	R&D, engineering and related technical services and R&D support functions	This support function includes activities related to experimental development, research, design, engineering and related technical consultancy, technical testing, analysis and certification.	Mathematicians, actuaries and statisticians; Architects, planners, surveyors and designers; Engineering professionals; Life science technicians and related associate professionals; Ship and aircraft controllers and technicians.
7	Other business functions	Activities related to maintenance and repair, security, as well as other activities not belonging to specific firm-level business functions. Also includes education and training.	Domestic, hotel and office cleaners and helpers; Protective services workers; Machinery mechanics and repairers; Armed forces officers; legislators and senior officials; religious professionals; Secondary education teachers.

To identify business functions at the country and industry level, occupational data from labour force surveys are used. The methodology relies on a simple correspondence between each occupation at the 3-digit level and one of the seven business functions listed in Table A2. Correspondence tables were developed at the OECD based on the description of the occupation in each national classification.

The database covers 39 of the WIOD countries over the period 2000-2014 (but the year coverage varies across countries). The 4 countries for which no occupational data at the required level of disaggregation could be found are China, Chinese Taipei, Indonesia and the Russian Federation. The sources and classifications are reported in Table A3.

Table A3. Sources for occupational data by industry

Country	Source	Year coverage	Wage info	Data
Australia	Labour Force, Australia	2000-2011	No	ANZSIC 2006, 3-digit ANZSCO 2006, 2-digit
Brazil	Pesquisa Nacional por Amostra de Domicílios (PNAD)	2001-2009, 2011-2014	Yes	ISIC Rev.3/Rev.4, 2-digit National classification of occupations, 3-digit
Canada	Canadian Labour Force Survey	All years	Yes	NAICS (43 industries) NOCS (47 occupations)
EU countries (28), Iceland, Norway, Switzerland and Turkey	Eurostat Labour Force Survey (EU LFS)	All years*	Selected years in the Earnings survey (SES)	NACE Rev. 1/Rev. 2, 2-digit ISCO 88/08, 3-digit
Japan	Population Census	2000, 2005, 2010	No	ISIC Rev.3/Rev.4, 2-digit National classification of occupations, 3-digit
Korea	Korean Labour & Income Panel Study	2000-2012	Yes	KSIC, 2-digit KSOC, 3-digit
India	National Sample Survey (NSS)	2003-2012	Yes	NIC 1998/2004/2008, 2-digit NCO 1968/2004, 3-digit
Mexico	Encuesta Nacional de Ocupación y Empleo (ENOE)	All years	Yes	NAICS, CAE-ENE National classification of occupations
United States	Occupational Employment Statistics (OES) Survey	All years	Yes	SIC/NAICS, 3-digit SOC 2000/2010, 6-digit

Based on labour force surveys, data on business functions are expressed in the number of workers employed in each industry. By combining this information with wage data (often available together with employment data in the labour force survey), a share of labour compensation for each business function can also be obtained. But the analysis in this report only relies on the employment data to maximise the country coverage.

The OECD Services Trade Restrictiveness Index (STRI)

The Services Trade Restrictiveness Index (STRI) is a database on regulatory measures affecting trade in services. It provides indices summarising all barriers to trade in services for 19 sectors in 44 countries. The STRI indices take the value from 0 to 1, where 0 is completely open and 1 is completely closed. By accepting some approximation in the correspondence between STRI sectors and WIOD industries (see Table A4), it is

possible to cover 18 services industries in the analysis.[11] As there is no STRI for Chinese Taipei and 5 EU countries that are not OECD Members, the analysis is limited to 37 countries of the WIOD dataset.

While the STRI is updated each year, the first year available in the dataset is 2014. Therefore, there is an overlap with the WIOD dataset only for this single year. It explains why we can only run regressions with STRI indices in a cross-section.

Table A4. Correspondence between WIOD industries and STRI indices

WIOD code	WIOD industry	STRI index used
F	Construction	Construction
G46	Wholesale trade, except of motor vehicles and motorcycles	Distribution
G47	Retail trade, except of motor vehicles and motorcycles	Distribution
H49	Land transport and transport via pipelines	Average of road freight transport and rail freight transport
H50	Water transport	Maritime transport
H51	Air transport	Air transport
H52	Warehousing and support activities for transportation	Average of cargo-handling, storage and warehouse, freight transport agency and customs brokerage services.
H53	Postal and courier activities	Courier services
J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	Average of motion picture, television and broadcasting, and sound recording
J61	Telecommunications	Telecommunications
J62_J63	Computer programming, consultancy and related activities; information service activities	Computer services
K64	Financial service activities, except insurance and pension funding	Commercial banking
K65	Insurance, reinsurance and pension funding, except compulsory social security	Insurance services
M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities	Average of legal services, accounting and computer services.
M71	Architectural and engineering activities; technical testing and analysis	Average of engineering, architecture and computer services
M72	Scientific research and development	Computer services
M73	Advertising and market research	Computer services
M74_M75	Other professional, scientific and technical activities; veterinary activities	Computer services

11. In particular, we use the index of computer services as a generic index for all the non-regulated business services since there are no sector-specific measures in the STRI for this sector.

The methodology behind the STRI is explained in Geloso Grosso et al. (2015). For each sector, there is a list of trade restrictive measures classified in five policy areas (restrictions on foreign entry, restrictions on the movement of people, other discriminatory measures, barriers to competition, regulatory transparency). The list of measures and the weight of each policy area was developed with the help of experts. Measures within each policy area receive equal weights but there are different scoring rules that account for their complementarity or hierarchies among them. Whether the market is competitive or not also changes the scoring and the lack of regulation can be regarded as a restriction if countries do not put in place the necessary pro-competitive measures. STRI indices were used in various empirical reports that have confirmed their ability to accurately reflect the level of trade restrictiveness across sectors and countries.

For the analysis in this report, we use both STRI indices from exporting countries (trade restrictiveness in sectors of exporters of services) and from importing countries (trade restrictiveness in the manufacturing industries importing services inputs).

Calculation of revealed comparative advantage (RCA) indices

RCA indices are calculated as in Balassa (1965) with data from the WIOD input-output tables. The main purpose of these indices is to compare a country's structure of exports with the world: a country that exports relatively more in an industry as compared to other countries has a comparative advantage in this industry identified through an index higher than 1. Using subscript i for countries ranging from 1 to N and j for industries ranging from 1 to K, the revealed comparative advantage index is:

$$RCA_{i,j} = \frac{\frac{X_{i,j}}{\sum_j^K X_{i,j}}}{\frac{\sum_i^N X_{i,j}}{\sum_i^N \sum_j^K X_{i,j}}}$$

Although traditionally calculated with X as exports, we extend the concept to three further variables: (1) value-added originating from industry *j* in exports of country *i*; (2) GVC income from country *i* in industry *j*; and (3) services value-added from industry *j* in manufacturing GVC income of country *i*.

Value added in the input-output framework is the difference between the industry gross output -which includes changes in inventories of finished goods– and intermediate consumption. In the WIOD tables, flows are valued at basic prices.

As for the GVC income, it is calculated as in Timmer *et al.* (2013) and corresponds to the domestic value-added that is contained in a final consumption product. For instance, let's consider the total final demand – irrespective of the country of destination – of apparel manufactured in Italy. The GVC income corresponds to all the value-added generated in Italy by sales of Italian apparel. It includes not only value added from the apparel industry but also the value added from other Italian industries that have provided inputs.

In our notation, any column vector is represented by a lower case; a hat corresponds to the diagonal matrix of this vector and matrices by upper cases. We use four subscripts i, j, m, n for respectively country, industry, partner country and partner industry.

- x is a column vector of size $N * K$ which corresponds to the gross output,
- v a column vector for the value-added to gross output ratio,
- $Y_{i,j}$ is the (N*K,K) matrix of final demand composed $y_{i,j}(m)$ that depicts the amount of dollar of industry j in country i that is absorbed in country m. This Y matrix can be converted into a column vector y for the total final demand of product j in country i irrespective of the country where it is absorbed. This is the sum across columns $y = \sum_m y(m)$.

- Z is a matrix of size (N*K,N*K) for intermediate consumption. Let's denote A the intermediate input requirement matrix: $A = Z * \hat{x}^{-1}$. A component $a_{(i,j)}(m,n)$ of the A matrix which is ranged from 0 to 1 corresponds to the unit of input from country m and industry n that is directly required for the production of one dollar of industry i in country j.

The demand-side Leontief model implies the following equality $x = Ax + y$. It constitutes a system of equations which resolution results in the Leontief matrix: $x = (I - A)^{-1} * y = L * y$. Contrary to A which components reflect only direct contribution, a component of the Leontief matrix $l_{i,j}(m,n)$ also contains the indirect contribution. When multiplying this equality by the value added diagonal matrix, the decomposition can be expressed as income components: $\hat{v} * L$ describes the input in terms of value added that is necessary to produce one unit of output.

By multiplying this by the output of the country, we obtain a (N,K) column vector identifying the origin of value-added of the final demand term of sector j in country i: $\hat{v} * L * y_{i,j}$

To identify the GVC income of country i, we use a (N*K,N*K) matrix D for domestic inputs which is equal to one on its diagonal blocks of size K. Let's define as DL the element wise multiplication of matrix D and L: $DL = D \circ L$.

$$GVC\ income = \left(\sum_{n}^{K} \left(dl_{i,j,m,n} \right) \right)' * y$$

Annex B.

Empirical models and econometric analysis

To empirically test whether barriers to trade in services affect patterns of specialisation, several empirical models are used and described in this Annex. The dependent variable in all models is a bilateral flow of value-added derived from a matrix describing the origin of value-added (by country and industry) in final production. This matrix is calculated on the basis of the WIOD tables by multiplying a vector of value-added (the share of value-added in gross output for each country and industry) by the global Leontief inverse (a matrix indicating the contribution of each country and industry to 1 dollar of final production) and by a vector of final demand.[12]

From this matrix, we extract all bilateral flows corresponding to services inputs going into manufacturing or services final products. In the case of final services, the analysis is limited to what we have defined in the report as 'commercial services' (from construction -F- to professional, scientific and technical activities -M- in the ISIC 4 classification). What is excluded are the public administration, social and personal services that are by their nature less prone to the fragmentation of production in global value chains. Since the STRI does not cover either social or personal services such as health or education, the selection of sectors for services is already biased towards commercial and business services.

The variable we obtain from the calculation of value-added in final demand is VA_{ijkl}. It has four dimensions corresponding to the country of origin (*i*), country of final output (*j*), industry of origin (*k*) and industry of final output (*l*). Concretely, we measure for example the value added by R&D services from Japan in the cars produced in Germany. This value-added analysis only takes into account the country of origin (where the primary factors of production such as labour and capital were used, here Japan) and the country of final production (where the production of final goods takes place, here Germany). The R&D service from Japan can be sold to a Korean company and embedded in a US car component before going into a car assembled in Germany. Or it can simply be a R&D service used as an input by a German car manufacturer. Whether the car is sold in Germany or exported to another country does not modify the value of the variable. It includes all final output from Germany, independently of the country of consumption.

The analysis is in "value-added terms" in the sense that all the value-added embedded in final products is decomposed according to its country and industry of origin, disregarding the concrete trade flows of intermediates that took place and countries through which the value-added travelled before reaching the stage of final production. This is why we only use the STRI of the country of origin (primary production) and the STRI of the country of final production.

12. With *N* the number of countries and *K* the number of industries, we multiply the diagonal of a *N*x*K* vector of value-added shares by the *NK*x*NK* global Leontief inverse $(I - A)^{-1}$ and by the diagonal of a *N*x*K* vector of final demand. The resulting *NK*x*NK* matrix is the full decomposition of world GDP according to four dimensions: country of origin of value-added, industry of origin of value-added, country of final output and industry of final output. It is different from a matrix of value-added in final demand that would look at the country of consumption and not of production of final products.

There are only two additional variables in the main empirical model, the STRI of the country of origin in the industry producing the services input ($STRI\_origin_{ik}$) and the STRI of the country of production of final products importing the services value-added ($STRI\_destination_{jk}$). For all other variables explaining bilateral flows of value-added, we rely on fixed-effects. Since STRI variables are at the country and industry level, we use country-pair fixed effects and industry fixed effects. Since we have only a cross-section (the STRI is only available for 2014 in the period covered by the WIOD dataset), these fixed effects can account both for the economic size of each country (e.g. their GDP) and bilateral variables such as distance or the existence of trade agreements. The empirical models are therefore not too different from traditional gravity equations as the bilateral country-pair fixed effects replace distance and geographical/historical dummies, as well as GDP and other country level unobserved variables (since it is a cross-section). Industry fixed effects are included for the final producers to account for their specificity. Table B1 provides descriptive statistics for the variables.

Table B1. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
va_ijkl	885,780	1.33635	12.11367	0	2833.868
stri_ik	885,780	0.2369366	0.1044951	0.0903218	0.8767654
stri_jk	885,780	0.2467136	0.1102985	0.0903218	0.8767654
GDP_i	885,780	1615133	3206124	24776.67	1.74E+07
GDP_j	885,780	1743045	3214571	24776.67	1.74E+07
Distance	885,780	4924.932	4418.417	160.9283	17981.98
1 for contiguity	885,780	0.0730678	0.2602479	0	1
1 for common language	885,780	0.0559981	0.2299182	0	1
1 for past colonial relationship	885,780	0.0076814	0.0873062	0	1
1 for same country now or in the past	885,780	0.0223803	0.1479169	0	1
1 for common legal origin	885,780	0.2124704	0.4090561	0	1

The model estimated is:

$$VA_{ijkl} = \beta^1 STRI_{ik} + \beta^2 STRI_{jk} + \delta_l + \gamma_{ij} + \epsilon_{ijkl}$$

where VA_{ijkl} is the value-added from country *i* and services industry *k* used in the final production of manufacturing or service industry *l* in country *j*.

Results are presented with pseudo-poisson maximum likelihood (PPML) estimations since the dataset includes a non-negligible share of zeroes (11.6% of the observations). We have also run OLS regressions to check the robustness of the results. In this case, the dependent variable is logged and observations equal to zero are not included in the estimation. Results are presented in Table B2 below together with other robustness checks.

Since the model estimated is close to a gravity equation, another robustness check carried out is a full specification with the log of distance and the traditional dummy variables found in the gravity literature (coming from the CEPII database), together with GDP variables (from the WIOD dataset). This estimation can reassure about the soundness of the strategy by explicitly modelling what is absorbed in fixed effects in the preferred model. The PPML estimator is used and the model is:

$$VA_{ijkl} = \beta^1 STRI_{ik} + \beta^2 STRI_{jk} + \beta^3 GDP_i + \beta^4 GDP_j + \beta^5 Dist_{ij} + \sum_n \beta^n Dummies_{ij} + \delta_l + \epsilon_{ijkl}$$

Table B2. Robustness checks

Dependent variable: bilateral exports of services value-added	OLS regressions			Gravity-like model		
	All GVCs	**Manufacturing GVCs**	**Services GVCs**	**All GVCs**	**Manufacturing GVCs**	**Services GVCs**
STRI_origin	-0.635***	-0.743***	-0.544***	-0.577***	-0.686***	-0.480***
	(0.034)	(0.036)	(0.032)	(0.063)	(0.072)	(0.063)
STRI_destination	-0.485***	-0.588***	-0.400***	-0.288***	-0.379***	-0.205***
	(0.036)	(0.039)	(0.035)	(0.074)	(0.089)	(0.070)
GDP_i				0.816***	0.814***	0.818***
				(0.019)	(0.023)	(0.019)
GDP_j				0.810***	0.853***	0.772***
				(0.025)	(0.030)	(0.026)
Distance				-0.585***	-0.565***	-0.605***
				(0.032)	(0.044)	(0.031)
1 for contiguity				0.352***	0.549***	0.160
				(0.110)	(0.140)	(0.104)
1 for common language				0.095	-0.162	0.317***
				(0.118)	(0.143)	(0.112)
1 for past colonial relationship				-0.319	-0.180	-0.465***
				(0.210)	(0.312)	(0.127)
1 for same country now or in the past				0.225**	0.300**	0.164
				(0.103)	(0.135)	(0.129)
1 for common legal origin				0.137*	0.122	0.154**
				(0.080)	(0.095)	(0.078)
Fixed effects	Pair and industry fixed effects			Industry fixed effects		
Number of observations	829,270	377,735	451,535	885,780	400,710	485,070
R-squared	0.671	0.680	0.700	0.217	0.193	0.241
Adjusted R-squared	0.671	0.679	0.699	-	-	-

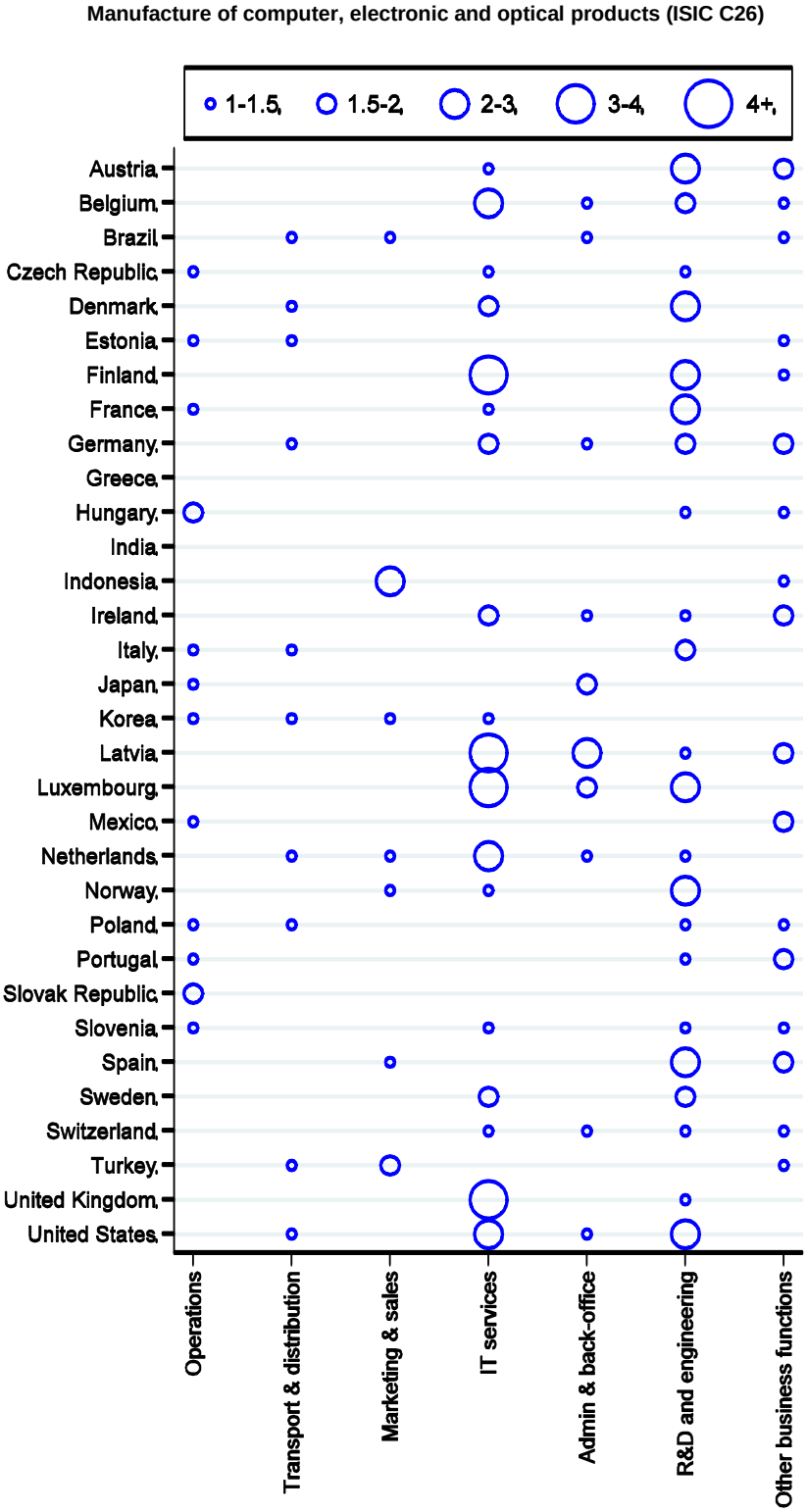
Note: Clustered standard errors are in parenthesis. Coefficients for the constant and fixed effects not reported. The stars denote the statistical significance percentage level: .01 - ***; .05 - **; .1 - *.

Annex C.

RCA by business function: Additional results

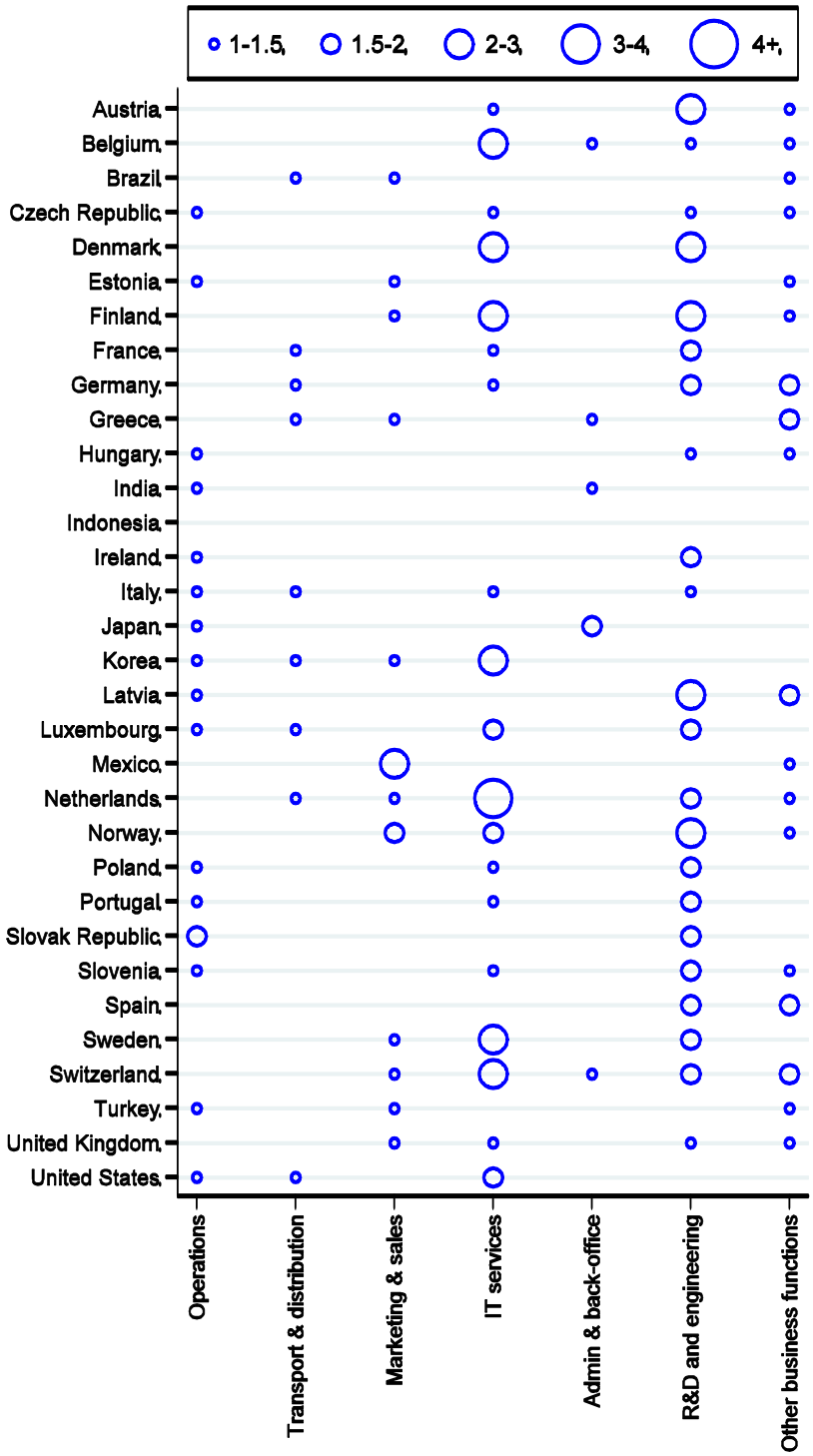
This annex includes additional figures for the GVC income RCA by business function, similar to Figure 8 in Section 2. The additional sectors are 'Manufacture of textiles, wearing apparel and leather products' (ISIC C13T15), 'Manufacture of computer, electronic and optical products' (ISIC C26) and 'Manufacture of machinery and equipment n.e.c." (ISIC C28).

Source: Authors' calculations based on WIOD 2016 and OECD business functions dataset.



Source: Authors' calculations based on WIOD 2016 and OECD business functions dataset.

Manufacture of machinery and equipment n.e.c. (ISIC C28)



Source: Authors' calculations based on WIOD 2016 and OECD business functions dataset.