Global trade in services, jobs, and incomes

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by

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Timon

Groningen, November 2019

Contents

Chapter 1

Introduction

1.1 Background and objective

The globalization of the world economy has accelerated cross-border movements of goods, services, labor, and capital. This has profound implications for the analysis of international trade and in determining the importance of trade for an economy's well-being.

The most significant development over the past 25 years has been the emergence of international production networks, also known as global value chains (GVCs), which increasingly dominate world trade (Baldwin, 2016; Gereffi and Fernandez-Stark, 2016). Although globalization has been with us for hundreds of years, Baldwin argues that GVCs represent a recent structural change in the type of trade flows. Trade used to involve the exchange of goods and services between countries that were mostly, if not entirely, produced by the domestic factors of production of the exporting economy and consumed by final users of the importing economy. Nowadays, international production networks have sliced up the production of goods and services into tasks that are dispersed across different countries. Design, assembly, marketing, distribution, and support activities are typically performed in a country that has a comparative advantage for one or more of these tasks. These export-oriented and specialized activities may themselves involve foreign-owned capital or cross-border workers. They are also often coordinated by multinational enterprises (MNEs).

The global fragmentation of production was made possible with rapidly decreasing transportation and communication costs and has led to a rapid rise in intermediate products (i.e., parts and components) crossing international borders (Baldwin 2006, 2016). Importantly, fragmentation has implications for what trade implies for an economy. This thesis contributes to the literature on GVCs by investigating the characteristics and potential benefits of trade in the context of global production fragmentation. There is also a large literature on the industry- and firm-level perspective of GVCs, for example of industry case-studies and 'upgrading' strategies (Gereffi, 1999; Gereffi and Fernandez-Stark, 2016). I restrict myself in this thesis to macro, country-level aspects.

Trade is traditionally measured in terms of gross exports. Bilateral gross export figures depict the gross flows of goods and services between countries and will continue to be the most important statistic for a country's customs officials. Nonetheless, these statistics have significant analytical limitations that are magnified by the restructuring of the world economy. First, gross exports reflect the industry of the exported product, which may differ from the upstream industries involved in its production. Services account for only a small share of countries' gross exports despite their critical importance as inputs and enablers of international production networks and the 'servicification' trend of manufacturing (Low, 2013). Second, gross export statistics do not differentiate between value added that was created domestically by the exporting country and value added that was created by other countries (i.e., foreign value-added). Hence, the domestic value-added embodied in a traded product, which contributes to a country's gross domestic product (GDP), may be less than the full export value. Third, gross exports are generally insufficient to identify a country's position in international production networks, i.e., in terms of differentiating between upstream vs. downstream activities and determining where a country is creating value. This makes it more challenging to evaluate the true economic benefits of a country's participation in GVCs and international trade.

These developments raise important questions. First, to what extent can conventional trade data still be used in the context of international production networks? What are alternative measures? Second, given the growing interconnectedness of the world economy through GVCs and multinational firms, what are the implications of trade nowadays for a country in terms of generating domestic value-added, contributing to national income, and enabling higher consumption possibilities? Taking into consideration the analytical limitations of gross export statistics, I apply existing and newly developed approaches to assess the importance and benefits of trade from different perspectives. I juxtapose three types of trade in particular: trade in gross exports, trade in value added (or the jobs embodied therein), and lastly, trade in income, to address the topics and questions that are introduced in this chapter. A point of focus is also to account for the role of foreign production factors in a country's domestic value-added production and their contributions to sustaining a country's overall consumption bundle.

It should be noted that these different perspectives are complementary. All my calculations use gross exports data to start with, so high-quality data on gross exports remain important. The noted limitations of gross exports are not an appeal to abolish gross trade statistics. Instead, the interpretation of pure gross exports differs. This means that policymakers and the media are susceptible to misinterpreting them. For example, gross exports are popularly applied to trade balances. The nature of the bilateral US trade deficit with China still receives much international attention. However, bilateral trade balances are overstated given that the contributions of foreign/intermediate suppliers to the traded products captured in these statistics do not come to light. Trade balances can also be analyzed in the context of value added or, in the more novel approach I employ in Chapter 5, in terms of the gross national income (GNI) induced in each country by foreign consumption of final products (i.e., final demands) in counterpart countries. A comparison of conventional trade balances with value-added and income perspectives would more completely and adequately depict the true nature of interdependencies between countries.

1.2 Indicators on global value chains

In Chapter 2, I review the main approaches and techniques used in the GVC literature. I critically evaluate and discuss an array of indicators for gross measures of trade and indicators derived from input-output frameworks. In my view, the existing literature has lacked a user-friendly guide on the different approaches that are available to measure trade and to characterize a country's position in international production networks. This is an indication that the field is 'young', and no convergence has been reached yet. In addition, as the field is still relatively new, many users struggle to fully understand what indicators are available, how they have been constructed, and how they should be used. The analytical potential of indicators relevant to GVCs is enticing not just to researchers, but also to policymakers and international organizations. Thus, it is essential to make them accessible also to non-specialists and to provide guidance to users on which indicators can be useful in empirical work. There is a need for a more comprehensive overview of the tools available, including the trade in value added approach, along the lines of recent surveys of the field by Los (2017) and Johnson (2018).

Chapter 2 has two main objectives. First, I introduce the current challenges of assessing countries' participation in international trade and production networks. I highlight the key issues that are involved, explain why GVC-based indicators are necessary, and lay the groundwork for my own empirical work in subsequent chapters of this thesis. The widespread use of relatively new databases, notably the World Input-Output Database (WIOD) and the OECD Trade in Value Added (TiVA) database, have given rise to a growing and active research field related to topics involving GVCs. This thesis contributes to this literature by developing new applications using the WIOD based on existing and newly developed GVC-based indicators. Second, the chapter is designed to be a guide for new users to the methodological approaches in the field. I summarize the current state of knowledge on measuring trade in international production networks by reviewing in a systematic and comparative manner many different indicators. I describe what these various measures indicate. This discussion goes beyond just the indicators that are employed later in the thesis.

The more popular GVC indicators use input-output frameworks and international input-output tables to measure the foreign value-added contained in a country's gross exports (= the degree of 'vertical-specialization') and/or the domestic value-added contributing to the consumption bundle of foreign countries (= 'value-added exports'). The indicators capture, among other aspects, the import content of exports and identify the industries that generate value added in trade. These indicators show that the ratio of domestic value-added to gross exports varies widely across countries, but is generally declining after 1990 (i.e., the foreign value-added content of a country's gross exports is rising) (Johnson, 2014). Also, it is revealed that manufacturing exports have a higher degree of vertical specialization than services exports.

1.3 Global trade in services

The first application of the GVC indicators focusses on the characteristics of trade in services. It is well-established in the GVC literature that services make up a larger share of value-added exports than gross exports. Services thus feature more prominently in international trade than would be perceived based on gross trade statistics (Johnson and Noguera, 2012; Heuser and Mattoo, 2017; Miroudot and Cadestin, 2017). This is because gross exports do not indicate the extent that services inputs are embodied in manufacturing exports or in the exports of other sectors. Services are critically important as value creators and enablers of international production networks (Low, 2013). Manufacturing firms increasingly look to services to add value to their products and to raise their productivity (leading to a bundling of services with goods).

However, services have remained an understudied aspect of international trade. Visibility of the importance of services is not sufficiently transmitted to the general public. This lack of awareness of the role of services is partly due to the focus on gross exports and a lack of suitable data until now. The indicators introduced in Chapter 2 and based on world input-output tables are well-suited to investigate the role of services. Indicators of value-added induced by foreign final demand measure the contributions of all trade-related activities to a country's GDP. The indicators not only capture direct services exports, but also indirect services, i.e., domestic services inputs such as energy, transport, software, and financing that are embodied in other traded products. Industry-level decompositions of these indicators separate out the trade-related value-added contributions of services (or of specific services industries) from the respective contributions of other sectors and industries.

In Chapter 3, I employ value-added export indicators and (for purposes of comparison) gross export-based indicators to investigate the role of services in globalization for the period 2000-2014. First, from an empirical perspective, it has not been studied to what extent services activities are becoming more important for trade relative to manufacturing activities in the European Union (EU-15 member states), North America, and East Asia. Hence, I ask: has trade of value-added in services (i.e., the value added created by domestic service industries and embodied in foreign consumption of final products) grown more than trade of value-added in manufacturing in these three regions? A confirmation of a growing role for services would emphasize the importance of the liberalization of services trade (efforts which may be boosted by a better availability of statistics). This could involve looking at policies to reduce the regulatory burdens of trade in services and strengthening regulatory cooperation between countries. Services face higher and more complex types of trade barriers relative to goods (Miroudot et al., 2013). Thus, beyond autonomous trade measures, new policy and (multilateral) trade negotiation methods may be necessary to unlock the full potential of services, e.g., in terms of increasing manufacturing competitiveness. This requires having the correct facts first about services.

Second, to my knowledge no previous work has analyzed whether trade in services is more likely to be intraregional (i.e., traded between countries in the same region) or interregional (i.e., traded between countries in different regions) when measured from the standpoint of the distance between the country of value creation and country of final consumption. It is a stylized fact that it is often concluded that trade in goods is still intraregional (Baldwin and Lopez-Gonzalez, 2015). But this may not necessarily also be the case for services. Hence, I ask: does trade of value-added in services travel further than trade of value-added in manufacturing?

1.4 Global trade in jobs

Chapter 4 applies a GVC framework by considering the jobs – both foreign and domestic – that are embodied in a country's consumption of final goods and services.

In the US, import competition from China and the election of President Trump drew much attention to the potential adverse impacts of trade. The current political climate reflects concerns about the ballooning US trade deficit, the growing influence of China, particularly since China's accession to the WTO in 2001, and the belief that trade is driving certain workers out of employment. These developments are closely related to the international fragmentation of production, which has increased outsourcing and offshoring opportunities. This has probably propelled a reallocation of jobs across countries, e.g., manufacturing jobs going from the US to China. In consequence, the US has been renegotiating major trade agreements, such as the Transatlantic Trade and Investment Partnership (TTIP), the North American Free Trade Agreement (NAFTA), and the free trade pact with South Korea.

Recent research tends to emphasize the ‘lost’ manufacturing jobs due to import competition – especially jobs going from the US to China (Acemoglu et al., 2016; Autor et al., 2013; Pierce and Schott, 2016). The possible benefits of trade with China, including access to lower-priced or more efficient foreign workers and suppliers, are also well-documented. Increased international specialization is commonly viewed as leading to overall welfare gains. However, what has not been studied intensely is the ‘labor footprint’ along supply chains.

In Chapter 4, I use the labor footprint to gain new insights into the implications of trade for employment and for a country’s consumption bundle. The labor footprint relates to the broader footprint concept popular in the analysis of other issues, including carbon emissions, water use, biodiversity, and inequality. Although the idea of using the labor footprint has recently started appearing in the literature to address social inequality issues (Gomez-Paredes et al., 2015), to my knowledge it has yet to be used for the analysis of jobs at the country-level. I define a country’s global labor footprint as the global amount of labor that is embodied in the final products that this country consumes. I ask: how much does the US rely on ‘imported’ foreign labor (of different skill-types and sectors) relative to its own domestic workers to sustain its consumption patterns and standards? Then I employ the labor footprint concept to assess the ability of a country to be self-sufficient in a counterfactual autarky situation (given certain assumptions). Would the US need to sacrifice some of its consumption of final goods and services if there were no involvement of foreign workers, i.e., in a situation of autarky? I focus on the US and the period 1995-2008, but the counterfactual exercises provide results for 39 other, mostly developed, countries. I also determine a country’s so-called labor gains of trade. Labor gains of trade are identified as a situation where the labor footprint in autarky exceeds the number of employed workers of this country. This would then imply a reduced consumption under autarky.

1.5 Global trade in incomes

While developed countries are concerned about losing manufacturing jobs, emerging and developing countries also have reasons to question the true benefits of certain outsourcing and investment arrangements. GVCs have helped many countries to integrate into the world economy and increase the amount of goods and services they trade. At the same time, MNEs and their foreign affiliates play a leading role in GVCs. They account for more than half of all international trade (Cadestin et al., 2019). This suggests that countries may not be able to translate all their domestic value-added from trade-related activities into national income. For example, MNE affiliates may send (i.e., repatriate) their capital profits to the country where the firm's headquarters or investors are located. Emerging and developing countries receiving much foreign investment may be most susceptible to repatriation.

The role of foreign suppliers of capital and labor could have the opposite implication for developed countries. Many of the largest MNEs are headquartered in developed economies and make large direct investments abroad. This may enable their home countries to capture more of the economic benefits linked to final demand abroad (including but not limited to income related to trade) than what is suggested by value-added exports. Suppose a US MNE operating in Mexico earns a profit on the goods and services it exports to Germany. Then value added is generated in Mexico and, quite possibly, some of the value added turns into income for US owners of capital. These income linkages could mitigate some concerns about the drawbacks of international integration in countries like the US, and impact trade and investment policies. The distinction between domestic value-added (GDP) and gross national income (GNI) is consequential in the context of the value-added indicators discussed and employed in earlier chapters. That is, the degrees to which a country's domestic value-added (GDP) and national income (GNI) depend on foreign final demand (also bilaterally) are likely to differ.

In Chapter 5, I propose a way of estimating the national income implications of foreign consumption by exploring cross-border income flows and the investment nexus. This income channel has already been identified in the GVC literature as a relevant issue (Ahmad and Ribarsky, 2014), but to my knowledge its importance has not yet been investigated empirically in a global analysis. This aspect has been neglected in the GVC literature due to data limitations. Another motivation for the analysis involves the depiction of bilateral dependencies between countries. This from-whom-to-whom perspective is relevant because it can help policymakers identify investment linkages and to forecast possible repercussions of economic shocks abroad. It should be noted that my analysis is broad and considers where all value added in a country, not only value added related to trade or MNE activities, ends up. Hence, I also account for the German cross-border worker employed in Luxembourg who is engaged in a non-tradable sector and generates value added in Luxembourg but income (via her/his wage) in Germany.

I begin by developing a general framework to show how much value added created in a country translates into income gains for this country's residents as opposed to income gains for foreign suppliers of capital and labor. Data on these bilateral relationships do not currently exist. My contribution is to deconstruct the GDP of 42 countries plus 'the rest of the world' into bilateral transfers of primary incomes by making novel use of the Balance of Payments, national accounts, and data on cross-border investment positions. The resulting GDP-GNI matrix indicates what share of GDP is part of the same country's national income and what shares end up as part of the national income of counterpart countries. The GDP-GNI matrix is used in conjunction with trade in value added data derived from world input-output tables to produce a new matrix of trade in income. This new matrix shows the exports of income for each country.

I use the new data to investigate who gains income from foreign consumption of final products. I compare the results to trade in value added measures. I then do similar comparisons for trade balances. Where do transfers of income (according to the GDP-GNI matrix) end up? And what shares of GNI do different countries export (according to the matrix of trade in income)? To what extent does the large US trade deficit - both overall and its bilateral deficits with countries like China and Mexico - differ in terms of value-added and income?

In Chapter 6, I summarize the main findings (and caveats) of my research, discuss policy implications and links between the chapters, and suggest future research directions.

Chapter 2

Indicators on global value chains: A guide for empirical work

ABSTRACT

Traditionally, the main source of data used to measure countries' participation in international production networks or global value chains (GVCs) has been conventional international trade statistics. However, international fragmentation of production has weakened the analytic interpretability of these data as intermediate goods but also services cross borders many times on the way to their final destination. This is often referred to as the double (or multiple)-counting problem of international trade statistics.

This, in turn, has led to the development of a new branch of trade statistics, referred to as Trade in Value-Added (TiVA) providing new insights on GVCs, and corresponding databases, notably the OECD-WTO TiVA database, which provide a measure of international interdependencies through the construction of global input-output tables that show how producers in one country provide goods and/or services to producers and consumers in others. But with the field still relatively new, many users are struggling to fully understand how these new indicators should be used and indeed how they have been constructed.

This document is designed to address those difficulties, providing, where appropriate guidance on "dos" and "don'ts". It also reviews many other typical GVC indicators derived outside of input-output frameworks; recognising that gross measures of trade, and indicators derived from them, remain important and relevant for policy making.

This chapter is based on Ahmad et al. (2017). I added endnotes at the end of this chapter to correct typos in the OECD Working Paper version (reproduced here) and to provide additional clarification or context.

2.1 Introduction

The increasing fragmentation of production processes into activities scattered across different countries has challenged economists and statisticians to find ways to measure the extent of these developments and their potential implications. This phenomenon is intrinsically related to a surge in international trade in intermediate products, which dominate world trade flows, characterised in large part, and indeed further complicated, by the increasing role played by multinational enterprises (MNEs) (whether through intra-affiliate transactions or indeed through the control of supply chains). Increasingly, countries and firms specialise in particular stages of production according to their comparative and competitive advantages, and are linked in vertical supply chains through trade in intermediate products. This trend has been facilitated by technological progress, which has reduced transportation and communication costs, together with significant declines in trade barriers.

Traditionally, the main source of data used to measure countries' participation in international production networks or global value chains (GVCs) has been conventional international trade statistics, which, in the case of goods, offer the advantage of timely availability for a large number of countries, with a high level of disaggregation (in terms of products and trading partners), and with a high degree of international comparability.

As shown below, these data can be used to generate a suite of indicators that reveal the diversity of a country's direct export and import partners, as well as the products in which it trades. However, international fragmentation of production has weakened the analytic interpretability of these data and, in particular, analyses that attempt to show the benefits of trade to an economy (be that in terms of value added or jobs), as well as the true nature of interconnectedness across economies. This is often referred to as the double (or multiple)-counting problem of international trade statistics.

Perhaps the classic example of the impact of the phenomenon concerns processing trade, where firms, typically at the end of value chains, import parts for final assembly. Conventional gross trade data would indicate that the country has a comparative advantage in the production of the final good, despite the fact that it may have added relatively little value to the actual good through low-skilled part tasks. Thus, the comparative advantage should more accurately be described in this case as low-skilled assembly labour, rather than high-tech goods production.

Some countries maintain a special set of customs statistics related to processing trade[1] that can provide insights (and account for) any related 'double-counting'. However, for most countries these data are not available. Moreover, often processing trade statistics only reflect the tip of the iceberg, as they only consider trade associated with a special type of sub-contracting or outsourcing arrangement, and do not cover all other activities (the majority) related to the geographic fragmentation of production.[2] Indeed very little of the goods exported today, with the possible exception of mineral and agricultural products (and even here imported know-how services play a role), are produced exclusively within any one country.

To tackle head-on the double-counting problem that affects conventional trade data, whilst also better revealing the true nature of international and interindustry interdependencies, statisticians have recently begun to develop indicators using global supply and use tables (SUTs) and input-output tables (IOTs), which link national SUTs or IOTs and bilateral trade data (e.g., OECD-WTO, 2013[3]). Perhaps the best known initiative in this area is the Trade in Value Added (TiVA) database, which reflects a concerted effort by the Organisation for Economic Co-operation and Development (OECD) and the World Trade Organisation (WTO) to mainstream the development of (and improvements to) the necessary data within official national statistical information systems.[4] Indeed, at the 2015 United Nations Statistics Commission meeting the official statistics community endorsed the recommendations of the Friends of the Chair Group on International Trade and Economic Globalisation, including, in particular, the following:

> *Mainstreaming the development of recurrent global supply and use tables and input-output tables and building on work undertaken by OECD, in order to expand the coverage of the OECD-WTO database on trade in value added.*

Rising to this challenge the international statistics community has stepped-up co-operation, with the OECD in particular coordinating the development of a network of international agencies (and countries), each playing their role as developers of regional IOTs (for the regions where they have expertise and formal networks of national statisticians) that can be brought

[1] This refers to the trade of export processing zones (EPZs), which offer firms special customs arrangements (like tariff exemptions or reductions) on condition that imported intermediates are re-exported after assembly activities are completed. Examples of these data sets are the US Offshore Assembly Programme (OAP) and the European Union Processing Trade statistics, used in several empirical studies on international fragmentation of production (e.g., Feenstra et al., 2000; Swenson, 2005; Egger and Egger, 2005; Baldone et al., 2007).

[2] Processing trade statistics capture the cases where intermediate products are imported to be processed internally and then re-exported, as well as those where intermediates are exported to be processed abroad and then re-imported.

[3] www.oecd.org/sti/ind/49894138.pdf.

[4] Annex A provides an overview of other initiatives in this area.

together and integrated within a global IOT. The United Nations' Economic Commission for Latin America and the Caribbean (UN-ECLAC) is actively working with the OECD to explore the feasibility of mainstreaming the activity within the Latin American region, which partly reflects the catalyst for this paper.

In that sense, this document is designed to accelerate that process and maximise its feasibility by describing, in a comprehensive and integrated manner, a set of core indicators that are typically used to trace and analyse production fragmentation across countries; highlighting in addition their limitations (in particular, with regards to the changes introduced in the latest version of international accounting standards, the 2008 System of National Accounts). In this sense it is important to note that the document does not set out to be exhaustive in its coverage. Many other indicators exist, including many that have recently been developed as a result of new innovations in TiVA type analysis. But these are not typically in widespread use and, with respect to the newer indicators, they remain, to some extent, works-in-progress.

The note is also motivated by growing calls from users for a better understanding of the 'dos and don'ts' of the suite of indicators generated by these new statistical tools, which can be fostered by describing their structure, applications and limitations.

The following section sets the scene by describing indicators based on traditional international trade data. Section 2.3 introduces the input-output framework, used to create trade in value added estimates. Finally, Section 2.4 concludes.

2.2 Indicators based on international trade statistics

2.2.1 Trade data

Merchandise trade data are arguably one of the richest sources of data available in the economic statistics information system. They provide product-level information (with the Harmonised System (HS) coding covering around 5 000 goods), with almost complete country coverage and the identification of partner relationships. As such, despite some comparability issues relating to the trade regime used in the country (special versus general trade), recorded country of import and recorded country of export, asymmetries,[5] and treatment of confidential data, merchandise trade data provide one of the most important sources of information to derive GVC indictors.

[5] Although the OECD has developed a balanced merchandise trade dataset, see www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=STD/CSSP/WPTGS%282016)18&docLanguage=En.

Trade in services data, collected according to the Extended Balance of Payments System (EBOPS), are also an important source of information. However, the quality of these data is significantly inferior to that on merchandise trade. For example, the level of product detail available rarely extends beyond dozens for most countries, and very few countries provide bilateral data.[6]

In addition, many countries have recently begun to develop new datasets that link the firms identified in customs records with the same firm recorded in statistical business registers (Trade by Enterprise Characteristics (TEC) database), to develop new insights on firms engaged in international trade.[7]

Because of the comparability issues regarding trade in services and the relative novelty and limited country coverage of TEC data, the more abundant and detailed merchandise trade data have typically formed the key focus of most traditional and conventional indicators on GVCs. In large part, this reflects the ability of merchandise trade data to differentiate between products on the basis of their likely end-use (for example, whether the goods are intermediate, consumption or capital in nature).

GVCs are seen as synonymous with international fragmentation of production. The ability to identify trade in intermediate products, as distinct from trade in final goods, can provide important insights into how countries integrate into GVCs, and indeed where they position themselves in those chains.

Notwithstanding the data on intermediate goods available in national SUTs and IOTs[8] (described in more detail below), the most commonly used definition of intermediate goods in merchandise trade is based on the United Nations' Broad Economic Categories (BEC) classification,[9] which provides a simple tool to link trade data to the three basic System of National Accounts' (SNA) classes: intermediate goods, capital goods and consumption goods.[10]

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[6] The OECD and WTO have developed a balanced view of trade in services with missing estimates generated using a gravity model, https://one.oecd.org/document/STD/CSSP/WPTGS%282017)4/en/pdf.

[7] https://one.oecd.org/document/STD/CSSP/WPTGS%282017)5/en/.

[8] For example, Hummels et al. (2001) use national IOTs to show that vertical specialisation (i.e., the use of imported inputs in producing goods that are exported) has increased over time, and explained 30% of the growth in exports of 14 OECD and emerging market countries between 1970 and 1990.

[9] The original BEC classification, issued in 1971, was defined in terms of the Standard International Trade Classification (SITC) revision 1. Since then, it has been updated three times: 1) in 1976 in terms of the SITC revision 2; 2) in 1986 in terms of the SITC revision 3; and 3) in 2002, based on the more detailed goods description provided by the 2002 edition of the Harmonized Commodity Description and Coding System (United Nations, 2003). This fourth version, set up with reference to the third revision of the SITC, can be found at http://unstats.un.org/unsd/cr/registry/regdnld.asp?Lg=1. The fifth revision was endorsed by the UN Statistical Commission at its 47th session in 2016.

[10] The SNA intermediate goods class corresponds to the BEC code numbers 111 (food and beverages mainly for industry, primary), 121 (food and beverages mainly for industry, processed), 21 (industrial supplies not elsewhere specified, primary), 22 (industrial supplies not elsewhere specified, processed), 31 (primary fuels and

Several studies investigate international production fragmentation using the BEC classification as a starting point (for references see Sturgeon and Memedovic, 2010). However, the BEC classification is far from perfect and has been criticised for its subjective allocation of products, which is based on expert judgment concerning descriptive characteristics, particularly with regards to the fact that some goods may be used both as intermediates and final products (for example flour, which is classified as intermediate but can also be a consumption good if bought by households), and which may not align with the equivalent allocations used in national SUTs. In addition, up until the 4th Revision, the BEC classification was not available for trade in services. This has been addressed in the latest (5th) revision but the high level of aggregation in services trade data (as well as its novelty and limited availability in many countries) has restricted its application.

This has led many to refine the BEC classification in their own analyses. Sturgeon and Memedovic (2010), for example, use industry-specific manufactured intermediate goods (MIG) classifications in order to isolate 'true' (differentiated, customised, product-specific) intermediates from generic intermediates. The OECD, as part of its work in producing TiVA, has also developed a refinement to the BEC system that introduces categories of mixed use (Bilateral Trade Database by Industry and End-Use Category, BTDIxE).[11]

2.2.2 Trade data-based GVC indicators

The most commonly used GVC indicators based on international trade statistics are presented below. They are shown in a way that is not contingent on any actual definition used to define intermediate trade (i.e., BEC or alternatives).

Share of intermediate goods in exports and imports

The most basic version of this indicator measures the share of a country's exports of intermediate goods in its total goods' exports, which provides broad insights into the relative position of a country within GVCs (i.e., more or less upstream in the production of intermediate goods compared to final demand goods):

$$\mathrm{XISH_c} = \frac{\mathrm{EXGRI_c}}{\mathrm{EXGR_c}} \tag{2.1}$$

lubricants), 322 (processed fuels and lubricants), 42 (parts and accessories of capital goods, excluding transport equipment), and 53 (parts and accessories of transport equipment).

[11] www.oecd.org/trade/bilateraltradeingoodsbyindustryandend-usecategory.htm.

where $\mathrm{EXGRI_c} = \sum_{q \in int} \mathrm{EXGR_c(q)}$ are country *c*'s exports of intermediate goods; $\mathrm{EXGR_c} = \sum_q \mathrm{EXGR_c(q)}$ are country *c*'s total goods exports; *q*=1, 2,…, Q is the product index; and $q \in$ int is the subset of products corresponding to intermediate goods.

A variation of this indicator quantifies the share of imports of intermediate goods in total goods imports, which is particularly useful for countries participating in the downstream stages of supply chains (i.e., the assembly of finished goods from imported components):

$$\mathrm{MISH_c} = \frac{\mathrm{IMGRI_c}}{\mathrm{IMGR_c}} \tag{2.2}$$

where $\mathrm{IMGRI_c} = \sum_{q \in int} \mathrm{IMGR_c(q)}$ country *c*'s imports of intermediate goods; and $\mathrm{IMGR_c} = \sum_q \mathrm{IMGR_c(q)}$ are country *c*'s total goods imports.

This indicator can also be used to provide insights into the integration of countries in bilateral and regional production networks, by calculating equivalent shares on a bilateral or regional basis.

Share of intermediate goods in total trade

This indicator shows the share of intermediates in total goods trade, including both exports and imports:

$$\mathrm{TISH_c} = \frac{\mathrm{EXGRI_c} + \mathrm{IMGRI_c}}{\mathrm{EXGR_c} + \mathrm{IMGR_c}} \tag{2.3}$$

It can also be computed considering bilateral or regional trade flows.

Although TISH provides a complementary view of a country's participation in GVCs to the two separate indicators described above, this is not a comprehensive view. For example, a country with high levels of imports and exports relative to its gross domestic product (GDP) may have a similar TISH ratio to a country with a low ratio of trade to GDP.

Relative importance of trade in intermediates

Dullien (2010) proposes a variant of the previous indicator, which attempts to address some of the inadequacies mentioned above. The indicator, referred to here as the "relative importance of trade in intermediates" (RITI), is defined as the ratio of intermediate goods trade to a country's GDP:

$$\mathrm{RITI_c} = \frac{\mathrm{EXGRI_c} + \mathrm{IMGRI_c}}{\mathrm{GDP_c}} \tag{2.4}$$

By relating intermediates trade to GDP, instead of to total trade, this indicator provides insights into the relative importance of a country's participation in international production networks to the economy. However, both the share of intermediates in total trade (TISH) and the RITI index have the shortcoming that a country that imports a large volume of intermediate goods and re-exports those goods as intermediates without adding much domestic value could exhibit high values of both indicators. Additionally, like TISH, the RITI index cannot provide information on a country's position in value chains. Finally, although the indicator provides a better measure of the relative importance of trade to the economy, comparisons across countries should be conducted with care as larger economies will typically have lower ratios, in part reflecting the larger relative importance of domestic consumption, but also the relative potential of internal domestic supply chains to provide intermediates.

Ratio of intermediate imports to exports

This indicator, also called coverage ratio, relates a country's imports of intermediates to its intermediate exports, and can be used as a broad measure of a country's position in GVCs:

$$\mathrm{CRI_c} = \frac{\mathrm{IMGRI_c}}{\mathrm{EXGRI_c}} \tag{2.5}$$

Countries located at the beginning of the production chain (upstream) tend to import fewer intermediates and export more, resulting in a relatively low value of CRI. In contrast, countries that specialise in assembly and are located at the other end of the supply chain (downstream) tend to import more intermediate goods and export relatively less, resulting in a comparatively high value of CRI. However, some care is needed in interpretation as the indicator is not able to address scale (i.e., differences in economic size), nor is it necessarily able to provide for robust and meaningful international comparisons. For example, a country that imports most intermediates for producing final goods destined for domestic markets, and that has relatively limited intermediate exports will have a significantly higher ratio than an equivalent country with higher intermediate imports and exports.

Grubel-Lloyd index

Intra-industry trade indices in intermediates serve as a proxy of a country's insertion in GVCs, as well as to identify bilateral production linkages between countries and regions. A high level of intra-industry trade in intermediates (i.e., two-way exchange of intermediate goods within the same industry) is interpreted as indicating greater production links between participating countries, which would reflect international fragmentation.[12]

The most widely used intra-industry trade measure is the Grubel-Lloyd (GL) index. This index relates the net exports of a group of products *q* (usually defined within a standard industrial classification) with total trade (i.e., the sum of exports and imports) of the same products. At the bilateral level, the GL index in intermediates can be computed as:

$$GL_{c,p} = 1 - \frac{\sum_{q \in int} \left| EXGR_{c,p}(q) - IMGR_{c,p}(q) \right|}{\sum_{q \in int} \left(EXGR_{c,p}(q) + IMGR_{c,p}(q) \right)} \tag{2.6}$$

where $EXGR_{c,p}(q)$ are country *c*'s exports of intermediate products *q* to country *p*; and $IMGR_{c,p}(q)$ are country *c*'s imports of intermediate products *q* from country *p*.

GL can be calculated for a country's world-wide trade as:

$$GL_{c} = \sum_{p} \left[\left(\frac{\sum_{q \in int} \left(EXGR_{c,p}(q) + IMGR_{c,p}(q) \right)}{\sum_{q \in int} \left(EXGR_{c}(q) + IMGR_{c}(q) \right)} \right) \left(1 - \frac{\sum_{q \in int} \left| EXGR_{c,p}(q) - IMGR_{c,p}(q) \right|}{\sum_{q \in int} \left(EXGR_{c,p}(q) + IMGR_{c,p}(q) \right)} \right) \right] \tag{2.7}$$

[13]

where $EXGR_{c}(q) = \sum_{p} EXGR_{c,p}(q)$ are country *c*'s total exports of intermediate products *q*; and $IMGR_{c}(q) = \sum_{p} IMGR_{c,p}(q)$ are country *c*'s total imports of intermediate products *q*.

The index takes values between zero and one: values close to zero indicate a low level of intra-industry trade, whereas values approaching one indicate a high level of intra-industry trade.[14]

One shortcoming of the GL index is that it is highly sensitive to the level of aggregation of the trade data used (De Backer and Yamano, 2012). Another drawback of this indicator is its static nature, in the sense that it refers to the pattern of trade in one year. When the structure of

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[12] It should be noted that, when intra-industry trade indices are computed including both intermediate and final goods, a high index value could not only indicate international fragmentation of production but also horizontal and vertical product differentiation for final goods (De Backer and Yamano, 2012).

[13] The index can also be calculated for a selected group of trade partners, as the weighted average of bilateral indexes.

[14] In the absence of intra-industry trade the index would be equal to zero (indicating pure inter-industry trade), while in the absence of inter-industry trade it would be equal to one (indicating pure intra-industry trade).

changes in trade patterns is important, marginal or "quasi-dynamic" intra-industry trade measures should be used (Brülhart, 2002).[15]

Revealed comparative advantages and product sophistication

The Revealed Comparative Advantage (RCA) index measures the intensity with which a country exports a product (or group of products). When applied to trade in intermediates, it can be computed as:

$$\mathrm{RCA_c(q)} = \frac{\mathrm{EXGR_c(q)}/\sum_{\mathrm{q\in int}}\mathrm{EXGR_c(q)}}{\sum_{\mathrm{c}}\mathrm{EXGR_c(q)}/\sum_{\mathrm{c}}\sum_{\mathrm{q\in int}}\mathrm{EXGR_c(q)}} = \frac{\mathrm{EXGR_c(q)}/\sum_{\mathrm{c}}\mathrm{EXGR_c(q)}}{\sum_{\mathrm{q\in int}}\mathrm{EXGR_c(q)}/\sum_{\mathrm{c}}\sum_{\mathrm{q\in int}}\mathrm{EXGR_c(q)}} \quad (2.8)$$

where $\mathrm{EXGR_c(q)}$ are country *c*'s exports of intermediate product(s) *q*.

First proposed by Balassa (1965), this index measures whether a product's share in a country's export basket is larger or smaller than the product's share in world trade (or, alternatively, whether a country's share in a product's world market is larger or smaller than the country's share in total world trade). Thus, a value larger (smaller) than one indicates that the country has a revealed comparative advantage (disadvantage) in the product(s).

Based on the RCA index, Hausmann et al. (2007) define a measure of product sophistication:

$$\mathrm{PRODY(q)} = \frac{1}{\sum_{\mathrm{c}}\mathrm{RCA_c(q)}}\sum_{\mathrm{c}}\mathrm{RCA_c(q)\ GDPPC_c} \quad (2.9)$$

where $\mathrm{GDPPC_c}$ is the GDP per capita of country *c*.

PRODY can be used to rank traded goods in terms of their implied productivity. Thus, the sophistication of a country's productive structure can be estimated as the weighted average PRODY of the products the country exports (where the weights are the shares of the products in the country's export basket).

The use of PRODY has been criticised due to the endogeneity of its definition (i.e., "rich countries export rich country products"). Hidalgo (2009) addresses this issue by proposing an alternative measure (referred to as $\widetilde{\mathrm{PRODY}}$), based on network analysis concepts:

[15] "Quasi-dynamic" measures of intra-industry trade consider trade flows in two different time periods, for example, by comparing two GL indices. This approach would be appropriate for a comparative static analysis, but it does not allow conclusions on the structure of the change in trade flows. See Brülhart (2002) for alternative "quasi-dynamic" and marginal intra-industry trade measures.

$$\widetilde{\mathrm{PRODY}}(\mathrm{q}) \approx \frac{1}{\mathrm{k_q}} \sum_{\mathrm{c}} \widetilde{\mathrm{RCA}}_{\mathrm{c}}(\mathrm{q})\, \mathrm{k_c} \tag{2.10}$$

where $\widetilde{\mathrm{RCA}}_{\mathrm{c}}(\mathrm{q}) = 1$ if $\mathrm{RCA_c}(\mathrm{q}) \geq \mathrm{RCA}^*$ (with RCA^* a threshold RCA level); $\mathrm{k_c} = \sum_{\mathrm{q}} \widetilde{\mathrm{RCA}}_{\mathrm{c}}(\mathrm{q})$ represents the diversification of country *c* (given by the number of connections that the country has in the RCA network; i.e., the number of products with RCA); and $\mathrm{k_q} = \sum_{\mathrm{c}} \widetilde{\mathrm{RCA}}_{\mathrm{c}}(\mathrm{q})$ is the ubiquity of product *q* in the network (given by the number of countries that export the product with RCA).

This alternative indicator is the basis of the so-called *method of reflections*, which allows estimating the complexity of countries' productive structures and the sophistication of products (Hidalgo, 2009; Hidalgo and Hausmann, 2009). The main downside of both measures is that they are derived using gross measures of trade. So, for example, a country engaged in assembly activities at the end of a high-tech value chain will appear to have a relative comparative advantage in the manufacture of high-tech goods, whereas the truth would more accurately reflect a comparative advantage in cheap labour.

2.2.3 Limitations of trade data

Indicators based on gross trade data have been widely used to evaluate the integration of countries into international production networks. This is facilitated by the fact that trade data are easily available and comparable across countries. However, and regardless of the definition of intermediate goods considered, conventional trade statistics have one key shortcoming that limits their suitability for the analysis of geographical production fragmentation. This chiefly reflects their inability to show the value added contributed by countries (firms) within each stage of the production process. Indeed, trade data on their own cannot reveal from which industries the value was added (i.e., products were exported) nor from which industries the products were imported. The inability of gross trade data to provide these perspectives is perhaps best characterised by the low shares of services trade in conventional statistics, relative to their contribution to overall economic activity, which reflects in large part the fact that the contribution of upstream services to goods exports is not accounted for in gross trade data.

A comprehensive and more accurate measurement of international production fragmentation, that tackles these shortcomings, requires combining trade data with data on the input-output structure of trading nations. This is the approach underlying the GVC indicators presented below.

2.3 Indicators based on input-output tables

2.3.1 Trade in value added

The emergence of GVCs as a dominant feature of world production poses challenges for empirical analysis of international trade. Since conventional trade statistics are affected by double-counting problems, their use may give a misleading perspective of the contribution of trade to economic growth and income (OECD-WTO, 2013).

Gross export data would only reflect actual benefits to the exporting economy's GDP[16], if the entire production process took place within that single country, which reflects an archaic view of production given the rise of international fragmentation. To the extent that exported goods usually require foreign inputs (either directly or indirectly[17]), the gross value of exports differs from the domestic value added contained in those exports. In fact, as shown below, gross export flows can be decomposed into domestic value-added components and imported components (foreign value added). While exports' contribution to economic well-being (in terms of income or employment) depends positively on their domestic value-added content, an increase in gross export flows may not necessarily imply a significant benefit to the exporting economy.

Additionally, the increasing complexity of international production networks is making it more difficult to identify the origin of goods. On the one hand, the value added incorporated in a final product may come from several countries, apart from the country of origin ascribed by customs records (Escaith, 2014b). For example, domestic value added exported by a country A to a country B may be indirectly exported to third countries by being embodied in country B's exports. Since customs records only reflect goods' last country of origin, value added could even end up being exported to a country with which no direct bilateral trade exists. Likewise, domestic value added may return to the exporting economy embodied in imported products. In addition, because they only have a product dimension, conventional gross trade statistics cannot on their own reveal the industries (and so production process used) of the economy where value added originates.

For the above reasons, there is an increasing recognition that analyses based on gross trade data can result in inaccurate assessments of the impact of international trade, which could lead

[16] The OECD is also leading international efforts to look through the pure trade and production, or GDP perspective, by developing accounting frameworks that also capture international flows related to value-added generated by foreign direct investment (a Gross National Income (GNI) perspective) (see Ahmad, 2015).
[17] Imported intermediates are used directly in the production of exported goods, and/or exported goods require intermediate inputs from domestic suppliers who, in turn, require foreign intermediates to produce those inputs.

to misguided political decisions. In contrast, the measurement of trade in value-added terms provides a better estimation of the contribution of trade to economic growth and job creation, as it aims to identify the domestic value (contribution) that each country adds to goods and services exports. In addition, bilateral trade imbalances measured in value-added terms may be very different from those implied by gross trade data (although total trade balances are the same[18]), since the latter exaggerate deficits with final goods producers (surpluses of exporters of final products).

In order to assess the actual contribution of each participating country and industry, the gross value of exports should be decomposed into value-added contributions from domestic and foreign industries. This can be done using international (intercountry or multiregional) IOTs, which combine national accounts and bilateral trade statistics linking production processes within and across countries. By capturing both direct and indirect linkages and exchanges between countries and industries, international IOTs are able to account for fragmentation of production, avoiding the double-counting problems that affect conventional trade data. Another key advantage of IOTs is that they classify products according to their use (as an input into another industry's production or as final demand).

2.3.2 Input-output analysis

In input-output analysis, the relationship between supply and demand of an economy *c* with K industries can be expressed in the following way[19]:

$$\mathbf{y}_c = \mathbf{Z}_c^{D}\boldsymbol{\iota} + \mathbf{f}_c \tag{2.11}$$

where $\mathbf{y}_c$ is a K×1 vector of the output of country *c* by source industry; $\mathbf{Z}_c^{D}$ is a K×K matrix of domestic intermediate demand for the products of country *c* (with $z_c^{D}(i, j)$ being the value of domestic products from industry *i* used as intermediates by industry *j*); $\boldsymbol{\iota}$ is a K×1 vector of ones; and $\mathbf{f}_c$ is a K×1 final demand vector for the products of country *c* by source industry (which includes both domestic final demand and gross exports).

Thus,

[18] Measuring trade in value-added terms does not change the overall trade balance of a country; it redistributes the surpluses and deficits across partner countries.

[19] An input-output model is constructed from observed data (expressed in monetary terms) for a particular economic area (usually a country) and a particular time period (usually a year). As it is customary in this literature, we use upper-case bold letters for matrices and lower-case bold letters for vectors. For simplicity, the time index is omitted here.

$$\begin{bmatrix} y_c(1) \\ \vdots \\ y_c(K) \end{bmatrix} = \begin{bmatrix} z_c^D(1,1) & \dots & z_c^D(1,K) \\ \vdots & \ddots & \vdots \\ z_c^D(K,1) & \cdots & z_c^D(K,K) \end{bmatrix} \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} + \begin{bmatrix} f_c(1) \\ \vdots \\ f_c(K) \end{bmatrix} \tag{2.12}$$

Each industry's intermediate demand of domestically produced products can be expressed in terms of technical coefficients, so that equation (2.11) translates into:

$$\mathbf{y}_c = \mathbf{A}_c^D \mathbf{y}_c + \mathbf{f}_c \tag{2.13}$$

where $\mathbf{A}_c^D$ is the K×K matrix of direct domestic input coefficients (or technical coefficients) of country *c*. Each coefficient $a_c^D(i,j)$ indicates the value of products from domestic industry *i* used by industry *j* as intermediate inputs to produce one (monetary) unit of output (i.e., $a_c^D(i,j) = z_c^D(i,j)/y_c(j)$).

Equation (2.13) represents the fundamental input-output identity introduced by Leontief (1936). The model can be rewritten as:

$$(\mathbf{I} - \mathbf{A}_c^D)\mathbf{y}_c = \mathbf{f}_c \tag{2.14}$$

where **I** is a K×K identity matrix.

Therefore:

$$\mathbf{y}_c = (\mathbf{I} - \mathbf{A}_c^D)^{-1}\mathbf{f}_c = \mathbf{B}_c\mathbf{f}_c \tag{2.15}$$

where $(\mathbf{I} - \mathbf{A}_c^D)^{-1}$ or $\mathbf{B}_c$ is the multiplier matrix, known as the Leontief inverse (or total requirements matrix). This matrix indicates how much output from each domestic industry is directly and indirectly required in country *c* to produce a given vector of final demand. For example, to satisfy one unit of final demand (i.e., to produce one unit of output) industry *j* requires $a_c^D(i,j)$ units from domestic industry *i*; in turn, to produce those $a_c^D(i,j)$ units industry *i* will require inputs from other domestic industries, generating in turn additional input requirements of those industries. Thus, the Leontief inverse captures all direct and indirect flows of domestic intermediate products involved in the production of one unit of each industry's output.

It is also possible to construct a $\mathbf{A}_c^M$ matrix of direct imported input coefficients of country *c*. Each coefficient $a_c^M(i,j)$ shows the foreign inputs from industry *i* required by domestic industry *j* to produce one unit of output (i.e., $a_c^M(i,j) = z_c^M(i,j)/y_c(j)$, where $z_c^M(i,j)$ is the value of imported products from industry *i* used as intermediates by industry *j*). As shown in subsection 2.3.4, matrices $\mathbf{A}_c^D$ (from which $\mathbf{B}_c$ is obtained) and $\mathbf{A}_c^M$ are the key components of most GVC indicators based on IOT information, which can be computed using national (i.e., single country) tables. Other indicators require the use of an international IOT.[20]

Following Johnson and Noguera (2012), in an international input-output framework with N countries equation (2.13) can be expressed as:

$$\mathbf{y} = \mathbf{A}\mathbf{y} + \mathbf{f} \tag{2.16}$$

with:

$$\mathbf{y} = \begin{bmatrix} \mathbf{y}_1 \\ \vdots \\ \mathbf{y}_N \end{bmatrix}, \quad \mathbf{A} = \begin{bmatrix} \mathbf{A}_{1,1} & \cdots & \mathbf{A}_{1,N} \\ \vdots & \ddots & \vdots \\ \mathbf{A}_{N,1} & \cdots & \mathbf{A}_{N,N} \end{bmatrix}, \quad \text{and} \quad \mathbf{f} = \begin{bmatrix} \sum_p \mathbf{f}_{1,p} \\ \vdots \\ \sum_p \mathbf{f}_{N,p} \end{bmatrix} \tag{2.17}$$

where each $\mathbf{y}_c$ is a K×1 vector of the output of country *c* by source industry (with $y_c(i)$ being the value of output in industry *i* of country *c*); each $\mathbf{A}_{c,p}$ is a K×K technical coefficient matrix with elements $a_{c,p}(i,j) = z_{c,p}(i,j)/y_p(j)$ (where $z_{c,p}(i,j)$ is the value of products from industry *i* in source country *c* used as intermediates by industry *j* in destination country *p*); and each $\mathbf{f}_{c,p}$ is a K×1 vector of final demand in country *p* of products from country *c* by source industry.[21]

Again,

$$\mathbf{y} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{B}\mathbf{f} \tag{2.18}$$

where **I** is a (K×N)×(K×N) identity matrix.

Matrix **A** (referred to here as global technical coefficient matrix) summarises the entire structure of within-country, cross-country, and cross-industry intermediate products linkages. Consequently, the global Leontief inverse **B** (or global total requirements matrix) indicates how much output from each country and industry is required to produce a given vector of world final demand **f**.

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[20] Matrices $\mathbf{A}_c^D$ and $\mathbf{A}_c^M$ can also be obtained from an international IOT.

[21] Thus, for each industry *i* in country *c* gross output is given by: $y_c(i) = \sum_p \sum_j z_{c,p}(i,j) + \sum_p f_{c,p}(i)$.

2.3.3 TiVA database

Although input-output analysis has a very long tradition, initiated by Wassily Leontief in 1936, its use has seen a resurgence in recent years. International (inter-country, world, global, multiregional or multi-country) IOTs provide a powerful tool for studying the interdependent structure that increasingly characterises production processes worldwide. They are an extension of the basic IOT framework in which the use of both intermediate and final imported products is broken down by origin country, showing in which foreign industry they were produced.

The construction of international IOTs requires harmonising and consolidating national IOTs (or SUTs) and bilateral trade data across countries, which usually needs significant transformation of data originally validated in national statistical systems. In recent years in particular, there have been a number of initiatives to develop such tables (see Annex A). The OECD Inter-Country Input-Output (ICIO) database that underpins the OECD-WTO TiVA database, is one of the best known of these initiatives, and the only one aiming to develop an internationally recognised 'official' international IOT within a coordinated network of national and international statistics agencies; a position reinforced at the 2015 meeting of the UN Statistical Commission.[22]

TiVA provides a publicly available dataset that includes a number of indicators of trade in value-added terms, as well as the underlying inter-country IOTs.[23] It currently covers 63 economies (all 34 OECD countries and 29 non-member countries, including Brazil, China, India, Indonesia, Russia, and South Africa), with a breakdown into 34 industries and availability for the years 1995 to 2011. The latest release of the database was in March 2017, which included estimates up to 2014 produced using nowcasting techniques. The initiative plans to continue releasing more detailed data in terms of country coverage and industry disaggregation, as momentum develops, and has seen extensions into a number of other policy relevant areas including on jobs and the environment[24], with additional extensions expanding industry granularity to provide insights on the role of SMEs and MNEs in GVCs[25]. Indicators currently included in the TiVA database, amongst many others include a decomposition of gross exports and the services content of gross exports by domestic and foreign origin, and the domestic value

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[22] http://unstats.un.org/unsd/statcom/doc15/2015-12-TradeStats-E.pdf.

[23] TiVA indicators can be accessed online at: http://www.oecd.org/industry/ind/measuringtradeinvalue-addedanoecd-wtojointinitiative.htm. The underlying inter-country IOTs are available for downloading at: http://www.oecd.org/sti/ind/input-outputtablesedition2015accesstodata.htm.

[24] http://oe.cd/io-emp and http://oe.cd/io-co2.

[25] www.oecd.org/std/its/enterprises-in-global-value-chains.htm and www.oecd.org/trade/OECD-WBGg20-gvc-report-2015.pdf.

added embodied in foreign final demand. In addition, the dataset includes information on bilateral trade balances based on flows of value added embodied in domestic final demand (which take into account the domestic or foreign origin of value added), and the intermediate imports embodied in exports.

The data was derived from the OECD's database of national IOTs and SUTs, which were integrated and harmonised into a global system using additional statistical sources, such as the Bilateral Trade in Goods by Industry and End-use (BTDIxE), International Trade in Services (TIS) and the Structural Analysis (STAN) industry databases. The main advantage, compared to other initiatives, is the statistical network within which this database was constructed, capitalising on the OECD's networks of official statistics agencies and its official Committees and Working Parties, omitting countries and industries that lacked sufficiently reliable data. This position is being further strengthened through the development of partnerships and closer collaboration with other regional initiatives (including Eurostat's FIGARO[26] and APEC-TIVA) and with UN regional agencies (including ECLAC). However, in recognition that some assumptions are required, meaning that Trade in Value Added is only estimated and not measured per se, the OECD refers to the indicators as estimates. Note however that the same limitations and assumptions in this instance also apply to other initiatives.

2.3.4 Input-output table based GVC indicators

The shortcomings of international trade statistics, in light of the increasing role played by international production networks in the world economy, have led to a greater use of input-output data to examine geographical production fragmentation and value added in trade. As a result, a number of indicators based on IOTs have been developed. This section presents a review of the main indicators, some of which may be computed from national IOTs (i.e., they do not require the use of an international IOT).

Ratio of imported inputs to domestic inputs

This indicator compares the values of imported and domestic intermediates used in production by country *c*. It can be computed on the basis of both national and international IOTs as:

$$\mathrm{RMD_c} = \frac{\boldsymbol{\iota}\mathbf{A}_{\mathrm{c}}^{\mathrm{M}}\mathbf{y}_{\mathrm{c}}}{\boldsymbol{\iota}\mathbf{A}_{\mathrm{c}}^{\mathrm{D}}\mathbf{y}_{\mathrm{c}}} \tag{2.19}$$

[26] Full International and Global Accounts for Research in Input-Output Analysis.

where ι is a 1×K vector of ones; $\mathbf{A}_c^M$ is a K×K matrix of direct imported input coefficients of country c; $\mathbf{A}_c^D$ is a K×K matrix of direct domestic input coefficients of country c; and y_c is a K×1 vector of the output of country c by source industry.[27] The indicator could also be computed at the sectoral level, as the ratio of imported inputs to domestic inputs used by each industry (see the equation in the Annex).

A value of RMD above (below) one indicates that imported (domestic) intermediates have a larger share in the country/industry's total inputs. Additionally, an increase (decrease) in the indicator over time would point to growing (decreasing) importance of international sourcing; however, care is needed in interpretation as movements over time may reflect differences in relative price variations, amongst other things. Moreover, the indicator only provides a limited perspective on countries' integration in GVCs, since it does not differentiate between imported inputs ultimately used to produce goods and services for domestic consumption and exports.

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Vertical specialisation

Vertical specialisation is defined as the use of foreign intermediates in producing exported products. According to Hummels et al. (2001), vertical specialisation occurs when: a) a good is produced in two or more sequential stages, b) two or more countries add value during the production of the good, and c) at least one country uses imported inputs in its stage of the production process, and some of the resulting output is exported. Therefore, while all imported intermediates are consistent with (a) and (b), only those that become embodied in exported goods are consistent with the third condition.

Four vertical specialisation indicators are presented below.

[27] From an international IOT, $\mathbf{A}_c^M$ can be obtained as: $\mathbf{A}_c^M = \sum_{p \neq c} \mathbf{A}_{p,c}$.

Direct import content of exports

The most basic indicator of vertical specialisation, referred to here as VSD, was initially suggested by Hummels et al. (2001):

$$\mathrm{VSD_c} = \frac{\boldsymbol{\iota}\mathbf{A}_\mathrm{c}^\mathrm{M}\mathbf{e}_\mathrm{c}}{\boldsymbol{\iota}\mathbf{e}_\mathrm{c}} \tag{2.20}$$

where $\mathbf{A}_\mathrm{c}^\mathrm{M}$ is the K×K direct import coefficient matrix of country *c*; $\mathbf{e}_\mathrm{c}$ is a K×1 vector of gross exports of country *c* by source industry; and ι is a 1×K vector of ones.

This indicator can be computed using both national and international IOTs. It provides an estimate of the direct import content of exports[28], and so is limited in the sense that it cannot reveal the importance of indirect imports (i.e., those used by upstream domestic suppliers to any given exporting industry). Amongst other things, this also means that the value of the indicator, at least for the total economy, will vary, potentially significantly, depending on the degree of aggregation (i.e., the value of K). Indeed, the greater the degree of disaggregation the lower the value of VSD.[i]

VSD can also be computed considering bilateral exports in the following way:

$$\mathrm{VSD_{c,p}} = \frac{\boldsymbol{\iota}\mathbf{A}_\mathrm{c}^\mathrm{M}\mathbf{e}_\mathrm{c,p}}{\boldsymbol{\iota}\mathbf{e}_\mathrm{c,p}} \tag{2.21}$$

where $\mathbf{e}_\mathrm{c,p}$ is a K×1 vector of gross exports from country *c* to country (or group of countries) *p* by source industry. Thus, imported inputs directly embodied in a country's exports can be decomposed by destination country or region. In addition, an international IOT provides the means to decompose VSD on the basis of the import's country of origin.

Total (direct and indirect) import content of exports

The production of exports requires the direct use of both domestic and foreign intermediates. In turn, inputs sourced from domestic suppliers may require the use of imported intermediates, as well as inputs produced by other domestic industries which, in turn, use foreign intermediates in their production process, and so on. As discussed above, ignoring these indirect import requirements leads to an underestimation of the foreign content of exports and, therefore, the importance of imports for production.

[28] In addition, imported inputs do not necessarily embody only foreign inputs (i.e., they may also embody inputs supplied by the importing country through an upstream exporting activity).

Following this logic, a second indicator of vertical specialisation – referred to as VS (Hummels et al., 2001) – incorporates both direct and indirect imported inputs embodied in a country's exports:

$$\mathrm{VS_c} = \frac{\boldsymbol{\iota}\mathbf{A}_c^M(\mathbf{I}-\mathbf{A}_c^D)^{-1}\mathbf{e}_c}{\boldsymbol{\iota}\mathbf{e}_c} = \frac{\boldsymbol{\iota}\mathbf{A}_c^M\mathbf{B}_c\mathbf{e}_c}{\boldsymbol{\iota}\mathbf{e}_c} \tag{2.22}$$

where $\mathbf{A}_c^M$ and $\mathbf{A}_c^D$ correspond, respectively, to the K×K direct import and domestic input coefficient matrices of country *c*; $\mathbf{I}$ is a K×K identity matrix; $\mathbf{B}_c$ is the K×K Leontief inverse of country *c*; $\mathbf{e}_c$ is the K×1 vector of gross exports of country *c* by source industry; and ι denotes a 1×K vector of ones.

Additionally, VS can be computed on a bilateral basis as:

$$\mathrm{VS_{c,p}} = \frac{\boldsymbol{\iota}\mathbf{A}_c^M(\mathbf{I}-\mathbf{A}_c^D)^{-1}\mathbf{e}_{c,p}}{\boldsymbol{\iota}\mathbf{e}_{c,p}} = \frac{\boldsymbol{\iota}\mathbf{A}_c^M\mathbf{B}_c\mathbf{e}_{c,p}}{\boldsymbol{\iota}\mathbf{e}_{c,p}} \tag{2.23}$$

where $\mathbf{e}_{c,p}$ is a K×1 vector of gross exports from country *c* to country (or group of countries) *p* by source industry.

Also, from VS and VSD the indirect foreign content of exports (as a share of total gross exports) can be computed as:

$$\mathrm{VSI_c} = \frac{\boldsymbol{\iota}\mathbf{A}_c^M\left(\mathbf{I}-\mathbf{A}_c^D\right)^{-1}\mathbf{e}_c - \boldsymbol{\iota}\mathbf{A}_c^M\mathbf{e}_c}{\boldsymbol{\iota}\mathbf{e}_c} = \frac{\boldsymbol{\iota}\mathbf{A}_c^M\left[\left(\mathbf{I}-\mathbf{A}_c^D\right)^{-1}-\mathbf{I}\right]\mathbf{e}_c}{\boldsymbol{\iota}\mathbf{e}_c} = \frac{\boldsymbol{\iota}\mathbf{A}_c^M(\mathbf{B}_c-\mathbf{I})\mathbf{e}_c}{\boldsymbol{\iota}\mathbf{e}_c} \tag{2.24}$$

A proxy of the domestic value added embodied in exports could be computed as the difference between gross exports and total (direct and indirect) foreign inputs contained in those exports:

$$\widetilde{\mathrm{DVAX}}_c = \boldsymbol{\iota}\mathbf{e}_c - \boldsymbol{\iota}\mathbf{A}_c^M(\mathbf{I}-\mathbf{A}_c^D)^{-1}\mathbf{e}_c = \boldsymbol{\iota}[\mathbf{I}-\mathbf{A}_c^M(\mathbf{I}-\mathbf{A}_c^D)^{-1}]\mathbf{e}_c = \boldsymbol{\iota}(\mathbf{I}-\mathbf{A}_c^M\mathbf{B}_c)\mathbf{e}_c \tag{2.25}$$

It should be noticed that VS provides only a first order approximation to the foreign value-added content of exports. It is not able to account for any domestic value added that may be embodied in imported inputs, reflecting, for example two-way trade in intermediates (i.e., when a country's exported products are used as inputs by other countries to produce goods that are shipped back home). That being said, the evidence suggests that for many countries, at least at the total economy level, estimates of VS (as well as VSI and $\widetilde{\mathrm{DVAX}}$) computed using national IOTs are very close to the equivalent estimates one would derive using an international IOT.

However, the relationship begins to breakdown when estimates are derived by partner and industry.

In addition, international IOTs can provide more detailed insights on the position of countries in international production chains, which cannot be done with a national IOT alone. A relatively higher value of VS for intermediates indicates a stronger integration in the upstream production of parts and components (for the production of other goods), while a higher value of VS for final goods reflects a greater importance of downstream assembly activities.

Exports embodied in other countries' exports

A third vertical specialisation indicator, called VS2, portrays an alternative perspective of a country's participation in GVCs by capturing the exports embodied in other countries' exports. While VSD and VS look at vertical specialisation from the viewpoint of an exporting country demanding intermediates from abroad, VS2 measures vertical specialisation from the viewpoint of an exporting country supplying intermediate inputs abroad (Yi, 2003):[29]

$$\mathrm{VS2}_{\mathrm{c}} = \frac{\sum_{\mathrm{p}\neq\mathrm{c}} \boldsymbol{\iota}\,\mathbf{A}_{\mathrm{c,p}}\left(\mathbf{I}-\mathbf{A}_{\mathrm{p,p}}\right)^{-1}\mathbf{e}_{\mathrm{p}}}{\boldsymbol{\iota}\mathbf{e}_{\mathrm{c}}} = \frac{\sum_{\mathrm{p}\neq\mathrm{c}} \boldsymbol{\iota}\mathbf{A}_{\mathrm{c,p}}\mathbf{B}_{\mathrm{p,p}}\mathbf{e}_{\mathrm{p}}}{\boldsymbol{\iota}\mathbf{e}_{\mathrm{c}}} \quad (2.26)$$

where $\mathbf{A}_{\mathrm{c,p}}$ is a K×K matrix of input coefficients of country *p* for the products imported from country *c* (with each coefficient $\mathrm{a}_{\mathrm{c,p}}(\mathrm{i,j})$ showing the inputs from industry *i* in country *c* required in country *p* by industry *j* to produce one unit of output); $\mathbf{A}_{\mathrm{p,p}}$ is the K×K matrix of direct domestic technical coefficients of country *p*; **I** is a K×K identity matrix; $\mathbf{B}_{\mathrm{p,p}}$ is the K×K Leontief inverse matrix of country *p* (given by the block matrix drawn from the global Leontief inverse); $\mathbf{e}_{\mathrm{p}}$ is a K×1 vector of the exports of country *p* by source industry; $\mathbf{e}_{\mathrm{c}}$ is a K×1 vector of the exports of country *c* by source industry; and $\boldsymbol{\iota}$ is a 1×K vector of ones.

Thus, VS2 indicates how much of a country's exports are used as intermediate inputs in the production of other countries' exports. Naturally, countries that participate heavily in the first stages of the production chain (such as the extraction of natural resources), and those specialised in the production of intermediates (e.g., parts and components), will tend to have higher ratios.

[29] As pointed out in UNCTAD (2013), "although the degree to which exports are used by other countries for further export generation may appear less relevant for policymakers as it does not change the domestic value-added contribution of trade, the participation rate is a useful indicator for the extent to which a country's exports are integrated in international production networks and it is thus helpful in exploring the trade-investment nexus".

Together, VS2 and VS give a more complete picture of countries' involvement in GVCs, both upstream (i.e., as a producer of intermediates to be included in other countries' exports) and downstream (i.e., as a demander of imported intermediates to include in one's own exports) (Hummels et al., 2001). Of note here is that VS measures, as defined above, are based on national IOTs and, so, do not adjust for any domestic value added that may be included in imports.

As in the case of the other two indicators of vertical specialisation presented above, VS2 can be computed considering bilateral or regional exports (by not summing over partner countries *p* or by summing over a subset of these countries, respectively).[30ii]

Vertical specialization-based trade

Amador and Cabral (2009) propose a relative measure of vertical specialisation-based trade (i.e., the use of imported inputs in producing goods that are exported) that combines information from IOTs and international trade data. International trade data is used in the identification and quantification of vertical specialisation activities, while input-output information is used to identify which products are intermediate goods employed in the production of other products.[31]

An international product specialisation index, based on Balassa (1965), is computed for both exports and imports in order to identify the relevant vertical specialisation activities. In terms of the notation previously used, the index for exports can be expressed as:

$$B^{*}_{EXGR_{c,i}} = \frac{\frac{EXGR_{c,i}}{EXGR_{c}}}{\bar{\mu}_{EXGR_{i}}} = \frac{\frac{EXGR_{c,i}}{EXGR_{c}}}{\frac{1}{N}\sum_{c=1}^{N}\frac{EXGR_{c,i}}{EXGR_{c}}} \tag{2.27}$$

[30] Also, the import content of exports could be computed in levels (i.e., the value of imported inputs embodied in exports), instead of being expressed as a share of gross exports like in equations (2.18) to (2.22) and (2.24). In addition, it could be disaggregated by exporting industry (either considering bilateral or total country's exports).

[31] Amador and Cabral (2009) use information from the 1997 IOT of the United States to identify the intermediate products used in the production of each good, assuming that the main characteristics of the production chain do not change over time and from one country to another. Although the authors recognise that this can be a strong assumption, they argue that "the inputs used in the production of each good probably depend more on technology than on cross-country differences", while "the fact that US produces most existing goods ensures abroad production coverage".

where $EXGR_{c,i}$ are country *c*'s exports of products from industry *i*; $EXGR_c$ are country *c*'s total exports; and $\overline{\mu}_{EXGR_i} = \frac{1}{N}\sum_{c=1}^{N}\frac{EXGR_{c,i}}{EXGR_c}$ is the unweighted average export share of industry *i* across N countries.[32]

Similarly, the index for imports can be written as:

$$B^*_{IMGR_{c,j}} = \frac{\frac{IMGR_{c,j}}{IMGR_c}}{\overline{\mu}_{IMGR_j}} = \frac{\frac{IMGR_{c,j}}{IMGR_c}}{\frac{1}{N}\sum_{c=1}^{N}\frac{IMGR_{c,j}}{IMGR_c}} \quad (2.28)$$

where $IMGR_{c,j}$ are country *c*'s imports of products from industry *j*; $IMGR_c$ are country *c*'s total imports; and $\overline{\mu}_{IMGR_j} = \frac{1}{N}\sum_{c=1}^{N}\frac{IMGR_{c,j}}{IMGR_c}$ is the unweighted average import share of industry *j* across countries.[33]

The basic intuition behind this vertical specialisation measure is that if a country shows simultaneously a high export share of a good and a high import share of a related intermediate product, relative to the world averages, then international vertical linkages are likely to play a role. The definition of high export and import shares depends on the distribution of B^*_{EXGR} and B^*_{IMGR}, respectively. In every period *t*, if $B^*_{EXGR_{c,i}} > B^{*PRC}_{EXGR_i}$ and $B^*_{IMGR_{c,j}} > B^{*PRC}_{IMGR_j}$, then product *j* is identified as associated with vertical specialisation activities in country *c*; where *j* is an intermediate good used in the production of *i*, and $B^{*PRC}_{EXGR_i}$ and $B^{*PRC}_{IMGR_j}$ are the threshold percentiles of the cross-country distribution of $B^*_{EXGR_{c,i}}$ and $B^*_{IMGR_{c,j}}$, respectively.[34]

Once identified, vertical specialisation activities are quantified. In each country and for each product *j*, the value of intermediate imports that surpasses the value implied by the threshold percentile is considered as trade due to vertical specialisation activities in period *t*. This "excess" of intermediate imports is estimated by first determining, for each country in each period, the level of imports that would make $B^*_{IMGR_{c,j}} = B^{*PRC}_{IMGR_j}$, which is given by the following expression:

[32] Alternatively, the index can be computed using average shares weighted by each country's participation in world exports: $\mu^{W}_{EXGR_i} = \sum_{c=1}^{N}\frac{EXGR_{c,i}}{EXGR_c}\frac{EXGR_c}{\sum_{c=1}^{N}EXGR_c}$.

[33] Also in this case, weighted average shares could be considered.

[34] Since the detection of relevant vertical specialisation activities using this procedure depends heavily on the percentile that defines the threshold, and in order to abstract from intra-industry trade or country characteristics that would justify trade flows somewhat higher than the world average, Amador and Cabral (2009) consider five different high-order threshold percentiles (75, 80, 85, 90, and 95). The use of different threshold percentiles provides an interval for the dimension of estimated vertical specialisation activities.

$$\mathrm{IMGR}_{c,j}^{PRC} = \frac{\frac{B_{\mathrm{IMGR}_j}^{*PRC}}{N}\left(\sum_{p\neq c}^{N}\frac{\mathrm{IMGR}_{p,j}}{\mathrm{IMGR}_p}\right)\left(\sum_{k\neq j}^{S}\mathrm{IMGR}_{c,k}\right)}{1-\frac{B_{\mathrm{IMGR}_j}^{*PRC}}{N}\left(1+\sum_{p\neq c}^{N}\frac{\mathrm{IMGR}_{p,j}}{\mathrm{IMGR}_p}\right)} \tag{2.29}$$
[35][iii]

Then, in each period *t* the relative measure of vertical specialisation activities for each country/product pair is computed as:

$$\mathrm{VSM}_{c,j}^{PRC} = \mathrm{IMGR}_{c,j} - \mathrm{IMGR}_{c,j}^{PRC} \tag{2.30}$$

Given its additive properties, in each period, $\mathrm{VSM}_{c,j}^{PRC}$ can be summed to provide a breakdown of vertical specialisation-related trade by country or by product over time. Also, the results can be grouped by geographical area or in accordance with any upper-level product classification.

To facilitate comparisons between countries or products and over time, the measure is computed as a percentage of total imports for each country/geographical area or for each product:

$$\mathrm{VSM}_{c}^{PRC} = \frac{\sum_j \mathrm{VSM}_{c,j}^{PRC}}{\sum_j \mathrm{IMGR}_{c,j}} \tag{2.31}$$

or

$$\mathrm{VSM}_{j}^{PRC} = \frac{\sum_c \mathrm{VSM}_{c,j}^{PRC}}{\sum_c \mathrm{IMGR}_{c,j}} \tag{2.32}$$

The relative nature of this measure is given by the fact that the yearly identification and quantification of vertical specialisation activities is based on the relative dimension of trade flows, which are compared with an international threshold that changes over time. As the

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[35] From equation (2.26): $B_{\mathrm{IMGR}_j}^{*PRC} = \frac{\frac{\mathrm{IMGR}_{c,j}^{PRC}}{\mathrm{IMGR}_c}}{\frac{1}{N}\left(\sum_{p\neq c}^{N}\frac{\mathrm{IMGR}_{p,j}}{\mathrm{IMGR}_p}\right)+\frac{1}{N}\left(\frac{\mathrm{IMGR}_{c,j}^{PRC}}{\mathrm{IMGR}_c}\right)}$. Thus:

$$B_{\mathrm{IMGR}_j}^{*PRC}\left[\frac{1}{N}\left(\sum\nolimits_{p\neq c}^{N}\frac{\mathrm{IMGR}_{p,j}}{\mathrm{IMGR}_p}\right)+\frac{1}{N}\left(\frac{\mathrm{IMGR}_{c,j}^{PRC}}{\mathrm{IMGR}_c}\right)\right] = \frac{\mathrm{IMGR}_{c,j}^{PRC}}{\mathrm{IMGR}_c}$$

$$B_{\mathrm{IMGR}_j}^{*PRC}\left[\frac{1}{N}\left(\sum_{p\neq c}^{N}\frac{\mathrm{IMGR}_{p,j}}{\mathrm{IMGR}_p}\right)\right]\left(\mathrm{IMGR}_{c,j}^{PRC}+\sum_{k\neq j}^{S}\mathrm{IMGR}_{c,k}\right) = \mathrm{IMGR}_{c,j}^{PRC}\left(1-\frac{1}{N}B_{\mathrm{IMGR}_j}^{*PRC}\right)$$

$B_{\mathrm{IMGR}_j}^{*PRC}\left[\frac{1}{N}\left(\sum_{p\neq c}^{N}\frac{\mathrm{IMGR}_{p,j}}{\mathrm{IMGR}_p}\right)\right]\left(\sum_{k\neq j}^{S}\mathrm{IMGR}_{c,k}\right) = \mathrm{IMGR}_{c,j}^{PRC}\left[1-\frac{B_{\mathrm{IMGR}_j}^{*PRC}}{N}\left(1+\left(\sum_{p\neq c}^{N}\frac{\mathrm{IMGR}_{p,j}}{\mathrm{IMGR}_p}\right)\right)\right]$, from which $\mathrm{IMGR}_{c,j}^{PRC}$ is obtained.

authors point out, the measure should be taken as conservative because, in dynamic terms, it only captures the cases where the increase of vertical specialisation activities is strong enough to translate into a growth of intermediate imports above that implied by the international threshold. This would result in an underestimation of vertical specialisation activities in situations where the international threshold is increasing.

The main advantage of this indicator, over related measures of vertical specialisation like Hummels et al. (2001), is the ability to generate estimates over a longer time period (Baldwin and Lopez-Gonzalez, 2015). VS requires an IOT for every year, whereas VSM only requires a general view of a production function (based on insights from IOTs at a given point in time), which is assumed to be stable and generalisable to all countries. However, evidence from national IOTs points to significant differences in production functions for a given industry across countries, enlarged in recent years by fragmentation of production; thus, some care is necessarily needed in making comparisons across countries and time. As before, care is also needed in interpreting measures over time on account of differential price changes across products.

Trade in value added indicators[iv]

In many respects, measures that capture the value added embodied in a country's exports mirror those that capture exports' import content. So, for example, using only a national IOT, and leaving aside taxes and subsidies, the complement of (i.e., 1 minus) the share of imports in a country's exports equals the domestic value-added (in basic prices) share. However, as noted above, in a global context the issue is more complex as, in reality, imports often include domestic value added that was exported and then re-imported.

Indeed, it is at least in part to capture these flows (in addition to better understanding the nature of interconnectedness) that global IOTs have been developed. Koopman et al. (2014) elaborate these arguments further and point out that the measures of vertical specialisation developed by Hummels et al. (2001), using only national IOTs, are implicitly based on the assumption that the value of imports originates wholly from foreign sources, which does not hold in the presence of two-way trade in intermediate goods. They highlight this by decomposing the value of gross export flows into distinct components that differentiate between domestic value added and import content, further broken down into different items such as intermediate exports passing to third countries, intermediates and finished exports that are consumed as final demand in the importing country, and domestic value added that returns to the host embodied in imports. These breakdowns, or variants of them, form the basis of many of today's key measures of trade in value added, described in more detail below.

One issue worth re-emphasising, although it is of general relevance to many of the indicators presented above, concerns the impact of aggregation within an input-output framework (whether that framework is national or multiregional). The underlying assumption in indicators that use IOTs is that the firms allocated to a given industry each have the same import content relative to their output and the same export propensity relative to their output. However, where information at the firm level is available, it points to exporting firms having different import intensities and export propensities (in particular, it points to exporting firms typically having higher imports per unit of output than non-exporting firms). This means for example that, all other things being equal, measures of the import content of exports based on IOTs will generally be downward biased, and estimates of the domestic value content of exports will be upward biased. Work is however on-going to improve the quality of national SUTs, through the construction of what have become referred to as Extended SUTs, encouraging splits of industries into grouping that better capture heterogeneity in import-output and export-output ratios (through a focus on characteristics of firms that are more homogeneous with regards to GVC measurement).[36]

Domestic value-added content of exports

As intimated above, the domestic value-added embodied in a country's exports can be divided into three components: direct value-added, indirect value-added and re-imported value-added. Direct value-added reflects the direct contribution made by the industry producing the exported product, indirect value-added reflects the indirect contribution of domestic suppliers made through upstream transactions, and re-imported value-added reflects the domestic value-added that returned home embodied in intermediate imports used by the industry in question (see also Ahmad, 2015). While direct and indirect domestic value-added can be computed using national IOTs, the calculation of re-imported domestic value-added requires a multiregional IOT.

Total (direct and indirect) domestic value-added contained in country c's gross exports is given by:

$$\mathrm{DVAX_c} = \boldsymbol{\iota}\hat{\mathbf{V}}_\mathrm{c}(\mathbf{I} - \mathbf{A}_\mathbf{c}^\mathrm{D})^{-1}\mathbf{e}_\mathrm{c} \tag{2.33}$$

[36] www.oecd.org/sti/ind/tiva/eSUTs_TOR.pdf.

where $\widehat{\mathbf{V}}_c$ is a K×K diagonal matrix of value-added coefficients of country *c* by source industry[37]; $\mathbf{A}_c^D$ is the K×K matrix of direct domestic input coefficients of country *c*; $\mathbf{I}$ is a K×K identity matrix; $\mathbf{e}_c$ is a K×1 vector of gross exports of country *c* by source industry; and $\boldsymbol{\iota}$ is a 1×K vector of ones.

The direct domestic value-added content of gross exports is computed as:

$$\mathrm{DVAXD_c} = \boldsymbol{\iota}\widehat{\mathbf{V}}_c\mathbf{e}_c \tag{2.34}$$

v

Thus, the indirect domestic value-added embodied in a country's gross exports (originating from domestic intermediates) is given by:

$$\mathrm{DVAXI_c} = \mathrm{DVAX_c} - \mathrm{DVAXD_c} = \boldsymbol{\iota}\widehat{\mathbf{V}}_c[(\mathbf{I} - \mathbf{A}_c^D)^{-1} - \mathbf{I}]\mathbf{e}_c \tag{2.35}$$

The domestic value-added content of gross exports can be decomposed into a sum of value-added exported to different destination countries (which could also be grouped in regions), by replacing vector $\mathbf{e}$ in equations (2.33) to (2.35) with a K×N matrix of gross exports from each industry of origin to each destination country. It could also be disaggregated by exporting industry (by not multiplying by $\boldsymbol{\iota}$).[vi]

Additionally, the domestic value-added content of gross exports can be decomposed into that contained in direct exports that serve foreign intermediate demand and direct exports that satisfy foreign final demand[38]:

$$\mathrm{DVAX_c^{INT}} = \boldsymbol{\iota}\widehat{\mathbf{V}}_c(\mathbf{I} - \mathbf{A}_c^D)^{-1}\mathbf{e}_c^{INT} \tag{2.36}$$

$$\mathrm{DVAX_c^{F}} = \boldsymbol{\iota}\widehat{\mathbf{V}}_c(\mathbf{I} - \mathbf{A}_c^D)^{-1}\mathbf{e}_c^{F} \tag{2.37}$$

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[37] $\widehat{\mathbf{V}}_c = \begin{pmatrix} v_{c,1} & 0 & \cdots & 0 \\ 0 & v_{c,2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & v_{c,K} \end{pmatrix}$, where the *i*th element of the diagonal is the value-added share (i.e., the ratio of value-added to gross production) of industry *i* from country *c*. Each $v_{c,i}$ can be computed as $v_{c,i} = 1 - \sum_j a_c(j,i) = 1 - \sum_j(a_c^D(j,i) + a_c^M(j,i))$(from national IOTs), or as $v_{c,i} = 1 - \sum_p \sum_j a_{p,c}(j,i)$(from an international IOT, where $a_{p,c}(j,i)$ is the value of inputs from industry *j* in source country *p* used by industry *i* in destination country *c* to produce one unit of output).

[38] The decomposition of gross exports by type of demand served requires the use of multiregional input-output data.

where $\mathbf{e}_c^{INT}$ is a K×1 vector of intermediate gross exports of country *c* by source industry; and $\mathbf{e}_c^F$ is a K×1 vector of final gross exports of country *c* by source industry. Both $DVAX_c^{INT}$ and $DVAX_c^F$ could be additionally decomposed by destination countries or regions, as well as by exporting industry.

The share of the domestic value-added content of exports in a country's total gross exports, called the VAX ratio in Johnson and Noguera (2012), provides a measure of the value-added generated throughout the economy for each monetary unit of exports[vii]:

$$DVAXSH_c = \frac{DVAX_c}{\boldsymbol{\iota}\mathbf{e}_c} \tag{2.38}$$

This indicator takes values between zero and one. The lower (higher) DVAXSH the higher (lower) the foreign content of exports and so the higher (lower) the importance of imports to exports. Beyond its direct application, it also provides insights on the degree of 'double-counting' in trade statistics.

The use of an international IOT allows the measurement of an additional component of a country's value-added exports, first formalized by Koopman et al. (2011): the domestic value-added embodied as intermediate inputs in third countries' exports. It also provides the basis to measure the re-imported domestic value-added contained in each country's gross exports.

A global value-added export matrix can be computed from multiregional input-output data as:

$$\mathbf{VAX} = \widehat{\mathbf{V}}\mathbf{BE} = \begin{pmatrix} \widehat{\mathbf{V}}_1 \sum_s \mathbf{B}_{1,1}\mathbf{e}_{1,s} & \cdots & \widehat{\mathbf{V}}_1 \sum_s \mathbf{B}_{1,p}\mathbf{e}_{p,s} & \cdots & \widehat{\mathbf{V}}_1 \sum_s \mathbf{B}_{1,N}\mathbf{e}_{N,s} \\ \vdots & & \vdots & \ddots & \vdots \\ \widehat{\mathbf{V}}_c \sum_s \mathbf{B}_{c,1}\mathbf{e}_{1,s} & \cdots & \widehat{\mathbf{V}}_c \sum_s \mathbf{B}_{c,p}\mathbf{e}_{p,s} & \cdots & \widehat{\mathbf{V}}_c \sum_s \mathbf{B}_{c,N}\mathbf{e}_{N,s} \\ \vdots & & \vdots & \ddots & \vdots \\ \widehat{\mathbf{V}}_N \sum_s \mathbf{B}_{N,1}\mathbf{e}_{1,s} & \cdots & \widehat{\mathbf{V}}_N \sum_s \mathbf{B}_{N,p}\mathbf{e}_{p,s} & \cdots & \widehat{\mathbf{V}}_N \sum_s \mathbf{B}_{N,N}\mathbf{e}_{N,s} \end{pmatrix} \tag{2.39}$$

where $\widehat{\mathbf{V}}$ is a (K×N)×(K×N) diagonal value-added coefficient matrix[39]; **B** is the (K×N)×(K×N) global Leontief inverse matrix (where each block $\mathbf{B}_{c,p}$ is a K×K matrix that gives the amount of sectoral gross output in producing country *c* required per unit of output by each industry in destination country *p*); and **E** is a (K×N)×N matrix of gross exports (where each $\mathbf{e}_{p,s}$ is a K×1 vector of gross exports of country *p* to country *s* by source industry).[viii]

The diagonal terms of matrix **VAX** measure the domestic value-added embodied in each country's gross exports (i.e., $\widehat{\mathbf{V}}_c \sum_s \mathbf{B}_{c,c}\mathbf{e}_{c,s}$ is a K×1 vector of domestic value-added contained in country *c*'s exports by source industry). Each country's indirect value-added exports (i.e., the domestic value-added embodied as intermediate inputs in third countries' gross exports) are given by the sum of off-diagonal elements along each row of matrix **VAX**[40]:

$$\mathrm{DVAX2}_c = \boldsymbol{\iota}\widehat{\mathbf{V}}_c \sum_{p \neq c} \sum_{s} \mathbf{B}_{c,p}\mathbf{e}_{p,s} \tag{2.40}$$

[41][ix]

Finally, the re-imported domestic value-added content of gross exports can be computed for each country *c* as the difference between total value-added exports and its direct and indirect components[42]:

$$\mathrm{DVAXR}_c = \boldsymbol{\iota}\widehat{\mathbf{V}}_c \sum_{s} \mathbf{B}_{c,c}\mathbf{e}_{c,s} - \mathrm{DVAXD}_c - \mathrm{DVAXI}_c \tag{2.41}$$

[x]

As noted above, these estimates are likely, in practice, to be upward biased.

39 $\widehat{\mathbf{V}} = \begin{pmatrix} \widehat{\mathbf{V}}_1 & 0 & \cdots & 0 \\ 0 & \widehat{\mathbf{V}}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \widehat{\mathbf{V}}_N \end{pmatrix}$, where each $\widehat{\mathbf{V}}_c$ is a K×K diagonal matrix of direct value-added coefficients of country *c* by source industry. The *i*th element of the diagonal of each $\widehat{\mathbf{V}}_c$ matrix is $v_{c,i} = 1 - \sum_{\mathbf{p}} \sum_{\mathbf{j}} a_{p,c}(j, i)$, where $a_{p,c}(j, i)$ is the value of inputs from industry *j* in source country *p* required by industry *i* in destination country *c* for one unit of output. Alternatively, $\widehat{\mathbf{V}} = \mathrm{diag}[(\mathbf{I} - \mathbf{A}')\boldsymbol{\iota}]$, where $\mathbf{A}'$ is the transpose of the (K×N)×(K×N) global technical coefficient matrix, $\mathbf{I}$ is a (K×N)×(K×N) identity matrix, and $\boldsymbol{\iota}$ is a (K×N)×1 vector of ones. Thus, the first set of K elements of the diagonal of $\widehat{\mathbf{V}}$ contains the value-added coefficients for country *c*=1, followed by the K value-added coefficients for country *c*=2, and so on.

40 The name given here to this indicator (DVAX2) was adopted following the criterion used for naming the measures of vertical specialisation presented before (i.e., VS and VS2).

41 The so-called reflected domestic value-added (i.e., the domestic value-added embodied in a country's intermediate exports used by the direct importer to produce goods shipped back to source) can be separated from indirect value-added exports in equation (2.38) (as $\boldsymbol{\iota}\widehat{\mathbf{V}}_c \sum_p \mathbf{B}_{c,p}\mathbf{e}_{p,c}$).

42 DVAX is equivalent to OECD-WTO's EXGR_DVA indicator, and DVAXSH is equivalent to OECD-WTO's EXGR_DVASH indicator. The OECD-WTO database also provides separate measures for the direct, indirect and re-imported components of the domestic value-added content of exports (called EXGR_DDC, EXGR_IDC and EXGR_RIM, respectively).

Foreign value-added content of exports

The foreign value-added content of exports, conceptually similar to Hummels et al. (2001) VS1 indicator, can be computed for each country *c* from a multiregional IOT as the sum of off-diagonal elements along each column of matrix **VAX**:

$$\mathrm{FVAX_c} = \sum_{\mathrm{p \neq c}} \boldsymbol{\iota}\widehat{\mathbf{V}}_{\mathrm{p}} \sum_{\mathrm{s}} \mathbf{B}_{\mathrm{p,c}}\mathbf{e}_{\mathrm{c,s}} = \sum_{\mathrm{p \neq c}} \boldsymbol{\iota}\widehat{\mathbf{V}}_{\mathrm{p}}\mathbf{B}_{\mathrm{p,c}}\mathbf{e}_{\mathrm{c}} \tag{2.42}$$

where $\widehat{\mathbf{V}}_{\mathrm{p}}$ is the K×K diagonal matrix of value-added coefficients of country *p*; $\mathbf{B}_{\mathrm{p,c}}$ is the K×K block matrix drawn from the global Leontief inverse that gives the amount of gross output in producing country *p* required for one unit of country *c*'s output (by origin and destination industries); $\mathbf{e}_{\mathrm{c,s}}$ is a K×1 vector of gross exports of country *c* to country *s* by source industry; $\mathbf{e}_{\mathrm{c}}$ is a K×1 vector of country *c*'s total gross exports by source industry; and $\boldsymbol{\iota}$ is a 1×K vector of ones.

This indicator can also be computed by breaking up exports by industry of origin, destination country, and/or type of demand served (final or intermediate), as in the case of DVAX. In addition, it can be decomposed by country of origin (i.e., $\mathrm{FVAX_{p,c}}$ representing the value-added from country *p* embodied in country *c*'s exports), and indeed by source industry within each origin country.

The FVAX ratio for country *c* is given by[43]:

$$\mathrm{FVAXSH_c} = \frac{\mathrm{FVAX_c}}{\boldsymbol{\iota}\mathbf{e}_{\mathrm{c}}} = 1 - \mathrm{DVAXSH_c} \tag{2.43}$$

xi

Equation (2.43) shows that the sum of domestic and foreign value-added contents of exports must account for all gross exports (i.e., value-added from all sources must sum to official trade flows), both at aggregate and sector level (where taxes and subsidies on production and taxes (and subsidies) on products incurred on intermediate consumption by industries in country *c* are included in measures of domestic value added).

GVC participation index

[43] FVAX is equivalent to OECD-WTO's EXGR_FVA indicator, and FVAXSH is equivalent to OECD-WTO's EXGR_FVASH indicator.

Koopman et al. (2011) propose an indicator, referred to as the GVC participation index, which aims to capture the nature of a country's involvement in vertically fragmented production processes. The index of country *c* is given by:

$$\mathrm{GVC\_participation_c} = \frac{\mathrm{DVAX2_c}}{\boldsymbol{\iota}\mathbf{e}_\mathrm{c}} + \frac{\mathrm{FVAX_c}}{\boldsymbol{\iota}\mathbf{e}_\mathrm{c}} \tag{2.44}$$

where $\mathrm{DVAX2_c}$ is the value-added of country c embodied as intermediate inputs in other countries' gross exports (or indirect value-added exports); $\mathrm{FVAX_c}$ is the foreign value-added embodied in country *c*'s gross exports; $\mathbf{e}_\mathrm{c}$ is a K×1 vector of country *c*'s total gross exports by source industry; and $\boldsymbol{\iota}$ is a 1×K vector of ones.

Often the index is used to compare countries' participation in GVCs relative to other countries and over time. Indeed, a common interpretation is that the higher the foreign value-added embodied in gross exports and the higher the domestic value-added contained in third countries' gross exports, the higher the country's participation in international production chains. This is however a mistake, as the indicator only provides a measure of the relative importance in a country's exports of upstream (backward linkages) and downstream (forward linkages) positions in international production networks (where the downstream component provides a narrow measure of upstream participation). For example, a country with exports amounting to a marginal share of GDP may have a participation index of one, while a country with a low participation index could have a very high share of exports to GDP –indeed it should be noted that, typically, the larger the economy the lower the index–. Thus, the indicator should instead be used to describe the nature of a country's participation in GVCs. For countries lying upstream in the value-chain (i.e., those who participate by providing inputs to other countries), the indirect value-added share in gross exports will generally be higher than the share of foreign value-added. In contrast, for countries lying downstream in the value-chain (i.e., those who use a large portion of imported intermediates to produce final goods for exports), the share of foreign value-added will be higher than that of indirect value-added exports.

Note, too, that the downstream component of the index strictly attempts to capture value added embodied in parts that are shipped through to a third country, to provide a narrow definition of GVC participation. As such, by design, it does not capture any domestic value added exported in intermediate inputs that are used by the importing country to produce goods for domestic final consumption. In other words, the indicator is likely to produce a lower estimate of GVC participation (as defined) for countries whose exports of intermediates are disproportionately directed to larger economies, where the capacity to further process the intermediates for selling on in their larger consumer market, is also larger, compared to smaller economies.

In addition, it should be noted that the measure is designed to capture the flows of value added as they pass through GVCs. In this sense, which is also a consideration for many other GVC indicators (including VS), it is important to note that the measure will be affected by the extent to which the parent firm, controlling a value chain with goods and services passing through affiliates, chooses to record flows related to management and control services, and in particular flows related to the use of intellectual property. In practice, especially because of the opportunities provided by fiscal optimisation, these can be recorded in official statistics as either primary income flows (and, so, not recorded as trade) or trade in services. In the latter case, participation indices will generally provide lower measures of participation, all other things being equal, for the countries where parent firms are located.

Value-added induced by final demand

The indicators that decompose gross export flows on the basis of the origin and destination of value-added presented above are not the only prism through which trade in value-added can be measured. A complementary approach is to look at where the value-added is consumed as final consumption at the end of the value chain.

Measures of trade in value-added based on this approach can be computed using multiregional input-output data, from which the global value-added production matrix is obtained as[44]:

$$\mathbf{VAF} = \widehat{\mathbf{V}}\mathbf{BF} = \begin{pmatrix} \widehat{\mathbf{V}}_1 \sum_s \mathbf{B}_{1,s}\mathbf{f}_{s,1} & \cdots & \widehat{\mathbf{V}}_1 \sum_s \mathbf{B}_{1,s}\mathbf{f}_{s,p} & \cdots & \widehat{\mathbf{V}}_1 \sum_s \mathbf{B}_{1,s}\mathbf{f}_{s,N} \\ \vdots & & \vdots & \ddots & \vdots \\ \widehat{\mathbf{V}}_c \sum_s \mathbf{B}_{c,s}\mathbf{f}_{s,1} & \cdots & \widehat{\mathbf{V}}_c \sum_s \mathbf{B}_{c,s}\mathbf{f}_{s,p} & \cdots & \widehat{\mathbf{V}}_c \sum_s \mathbf{B}_{c,s}\mathbf{f}_{s,N} \\ \vdots & & \vdots & \ddots & \vdots \\ \widehat{\mathbf{V}}_N \sum_s \mathbf{B}_{N,s}\mathbf{f}_{s,1} & \cdots & \widehat{\mathbf{V}}_N \sum_s \mathbf{B}_{N,s}\mathbf{f}_{s,p} & \cdots & \widehat{\mathbf{V}}_N \sum_s \mathbf{B}_{N,s}\mathbf{f}_{s,N} \end{pmatrix} \qquad (2.45)$$

where $\widehat{\mathbf{V}}$ is the (K×N)×(K×N) diagonal value-added coefficient matrix; $\mathbf{B}$ is the (K×N)×(K×N) global Leontief inverse matrix (where each block $\mathbf{B}_{c,s}$ is a K×K matrix that

[44] Based on Koopman et al. (2014).

gives total requirements from country *c* for one unit of country *p*'s gross output, by origin and destination industries); and $\mathbf{F}$ is a (K×N)×N matrix of final demand (where each $\mathbf{f}_{s,p}$ is a K×1 vector of final products produced in country *s* and consumed in country *p*).

Thus, elements in the diagonal columns of the (K×N)×N matrix resulting from equation (2.45) (i.e., $\widehat{\mathbf{V}}_c \sum_s \mathbf{B}_{c,s}\mathbf{f}_{s,c}$) give each country's production of value-added absorbed at home (including the domestic value-added that returns home after being processed abroad: $\widehat{\mathbf{V}}_c \sum_{s\neq c} \mathbf{B}_{c,s}\mathbf{f}_{s,c}$). Exports of value-added that are finally consumed as final demand are given by the elements in the off-diagonal columns of matrix **VAF**.

From the final demand perspective, total domestic value-added induced in country *c* by foreign final demand (or total value-added exports) can therefore be computed as:

$$\mathrm{DVAF_c} = \boldsymbol{\iota}\widehat{\mathbf{V}}_c \sum_{p\neq c}\sum_{s} \mathbf{B}_{c,s}\mathbf{f}_{s,p} \tag{2.46}$$

where $\boldsymbol{\iota}$ is a 1×K vector of ones.[xii]

Following Koopman et al. (2014), DVAF can be decomposed according to where and how value-added exports are absorbed:

$$\mathrm{DVAF_c} = \boldsymbol{\iota}\widehat{\mathbf{V}}_c \sum_{p\neq c} \mathbf{B}_{c,c}\mathbf{f}_{c,p} + \boldsymbol{\iota}\widehat{\mathbf{V}}_c \sum_{p\neq c} \mathbf{B}_{c,p}\mathbf{f}_{p,p} + \boldsymbol{\iota}\widehat{\mathbf{V}}_c \sum_{p\neq c}\sum_{s\neq c,p} \mathbf{B}_{c,p}\mathbf{f}_{p,s} \tag{2.47}$$

The first term in equation (2.47) is the domestic value-added content of country *c*'s (direct) final exports; the second term denotes the domestic value-added embodied in country *c*'s intermediate exports used by the direct importing country to produce final products that are consumed domestically; and the third term is the domestic value-added in country *c*'s intermediate exports used by the direct importing country to produce final products for third countries.

Thus, the demand-side approach provides a measure of the value-added of one country directly and indirectly contained in other countries' final demand. By reflecting the domestic value embodied in each country's exports of intermediates that are further processed and sold to final consumers in other countries, DVAF shows how industries in one country are connected to consumers in other countries, even where no direct trade relationship exists (Ahmad, 2015).

Value-added exports can also be expressed as a share of gross exports:

$$\mathrm{DVAFSH_c} = \frac{\mathrm{DVAF_c}}{\boldsymbol{\iota}\mathbf{e}_\mathrm{c}} \tag{2.48}$$

where $\mathbf{e}_c$ is a K×1 vector of country *c*'s gross exports by source industry.

In addition, it is possible to calculate the foreign value-added induced by each country's domestic final demand (i.e., the value-added used by one country to satisfy its final demand but created in other countries). For each country *c*, total foreign value-added embodied in domestic final demand (or total value-added imports) can be computed as:

$$\mathrm{FVAF_c} = \boldsymbol{\iota}\sum_{\mathrm{p}\neq\mathrm{c}}\sum_{\mathrm{s}}\widehat{\mathbf{V}}_\mathrm{p}\mathbf{B}_{\mathrm{p,s}}\mathbf{f}_{\mathrm{s,c}} \tag{2.49}$$

Similarly to DVAF, FVAF can be decomposed according to where and how value-added imports originate:

$$\mathrm{FVAF_c} = \boldsymbol{\iota}\sum_{\mathrm{p}\neq\mathrm{c}}\widehat{\mathbf{V}}_\mathrm{p}\mathbf{B}_{\mathrm{p,c}}\mathbf{f}_{\mathrm{c,c}} + \boldsymbol{\iota}\sum_{\mathrm{p}\neq\mathrm{c}}\widehat{\mathbf{V}}_\mathrm{p}\mathbf{B}_{\mathrm{p,p}}\mathbf{f}_{\mathrm{p,c}} + \boldsymbol{\iota}\sum_{\mathrm{p}\neq\mathrm{c}}\sum_{\mathrm{s}\neq\mathrm{c,p}}\widehat{\mathbf{V}}_\mathrm{p}\mathbf{B}_{\mathrm{p,s}}\mathbf{f}_{\mathrm{s,c}} \tag{2.50}$$

Therefore, total value-added imports of country *c* include the foreign value-added embodied in country *c*'s intermediate imports used to produce final products that are consumed domestically (first term of equation (2.50)); the foreign value-added that comes directly from a partner country to satisfy country *c*'s final demand (second term of equation (2.50)); and the foreign value-added in country *c*'s final imports that has been indirectly transferred through other partner countries (last term of equation (2.50)). Thus, this indicator shows how industries abroad are connected to consumers at home, even where no direct trade relationship exists.

The difference between DVAF and FVAF gives the country's trade balance in value-added terms:

$$\mathrm{TBVAF_c} = \mathrm{DVAF_c} - \mathrm{FVAF_c} \tag{2.51}$$

The domestic value-added induced by foreign final demand (or value-added exports) can be decomposed into the value-added generated by final demand in different countries (which could also be grouped into regions). It can also be disaggregated by exporting industry. Similarly, foreign value-added induced in each country by domestic final demand (or value-added imports) can be decomposed by origin country and/or source industry, showing where this value-added originates. Thus, countries' trade positions in value-added terms can be calculated at the bilateral level.[45]

Length of GVCs[xiii]

The length of GVCs is defined by the number of production stages involved. It is related to the "average propagation length", an indicator whose origins lie in traditional input-output analysis (Dietzenbacher and Romero, 2007). Based on the index of the number of production stages proposed by Fally (2012a, 2012b) for a single country IOT, in an international IOT framework an index providing an indication of the length of GVCs can be computed as:

$$\mathbf{n} = \boldsymbol{\iota}(\mathbf{I} - \mathbf{A})^{-1} = \boldsymbol{\iota}\mathbf{B} \quad (2.52)$$

where $\mathbf{n}$ is a 1×(N×K) vector with the indexes for all countries and industries; $\boldsymbol{\iota}$ is a 1×(N×K) vector of ones; and $\mathbf{B} = (\mathbf{I} - \mathbf{A})^{-1}$ is the global Leontief inverse.

An index value of one indicates that there is only a single production stage in the final industry, and increasing values reflect additional inputs from the same industry or other industries. It can also be computed distinguishing between domestic and imported inputs, illustrating the relative importance of domestic and foreign stages of the value chain.

Some care is however needed in using the index. For a start, it is important to note that the index is not in and of itself, in practice, a measure of length. More accurately, the index is a measure of the average number of stages (plants) involved in the production chain, weighted by the value added at each stage, and this in turn presupposes that the production chain follows a sequential (snakes) rather than concurrent (spiders) process (Baldwin and Venables, 2013).

In addition, the index in theory requires establishment (or plant) level data, which is not typically available in a conventional IOT (which instead provides data on the basis of industries, i.e., aggregations of plants). This means that the results can be, in turn, sensitive to the level of industry aggregation used in IOTs, and indeed the nature of the statistical unit (e.g., many European economies create their tables using information on enterprises and not establishments), and indeed whether transactions within firms are consolidated or not – typically the smaller the statistical unit, and the lower the degree of consolidation, the higher the estimate of the stages of production. Nevertheless, despite these caveats, the indicator provides useful, albeit broad, insights on the length and evolution of the value chains.

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[45] OECD-WTO's demand-side indicators include the domestic value-added embodied in foreign final demand (FFD_DVA), the foreign value-added embodied in domestic final demand (DFD_FVA), as well as the bilateral trade balance in value-added terms (BALVAFD).

Distance to final demand[xiv]

Distance to final demand reflects countries' location in the value chain (upstream or downstream). Fally (2012a, 2012b) and Antràs et al. (2012) propose a measure of "upstreamness", based on the number of stages between the production of a good and final demand. Thus, starting from one industry in a given country, the index measures how many stages of production are left before the goods or services produced by this industry reach final demand.

In an international IOT framework, a measure of the distance to final demand can be computed as:

$$\mathbf{d} = \boldsymbol{\iota}(\mathbf{I} - \mathbf{G})^{-1} \tag{2.53}$$

where $\mathbf{d}$ is a 1×(N×K) vector with the indexes for all countries and industries; $\boldsymbol{\iota}$ is a 1×(N×K) vector of ones; $\mathbf{I}$ is a (K×N)×(K×N) identity matrix; $\mathbf{G}$ is a (K×N)×(K×N) global matrix of output coefficients (or allocation coefficients); and $(\mathbf{I} - \mathbf{G})^{-1}$ is the so-called Ghosh inverse.[46] Note that the measure corresponds to the more traditionally known Ghosh-inverse forward-linkage measure.

A larger value of $d_c(i)$ implies that industry i in country c is more specialised in the production of inputs at the beginning of the value chain, relative to other industries with lower indexes. The same caveats presented above for length of GVCs are also relevant here.

2.3.5 Limitations of IOT based statistics

The use of multiregional IOTs has become a common approach for empirically evaluating countries' participation in GVCs. However, it is important to note that this data source poses some limitations. The construction of these tables is a data-intensive process and presents numerous challenges, creating a trade-off between country and time coverage and degree of reliability, because for certain countries the quality of the data is poor. In particular, the precise identification of the links between exports of one country and the purchasing industries or final demand consumers in the importing country is subject to numerous problems, due to data restrictions and inconsistencies across countries (Ahmad, 2015).

[46] Each coefficient of matrix **G** is given by $g_{c,p}(i,j) = z_{c,p}(i,j)/y_c(i)$, where $z_{c,p}(i,j)$ is the value of products from industry i in source country c used as intermediates by industry j in destination country p, and $y_c(i)$ is the value of industry i's output in country c. Thus, these allocation coefficients represent the distribution of industry i's output across domestic and foreign industries.

The allocation of trade flows by country and industry of origin and destination is based on a number of assumptions. The main one is the proportionality assumption, according to which the origin-country share of a given imported product consumed in a given country, and recorded in the import flow tables that often accompany national IOTs (which show imports by product, by industry or category of final demand), is the same for all industries in that country. Furthermore, for countries with no import flow tables available, the same share of intermediate imports in total intermediate consumption is assumed, for each product, for all purchasing industries.[47] This proportionality assumption may not reflect the actual origin when the quality of intermediate products required differs across industries and countries of origin specialise in particular qualities (Escaith, 2014b). The allocation of flows is even more challenging in the case of services, as the availability of data on bilateral trade in services is limited, especially for developing countries.

As noted above, another drawback of multiregional IOTs is their high degree of sectoral aggregation, which does not reflect the detailed level of specialisation that characterises the fragmentation of production processes across countries. This creates an aggregation bias, as different firms (and different underlying GVCs) are allocated to a single industry. It is assumed that all firms in that industry use the same production technique to produce the same products, which are sold to the same consumers and markets. However, in reality exporting firms may differ widely in their production techniques and use of foreign inputs from firms producing only for the domestic market (Escaith, 2014b). This will generally result in lower shares of foreign content than might be recorded if more detailed IOTs were available (Ahmad, 2015).

To account for firm heterogeneity, more detailed information is needed. As pointed out by Ahmad (2015), this does not necessarily demand increasing the number of industries but disaggregating industries available within current IOTs into characteristics required to better measure GVCs (for example, into groups of exporting firms and non-exporting firms). Micro-level measurement and analysis of GVCs would also allow controlling for firm heterogeneity, establishing the links between firms in the different countries and in different stages of the production process; however, further micro-data disclosure and sharing is required to allow for progress in this front (Amador and Cabral, 2014).

An important new challenge for trade in value added indicators based on IOTs concerns the recent changes introduced in the 2008 SNA. The two most relevant in this respect are the changes related with 'goods sent abroad for processing' and 'merchanting'. The 2008 SNA

[47] The standard assumption is to apply a fixed import proportion to all product's purchasers (industries and final consumers), equal to the ratio of imports to total domestic demand for that product.

recommends that imports and exports should be recorded on a strict change of ownership basis. That is, flows of goods between the country owning the goods and the country providing the processing services should not be recorded as imports and exports of goods. Instead, the fee paid to the processing unit should be recorded as an import of processing services by the country owning the goods and an export of processing services by the country providing it. The consequence of this for trade-in-value-added based indicators may be profound. For example, following the implementation of the 2008 SNA recommendations, countries with large processing activities, and therefore with a high import content of exports in current trade in value added estimates, will see significant falls in these ratios (as any intermediate import used in the processing activity whose ownership remains with the principal firm supplying the processor will no longer be recorded as intermediate consumption on official SUTs and IOTs). Other indicators, for example the backward component of the GVC participation index, will be similarly affected. For mechanting, complications will be introduced whenever purchases and subsequent sales by a merchanter cross over two periods, as in the first period an imputation for imports as a negative export will necessarily be made in the country where the merchanter is resident. To overcome these challenges, the OECD is working with partners to investigate the scope to re-impute flows for goods for processing, such that intermediate consumption of imports continues to be recorded (in other words, assuming that ownership has changed).

2.4 Some final considerations

The increasing fragmentation of production processes across countries has challenged economists and statisticians to find new ways to measure the extent of this phenomenon and its potential implications. The purpose of this paper is to present a review of the main indicators on GVCs currently in widespread use, and to serve as a guide for empirical work.

The indicators commonly used to analyse countries' participation in international production networks, based on either international trade data or IOTs, each have their strengths and weaknesses. Measures based on international trade data have the advantage of high coverage (in terms of countries and time periods) and low complexity of the required data, as well as an acceptable degree of comparability across countries. In addition, the detailed product-level information on trade in intermediate goods –relative to that of IOTs – allows for a more precise characterisation of countries' specialisation patterns. However, a shortcoming of trade data is that there is no link to production, and so to the industry of origin or indeed the industry actually using any intermediate in its production process. Additionally, the growing complexity of international production networks makes it increasingly difficult for conventional trade measures to capture the full linkages among countries (since customs records often only reflect a product's last country of origin, although efforts are being made to improve this through the compilation of additional data such as country of consignment). Another important drawback of trade data is that they are affected by double-counting issues, as the value of intermediate products is counted each time they (or the good in which they are subsequently embedded) cross a national border, which can artificially inflate the importance of trade. Also, available trade data only insufficiently account for trade in services, since they do not reflect the value originating in service-related activities that is embodied in traded goods.

Indicators based on input-output statistics improve upon measures based on conventional trade data in terms of the accuracy of the resulting quantification and characterisation of GVCs. By capturing both direct and indirect linkages and exchanges between countries and industries, multiregional IOTs allow for the measurement of the foreign content of exports and the value truly generated by each country (and industry). This avoids the double-counting problems inherent in trade statistics, fully tracking the original sources of the value-added embodied in gross trade flows. However, the accuracy of the measurement of production fragmentation is constrained by the high degree of sectoral aggregation in IOTs, which creates an aggregation bias and generally, at least following the 1993 SNA, results in lower shares of foreign content than might be recorded if more detailed tables were available. Accuracy is also affected by the proportionality assumption, on which the allocation of trade flows by country of origin and destination is based. Additionally, the limited availability of comparable input-output data (especially for developing countries) hampers the country and time coverage of indicators based on input-output statistics.

Notwithstanding that indicators based on multiregional IOTs represent a substantial methodological advance, considerable work still needs to be done in order to adequately map and measure countries' participation in GVCs. The existing databases allow macro-sectoral level analyses, but more detailed information is required to account for firm heterogeneity (for example, by splitting industries into groups of exporting firms and non-exporting firms). The use of firm-level data, a line of research that has emerged recently, can also improve the quality of the information provided by IOTs; however, further micro-data disclosure and sharing is required to allow for progress in this front. Also, the coverage of developing countries in international IOTs should be extended using official data, in order to adequately reflect the actual specificities of these countries (Escaith, 2014b).

Appendix Chapter 2

OECD Inter-country Input-Output (ICIO) database

The OECD ICIO underpins the OECD-WTO TiVA database. The latest version of the ICIO contains data for 63 economies and 34 industries (on an ISIC Rev 3 basis) following the 1993 SNA, and cover the years 1995-2011, with additional tables based on now-casting techniques available for the 2012-2014 period. Future releases in 2018 and beyond will be on a 2008 SNA basis, as countries increasingly implement the latest accounting standards. The efforts in this regard are expected to be bolstered as regional partners engaged in similar initiatives, such as Eurostat's FIGARO initiative, APEC-TiVA, ECLAC, TiVA and NAFTA-TiVA, gather momentum.

A. Other initiatives to create inter-country input-output tables

An early example of efforts to look at inter-country relationships is the Global Trade Analysis Project (GTAP), coordinated by the Center for Global Trade Analysis of Purdue University. Set up in the 1990s, primarily for economic modelling purposes, the GTAP database is a "cross-section of consistent data on consumption, production, and trade" for a particular reference year.[48] Although the sources of the database are national IOTs, GTAP is not an international IOT (as this concept is understood). One drawback of this database is that it does not provide separate data for trade in intermediate and final products, thus making it necessary to transform trade flows in order to construct inter-country IOTs from GTAP data (Tsigas et al., 2012). Also, since it is benchmarked only on trade statistics, sector level supply and demand data for individual countries may show large discrepancies with corresponding national accounts statistics. Another shortcoming of the GTAP database is that there is no consistency imposed between its different versions, which makes it difficult to perform comparisons over time.

The first true inter-country IOT is the Asian International Input-Output Table (AIIOT), produced by the Institute of Developing Economies-Japan External Trade Organization (IDE-JETRO) in collaboration with the national statistical offices and research institutes of the participating countries. AIIOT comprises 9 Asian economies (China, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Singapore, Taiwan, and Thailand) plus the Unites States, with five-year interval tables for the period 1985-2005. More recently, international IOT

[48] The last version available (version 9), released in May 2015, has three reference years (2004, 2007 and 2011), 140 regions (countries) and 57 sectors. For a description of this and previous versions see www.gtap.agecon.purdue.edu/databases/default.asp.

databases with a more 'global' scope have become available, including the Trade in Value-Added (TiVA) database and the two described next: the World Input-Output Database (WIOD), and Eora.[49]

a) World Input-Output Database

The WIOD is a publicly available multiregional input-output database developed by a consortium of European institutions to "analyze the effects of globalization on trade patterns, environmental pressures and socio-economic development" (Timmer, 2012).[50] The most recent version, released in 2016, covers 43 countries which account for more than 85% of world GDP (the 28 members of the European Union, Norway, Switzerland, and 13 major non-European economies), and estimates for the non-covered part of the world (presented as "Rest of the world"), with a timeframe spanning 15 years (from 2000 to 2014).[51] This is an update to the 2013 release of the database, which covered 40 countries with a slightly earlier timeframe (from 1995 to 2011).[52]

The first step in the construction of the database was building a time series of national SUTs. National SUTs (or IOTs) published by the National Statistical Institutes were taken as a starting point to construct harmonised and standardised SUTs with 56 industries that together cover the entire economy.[53] These harmonized SUTs were then benchmarked to National Accounts and used to estimate national tables for non-benchmark years (using the so-called SUT-RAS method, developed for this specific purpose). The second step consisted in linking national SUTs across countries through detailed bilateral international trade statistics, to

[49] Other multiregional input-output databases are the GTAP-MRIO (based on the GTAP database) and EXIOPOL (see Tukker and Dietzenbacher, 2013; Andrew and Peters, 2013; and Tukker et al., 2013). Unlike WIOD, Eora and TiVA, these two databases are not publicly available and have a greater emphasis on environmental issues.

[50] The WIOD project, funded by the European Commission, included the following institutions: University of Groningen, and CPB Netherlands Bureau for Economic Policy Analysis (The Netherlands); Institute for Prospective Technological Studies (Spain); The Vienna Institute for International Economic Studies, and Österreichisches Institut für Wirtschaftsforschung (Austria); Zentrum für Europäische Wirtschaftsforschung, and Hochschule Konstanz (Germany); The Conference Board Europe (Belgium); Institute of Communication and Computer Systems (Greece); Central Recherche SA, and the Organisation for Economic Cooperation and Development (OECD) (France). The full database is available free of charge at www.wiod.org, and a detailed description of its construction can be found in Dietzenbacher et al. (2013).

[51] The non-European countries covered are Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Republic of Korea, Russia, Taiwan, Turkey, and the United States. Estimations for "Rest of the World" are based on bilateral trade data and totals for industry output and final use categories from the UN National Accounts, assuming the average input structure of key emerging countries (Brazil, Russia, India, China, Indonesia, and Mexico).

[52] See Timmer et al. (2016) for more information on the updated WIOD and how it compares to the initial release.

[53] Products classification is based on the international Classification of Products by Activity (CPA), while industries classification is based on revision 4 of the International Standard Industrial Classification of all economic activities (ISIC Rev. 4) (or ISIC Rev. 3 in the 2013 release of the WIOD). The tables adhere to the 2008 version of the SNA (in the 2013 release of the WIOD, the 1993 version of the SNA is used).

construct international SUTs in which the use of products is broken down according to origin country.[54] Finally, international SUTs were transformed into symmetric World Input-Output Tables (WIOTs) of the format 56 industries by 56 industries.

The WIOD database consists of time series of: 1) national tables (national IOTs at current prices and national SUTs at current and previous year prices), and 2) world tables (international SUTs at current and previous year prices, WIOTs at current and previous year prices, and interregional IOTs for 6 regions (Euro-zone, Non-Euro European Union, NAFTA, China, East Asia, and BRIIAT[55])). Additionally, the database provides detailed socio-economic and environmental satellite accounts (capital stock, investment, wages and employment by skill type, energy use, emissions, land use, materials use and water use). The tables trace the flows of consumption, production and incomes within and across countries, and break down products according to their origin. Thus, WIOD can be used for both inter-temporal and cross-country comparisons.

b) Eora database

Eora is a publicly available multiregional input-output database that focuses on environment issues and has as primary aim the comprehensiveness of coverage, both in terms of countries and industries.[56] It covers 187 countries with a time frame spanning from 1990 to 2011, and includes 25-500 industries (depending on the country).

The database draws upon information from a variety of primary data sources: national IOTs, SUTs and national accounts data from countries' statistical offices; macroeconomic aggregates from the United Nations National Accounts Main Aggregates Database; and trade data from the United Nations Commodity Trade Statistics Database (COMTRADE) and the United Nations Service Trade Statistics Database. In order to create a continuous time series of balanced and consistent multiregional IOTs, combining the often conflicting data sources and dealing with missing data, interpolation and estimation techniques are used. Since the tables are balanced to match principally data from large economies, there are important deviations from

[54] Use tables were first split into domestic products and foreign products (based on a distinction by end-use categories derived from a refinement of BEC codes); in a second stage, the use of foreign products was split according to country of origin.
[55] BRIIAT comprises Brazil, Russia, India, Indonesia, Australia, and Turkey.
[56] The Eora project was developed by the University of Sydney and funded by the Australian Research Council. The full database can be downloaded for free at http://worldmrio.com, and a description of its construction can be found in Lenzen et al. (2013). The UNCTAD TiVA dataset, which provides statistics related to trade in value-added, was constructed using the Eora multiregional IOTs.

observed trade flows and GDP (Cattaneo et al., 2013).[57] Therefore, the database should be used with caution, especially if a high reliability and precision of the results on smallest countries (for which input-output data availability is often very limited) is important.[58]

A guiding principle of Eora is close adherence to the raw data, in the sense that changes to the structure of the original raw data are avoided as much as possible, for the sake of transparency. Thus, the database includes original SUTs, industry-by-industry or product-by-product IOTs, depending on the country, with data expressed in current national currencies. These different national tables are linked into one yearly compound multiregional IOT (constructed in current US dollars), where original national sectoral disaggregations are maintained. However, Eora also provides a time series of harmonised multiregional IOTs, based on a 25-industry classification. The monetary tables are complemented by satellite accounts covering 35 environmental and resource use indicators.

The main advantage of Eora over WIOD is its broader country coverage, which makes possible a more comprehensive analysis of developing countries' participation in GVCs. However, the inclusion of data-poor countries reduces the level of statistical rigor, raising concerns about the accuracy of such analysis.

c) EXIOPOL database

EXIOPOL is a detailed, transparent, harmonised, global Multi-Regional Environmentally Extended Input-Output Table that covers 43 countries with 129 industry sectors and products. It also, by design, includes data on 30 emitted substances and 80 resources by industry. The latest version covers data for 2007.

[57] The database provides information on the reliability of the raw data by means of standard deviation estimates, which reflect the extent to which each data point was interpolated or estimated, during the process of assembling the global multiregional IOTs, from constituent primary data sources. However, in many cases the standard deviations of raw data are based on assumptions, since very little information on the uncertainty of macroeconomic and input-output data is available.

[58] For 74 of the 187 countries covered in the database, specific IOTs or SUTs were obtained from various statistical agencies. For a small number of countries (including Australia, the United Kingdom and some Central Asian economies) tailor-made input-output data sets were used. In other cases, national IOTs were estimated from actual macroeconomic aggregates using a "template" 25-sector IOT, which is considered to describe a typical economic structure.

Endnotes *These endnotes correct typos in the OECD Working Paper version (post-publication) and provide additional clarification or context.*

[i] *(p. 27)* The statement is not true in all situations (Hummels et al., 2001). For example, suppose a sector produces two goods: one that relies heavily on imported intermediates and is heavily exported; the second good uses no imported inputs and is not exported. At the sectoral level, VSD is underestimated (hence a disaggregation increases VSD). Aggregation matters and can lead to either an underestimation or overestimation of VSD.

[ii] *(p. 30)* The footnote should refer to equations (2.20), (2.22), and (2.26).

[iii] *(p. 32)* The footnote should refer to equation (2.28), not to (2.26).

[iv] *(p. 33)* The OECD-WTO TiVA initiative considers Trade in Value Added to include indicators that measure value-added embodied in gross trade *and* indicators that measure value-added embodied in (foreign) final demand. The OECD does not make a distinction in terminology between those two sets of indicators. However, in the Groningen tradition, only the latter set of indicators refers to trade in value-added (along the lines of Johnson and Noguera, 2012) while the former would be considered indicators based on vertical specialization (along the lines of Hummels et al., 2001).

We use the broad OECD meaning of trade in value added, which includes all the above indicators, to be consistent with the terminology still used by the organization that published this document. Thus the sections "Domestic value-added content of exports" and "Foreign value-added content of exports" (based on VAX notation) refer to indicators related to value-added embodied in gross trade (i.e., using the vertical specialization approach); and the section "Value-added induced by final demand" (based on VAF notation) refers to indicators related to value-added embodied in final demand (i.e., using the value-added exports approach). Note that our references to VAX do not relate to the VAX-ratio measure by Johnson and Noguera (2012).

For further information and a list of OECD indicators, many of which are similarly defined as ours, see: OECD (2019).

[v] *(p. 35)* Equation (2.34) contains a typo: instead of $\mathrm{VAXD_c}$ it should be $\mathrm{DVAXD_c}$.

[vi] *(p. 35)* The sentence in parenthesis is incorrect. The correct way of disaggregating the domestic value-added content of gross exports is by post-multiplying by a K×K diagonal matrix $\hat{\mathbf{E}}_\mathrm{c}$, indicating all exports for each separate industry, i.e., $\boldsymbol{\iota}\hat{\mathbf{V}}_\mathrm{c}[(\mathbf{I}-\mathbf{A}_\mathrm{c}^\mathrm{D})^{-1}-\mathbf{I}]\hat{\mathbf{E}}_\mathrm{c}$.

[vii] *(p. 36)* Equation (2.38) is misattributed as Johnson and Noguera's (2012) proposed VAX ratio. This is incorrect because the VAX ratio indicates the exports of value-added induced by foreign final demand (i.e., value-added exports) for each monetary unit of exports, not $\mathrm{DVAX_c}$ (which we had defined as domestic value-added embodied in gross exports).

[viii] *(p. 37)* This sentence contains a typo relating to the definition of the Leontief inverse. The Leontief inverse refers to the (extra) amount of sectoral gross output in producing country *c* required per (extra) unit of final demand (not "per unit of output").

[ix] *(p. 37)* The footnote should refer to equation (2.40), not to (2.38).

[x] *(p. 37)* In equation (2.41), $\mathrm{DVAXD_c} - \mathrm{DVAXI_c}$ can be simplified as $\mathrm{DVAX_c}$.

[xi] *(p. 38)* Equation (2.43) is only true if $\mathrm{DVAX_c} = \boldsymbol{\iota}\widehat{\mathbf{V}}_{\mathrm{c}}\mathbf{B}_{\mathrm{c,c}}\mathbf{e}_{\mathbf{c}}$. The previous paragraphs correctly explain how to measure the domestic value-added in gross exports using multi-regional or global IOTs (based on block matrices derived from the global Leontief inverse). This is what was intended to be reflected in equation (2.43). However, equation (2.33) had defined $\mathrm{DVAX_c}$ based on a national IOT, which could cause confusion in its interpretation. The definition of $\mathrm{DVAX_c}$ in equation (2.33) would be incorrect if used in the context of equation (2.43).

[xii] *(p. 41)* Note that Johnson and Noguera's (2012) VAX-ratio indicator is obtained by dividing $\mathrm{DVAF_c}$ by gross exports of country *c*.

[xiii] *(p. 43)* Equation (2.52) on length of GVCs is based on an indicator in De Backer and Miroudot (2014) and Los (2017). This indicator is inspired by Fally's indicator on GVC length (based on a national IOT), which we adapted to an ICIO table. We emphasize that this is only an indicator of the length of the value chain, not an actual measure of GVC length (which requires plant-level information).

Los (2017) observes that there are two key differences between the type of indicator we present in equation (2.52) and the measure of average propagation lengths (APL) proposed by Dietzenbacher and Romero (2007). First, the sale of a product to final users is a transaction in the production process. An index value of one thus implies that all goods and services produced are directly purchased by final consumers (i.e., no intermediate inputs are used to produce a final good or service). Second, the indicator aggregates all upstream industries *i* when measuring the average number of transactions required before final users are the owners of a product delivered by industry *j*.

Hence, Los (2017) argues that the indicator is appropriately characterized as showing the importance of specialized activities in GVCs. This is based on a weighted average of the production length involved in the industries that provide inputs to the production process. If equation (2.52) is element-wise post-multiplied by a (K×N)×(K×N) matrix of zeroes in the diagonal blocks and ones elsewhere, the average number of international transactions (giving the physical degree of international fragmentation of production processes) is computed.

[xiv] *(p. 44)* Equation (2.53) is better characterized as showing the position of countries in the value chain and gives the average number of production stages for industry output to be absorbed in final demand. This is also based on an indicator in De Backer and Miroudot (2014) and Los (2017). The measure corresponds to the row sum of the Ghosh Inverse matrix. The row sum gives the strength of total forward linkages in the production process (Johnson, 2018). Note that there is a mistake in the equation in De Backer and Miroudot (2014), which is also reflected in equation (2.53). The Gosh inverse should be post-multiplied (instead of pre-multiplied) by a vector of ones. Thus, the correct equation for distance to final demand (see e.g., Los, 2017) is $\mathbf{d} = (\mathbf{I} - \mathbf{G})^{-1}\boldsymbol{\iota}$, where $\boldsymbol{\iota}$ is a column-vector of ones and $\mathbf{d}$ is also a column-vector.

Chapter 3

The role of services in globalisation

ABSTRACT

This paper explores the role of services in international trade and global value chains, and adds to our knowledge on recent trends in globalisation. We employ indicators for trade in value-added (VA) and for gross exports, and address the following two questions: (i) has trade of VA in services (i.e., the VA created by domestic service industries and embodied in foreign consumption of final products) grown more than trade of VA in manufacturing; and (ii) does trade of VA in services travel further than trade of VA in manufacturing. Based on the World Input-Output Database (WIOD), we find, in general, that for the period 2000–14, the share of services in exports of VA grew over time, whilst the share of manufacturing remained constant (or grew relatively less). Second, throughout the entire period, services had a larger share in interregional exports of VA than in intraregional exports of VA, whilst the opposite was true for manufacturing. Services were thus more global than manufacturing.

This chapter is based on Bohn et al. (2018).

3.1 Introduction

Empirical trade research is focused on manufactured goods despite the rapid growth of services trade (Feenstra, 2016). To a large extent, this is caused by data restrictions on services trade. Services are not only directly traded but also indirectly embodied in manufacturing exports (Drake-Brockman and Stephenson, 2012). The indirect contributions of (domestic) services inputs in exported manufactured goods are not captured by traditional statistics such as balance of payments statistics.[59] Gross exports thereby—potentially—understate the significance of services, and also the extent of globalisation (Johnson, 2014).

This paper focuses on the role of services and addresses the following two questions to highlight the growing importance of services trade. First, it is often stated that the growing usage of information and communication technologies has expanded the scope of services and enhanced their tradability (Baldwin, 2016). Is this trend reflected in a rising importance of trade in services relative to trade in manufactured goods over time? Second, assuming relatively low transport barriers related to services, trade in services (when compared to manufacturing) could be more important in interregional trade than in intraregional trade. The ICT revolution reduces trade barriers and facilitates fragmentation of the production process (Baldwin, 2016). Do services, which we define in a broad sense to include both embedded services and direct services exports, therefore travel further than manufactured goods? These questions follow Low's (2013) call for more analytical research on the characteristics of services in global value chains. They also serve the goal of Baldwin and Lopez-Gonzalez (2015) to stimulate more empirical and theoretical work on how the internationalisation of production has altered the nature and impact of globalisation.

The analysis is primarily based on trade in value-added. The trade in value-added perspective employs a different method than does a standard trade analysis based on gross trade. This approach involves using input–output analysis to measure the value-added produced in one country that ends up in the consumption bundle of another country. In the case of services trade, this captures the direct value-added of domestic services industries that is embodied in a product traded by industries in trade. We use two indicators to capture the significance of services both from an upstream and a downstream viewpoint.

[59] Trade in services data is collected according to the Extended Balance of Payments System (EBOPS) in the International Monetary Fund's *Balance of Payments Statistics*, but the quality is lower than for goods trade; in addition, few countries provide bilateral data or much product level detail (Ahmad et al., 2017).

Previous research shows that three-quarters of all services embodied in value-added trade are embedded services rather than directly traded (Heuser and Mattoo, 2017). To provide a complementary analysis that considers only directly traded products, we compare the value-added data to a more conventional approach that draws upon gross exports. Gross exports provide only the value of all products directly exported by services industries and manufacturing industries (even if there are industries from other sectors that contribute to their respective total export values). The distinction between embedded services and directly traded services is important when the relative distances of services and manufactured goods in trade are analysed in Section 3.4.2. The main source for the analyses is the World Input-Output Database (Dietzenbacher et al., 2013), containing time-series data on trade linkages for 43 countries and 56 industries.

In general, we find that trade in value-added created in services increased more than trade in value-added created in manufacturing during the period 2000–14. This holds especially for the European Union and North America. Second, trade of value-added in services is traded over longer distances than trade of value-added in manufacturing. That is, services had a larger share in the interregional exports of value-added than in the intraregional exports of value-added and the opposite held for manufacturing. In Europe, it was especially the value-added created in financial intermediation services and business services (IT and consulting) that was more important in interregional trade in value-added. The findings hold not only for trade in value-added indicators (which account for the large indirect value-added created by services industries) but also when indicators are used that capture the direct exports of services industries themselves (gross export figures). These findings add to our knowledge of globalisation: trade is increasing worldwide, and interregional globalisation in the sense of rising trade between countries from different regions is related to the role of services being more truly global than the role of manufacturing.

The paper is structured as follows. Section 3.2 explains why services may be growing in importance in trade. It is explained how a value chain-based approach provides a better statistical depiction of the services embodiment of trade. Section 3.3 describes the approach to measure services trade and presents the methodology and data sources. Indicators are introduced to measure a country's dependence on trade as a share of its GDP and final demand. Section 3.4 applies the indicators to answer the research questions. Section 3.5 concludes and discusses some implications.

3.2 Literature

3.2.1 The growing importance of services

Recent growth in world trade is closely intertwined with the emergence of global production networks.[60] Specialisation no longer refers to sectors within countries but to specialisation in different activities within production networks. This implies that international trade is characterised by trade in intermediate products (Jones and Kierzkowski, 2001). The international fragmentation of production has been helped by the ICT revolution that came on top of the sharp decline in trade barriers since the late 1980s. Baldwin (2006, 2016) refers to this phenomenon as the "second unbundling" and argues that it represents the transition to a new era of globalisation.[61] These developments can be illustrated from the perspective of global value chains (GVCs). A GVC encompasses all productive (value-adding) activities across countries involved in bringing a product to the final consumer. This includes initial conception (e.g., R&D), production, assembly, marketing and distribution, final delivery and support (Gereffi and Fernandez-Stark, 2016). While the final product in a GVC is completed in one country only and then sent to the consumer, the product contains intermediate inputs and value-added contributions sourced from one or more countries.

The "second unbundling" is not just a technological revolution in manufacturing but also a revolution in services as the use of services is pivotal in the spatial unbundling of tasks. The rise of information and communication technologies (ICT) reduced the coordination costs of complex production processes, enabling the global fragmentation of production. Embodied services were also traded in antiquity (see O'Rourke and Williamson, 2002; who debate how long ago globalisation began), but sophisticated ICT services, transport and financial services have in recent decades helped to facilitate highly fragmented production processes that source inputs (parts and components) from all over the world. For these reasons, services have been referred to as the "glue" linking fragments within production chains together (Drake-Brockman and Stephenson, 2012; Low, 2013). So, services can be expected to play an increasingly essential role in trade.

This also has policy consequences. The National Board of Trade (2012) of Sweden, for instance, indicates how GVCs have implications for trade policy and management of trade

[60] Equivalent terms commonly used to refer to the importance of international production networks include the unbundling or fragmentation of production, supply chain trade, trade in tasks and vertical specialisation.
[61] Globalisation's "first unbundling" began in the 1820s with the spatial separation of production and consumption. One prominent study calls this first unbundling, fueled by the transport revolution, the "big bang" of globalisation (O'Rourke and Williamson, 2002).

agreements. The authors argue that trade negotiators should not focus on manufactured goods or services in isolation but rather consider the interdependencies of the two and take the value chain into account.[62] Recent research also suggests that trade liberalisation in services, broadly defined as opening up the domestic market for foreign services providers, can induce a comparative advantage for downstream production processes that rely heavily upon services inputs. Countries that reduce trade restrictions for services and have complementary domestic regulatory policies are more likely to gain a comparative advantage in producing manufactured goods that depend on services (Van der Marel, 2016). Furthermore, liberalisation in services can stimulate productivity in manufacturing (Arnold et al., 2016).

Services account for 75% of GDP and 80% of employment in OECD countries (Nordas and Rouzet, 2017). However, the role of services in cross-border trade and production networks remains less understood. This is mainly caused by a lack of reliable data at the aggregate level and conceptual difficulties as to how to define a service and what the balance of payments measure (Broussolle, 2014, 2015). The rise of GVCs adds to this statistical challenge. Take for example, a Boeing 787 aircraft composed of parts and components produced in 5,000 factories worldwide before being assembled in the US (Kelly, 2012). The production of each component in turn requires subcomponents sourced from even more countries. In the current accounting system based on gross exports, these intermediates are counted each time they cross the border, including when embodied in downstream goods and services. This raises issues related to multiple-counting.

The current accounting system retains legitimacy as long as countries exist because actual trade is still bilateral and these are the transactions that are registered by customs officials. However, relying solely on gross exports may lead to misleading interpretations when they are used by policymakers to assess trade competitiveness because sophisticated inputs may have been imported. The Boeing 787's final assembler, for example, contributes considerably less to the plane's production value than what is suggested by the plane's final export price. A GVC perspective can identify the largest value creators and also identify the final consumers in the end-market, whose demand triggers value-added production in other countries through their consumption of final goods and services. For these reasons, both the standard and GVC views have their legitimacy and contribute in complementary ways to the analysis of trade.

[62] This discussion refers indirectly to the effective rate of protection (Bhagwati et al., 1998). This concept of protection explicitly includes supply chain effects.

3.2.2 Two questions

Manufacturing industries that are involved in trade—especially those involved in the production of elaborately transformed and high-value-added goods—depend on domestic services (Drake-Brockman and Stephenson, 2012). This implies that there are more services being traded than what is suggested by gross export statistics. Gross export statistics report the directly traded services, such as communications services, but not the domestic services that are embodied in the export of manufactured goods, commodities or even other services (which are hence traded indirectly). Therefore, focusing on the trade of value-added in service industries has two advantages. First, value-added trade has a higher correlation with domestic non-tradable services that are used as inputs than gross exports trade data. The latter only reflects the total value of the traded product and does not separate out the domestic non-tradable services component that contributes to its final value, such as embedded software in aircraft. Second, inputs passing through multiple countries within production networks are not double counted.

Whenever we refer to exports (or imports) of value-added, for example, the trade of value added in services industries, we refer to the domestic value-added generated by the industries of this sector (i.e., services) that is consumed abroad (respectively imported and consumed domestically). In this way, there can be trade in value-added between two countries even if there is no bilateral trading relationship because the value-added may be delivered to final consumers via a third country. The final demand approach provides the location where the value-added is ultimately consumed, home or abroad, but does not decompose gross exports. Thus, while all value-added contributions of services industries to trade are accounted for, this inclusive approach does not distinguish between the trade of value-added in services that is embodied in products traded by manufacturing industries, traded by the same or different services industries or traded by other sectors (e.g., agricultural production). Similarly, the trade of value-added in manufacturing is considered to be all domestic value-added created in manufacturing industries—even if the value-added is embodied in a traded service—that ends up in the foreign consumption of final products. The industries included in the manufacturing sector, services sector and other production sector are provided in Appendix Table 3.A1. A more detailed explanation of the method and computations are provided in Section 3.3 on analytical framework.

The first question considers the increased tradability and importance of services over time, which Saez et al. (2014, p. 2) refer to as "one of the most important changes in trade patterns over the last quarter of the 20th century." Value-added trade of services industries is growing relative to value-added trade of manufactured goods industries.

The growth of services in value-added trade is documented in previous studies (Heuser and Mattoo, 2017; Miroudot and Cadestin, 2017). For example, Heuser and Mattoo (2017) show that the share of services in world value-added exports increased from about 30% to more than 40% since 1980. Our approach differs in that we use a final demand perspective and decompose the trade in value-added and gross exports on a regional basis (Europe, North America and East Asia). This could demonstrate how patterns in different regions may differ and whether the overall growth in services is a truly global phenomenon. Therefore, we ask the following question:

Question 1: Has trade of value-added in services industries become more important relative to trade of value-added in manufactured goods industries between 2000 and 2014?

Next, we will focus on the distance traversed from the point of value creation to the point of consumption. In other words, does the value-added contributed by services or by manufacturing industries travel "further"? A clear difference in their average distances (in connection to the answer to the first question) may contribute to our understanding of the spatial reach of trade; the ICT revolution could have facilitated services trade of longer distances. Here too, value-added trade refers to both direct cross-border services trade and services embodied, for example, in the trade of manufactured goods. Due to data limitations on services, no existing study has looked into this issue.

Direct (non-embedded) services exports are by themselves not subject to transportation costs and this should in theory facilitate their trade over large distances. But also embedded services may traverse a longer distance because they add value to the exports of manufactured goods. Customised and elaborated products that embody more services (such as software) might reduce the impact of distance by decreasing relative transport costs. Even manufactured goods that do not embody many services, but which travel a longer distance will increase the role of services for the simple fact that transport costs are themselves considered a service.

On the other hand, recent studies have shown that trade costs for direct services trade are several times higher than for goods (Anderson et al., 2014; Miroudot et al., 2013). Significant regulatory burdens, non-tariff barriers and trade restrictions for services persist and these are magnified as barriers for trade in goods decline. Impediments to services trade are highlighted by the OECD's Services Trade Restrictiveness Index. One could argue that regulatory burdens are greater across larger distances if the well-known liability of foreignness equally applies to trade in direct services. Restrictions on direct services trade also have an effect on embedded services because exported goods may depend on services inputs that need to be imported. This would suggest that value-added created by service industries may not travel further than value-added created by manufacturing industries.

Another factor that could play a role is that countries belonging to regional agreements may have a higher level of regulatory convergence in services. This suggests they may trade more direct services and also more embedded services because it would be easier to import foreign services inputs. Deeper agreements that also provide provisions for services are more common amongst geographically proximate countries (e.g., the EU), and hence, this could lead to a stronger regional nature of services trade. However, deeper regional agreements that promote regulatory convergence in services would likely also have provisions that stimulate the trade of manufactured goods. Thus, it is not clear whether the trade facilitating effect of regulatory convergence would be stronger on the services sector or on the manufacturing sector.

Question 2: Does trade of value-added in services industries travel further than trade of value-added in manufactured goods industries?

3.3 Analytical framework and data sources

To investigate the two research questions, we use world input–output tables (WIOTs). WIOTs illustrate flows (i.e., sales and purchases) of industry outputs (final and intermediate) within an economy.[63] WIOTs enable researchers to trace interdependencies in global production and the division of income in trade between industries, countries and regions. Value-added refers to the "difference between the value of output minus the sum of required intermediate inputs of goods and services" (Escaith, 2014a, p. 1). This is equivalent to total compensation for labour and capital.

There are two main approaches to measure value-added trade. The demand-side absorption approach (or "trade in value-added") computes how much value-added that is created in industry i in country r is contained in the demand for final products by country s (Johnson and Noguera, 2012). Final demand consists of the categories household consumption, government expenditures and investments. Note that it is possible that country s does not import from country r, whereas s's consumption bundle still embodies much value-added generated in r. In

[63] This follows the OECD's definition: http://www.oecd.org/trade/input-outputtables.htm.

that case, there is no dependence in gross trade between r and s, whereas dependence in terms of trade in value-added does exist. Hence, even country pairs that have no gross bilateral trade may still be mutually dependent via third countries.

By comparison, the supply-based approach (or "value-added in trade") estimates country r's value-added embodied in its bilateral or total gross exports (Koopman et al., 2014). The domestic value-added in gross exports is decomposed into three parts. First is direct domestic value-added created by the exporting industry in country r. Second is indirect domestic value added through the exporting industry's use of inputs from domestic upstream industries. Third is re-imported domestic value-added. This is relevant in certain outsourcing arrangements such as circular trade. Semi-finished products may be shipped from the United States to Mexico for assembly before returning to the US for re-export. This method separates foreign value-added embodied in a country's exports from domestic value-added—also solving double-counting. Both demand-side and supply-side approaches are consistent in that they lead to similar total trade figures on the global level (Escaith, 2014b). A country's total trade surplus or deficit will be the same using either method, but bilateral trade balances between countries may differ.

This study applies the demand-side absorption approach which essentially answers the question "who generates how much value-added for whom?". The answer can be viewed from two different perspectives. These are the seller's or downstream viewpoint (which traces where the value-added goes to) and the buyer's or upstream viewpoint (which traces where the value added—that composes all final demand—comes from). We employ measures that consider both upstream and downstream value-added based dependencies, formalising the concepts introduced by Johnson and Noguera (2012). Our starting-point is the WIOT in Table 3.1 with m countries, each with n industries.

The $mn \times mn$ matrix $\mathbf{D}$ of intermediate deliveries,[64] the $mn \times m$ matrix $\mathbf{F}$ of final demands, the mn-element output vector $\mathbf{z}$, and the mn-element value-added vector $\mathbf{v}$ are (in partitioned form) given by

[64] Matrices are in bold capital letters (e.g., $\mathbf{D}$ or $\mathbf{D}^{rs}$), vectors are in bold lower case letters (e.g., $\mathbf{z}$ or $\mathbf{z}^r$), and scalars are in italicized letters (e.g., n, z_i^r, or d_{ij}^{rs}). A circumflex (or "hat") is used to indicate a diagonal matrix (e.g., $\hat{\mathbf{z}}$ or $\hat{\mathbf{z}}^r$) and an apostrophe (or "dash") for transposition (e.g., $\mathbf{z}'$ or $(\mathbf{z}^r)'$).

Table 3.1. WIOT with *m* countries

	Intermediate deliveries							Final demands							Total
	1	⋯	*r*	⋯	*s*	⋯	*m*	1	⋯	*r*	⋯	*s*	⋯	*m*	Total
1	$\mathbf{D}^{11}$	⋯	$\mathbf{D}^{1r}$	⋯	$\mathbf{D}^{1s}$	⋯	$\mathbf{D}^{1m}$	$\mathbf{f}^{11}$	⋯	$\mathbf{f}^{1r}$	⋯	$\mathbf{f}^{1s}$	⋯	$\mathbf{f}^{1m}$	$\mathbf{z}^{1}$
⋮	⋮	⋱	⋮		⋮		⋮	⋮	⋱	⋮		⋮		⋮	⋮
r	$\mathbf{D}^{r1}$	⋯	$\mathbf{D}^{rr}$	⋯	$\mathbf{D}^{rs}$	⋯	$\mathbf{D}^{rm}$	$\mathbf{f}^{r1}$	⋯	$\mathbf{f}^{rr}$	⋯	$\mathbf{f}^{rs}$	⋯	$\mathbf{f}^{rm}$	$\mathbf{z}^{r}$
⋮	⋮		⋮	⋱	⋮		⋮	⋮		⋮	⋱	⋮		⋮	⋮
s	$\mathbf{D}^{s1}$	⋯	$\mathbf{D}^{sr}$	⋯	$\mathbf{D}^{ss}$	⋯	$\mathbf{D}^{sm}$	$\mathbf{f}^{s1}$	⋯	$\mathbf{f}^{sr}$	⋯	$\mathbf{f}^{ss}$	⋯	$\mathbf{f}^{sm}$	$\mathbf{z}^{s}$
⋮	⋮		⋮		⋮	⋱	⋮	⋮		⋮		⋮	⋱	⋮	⋮
m	$\mathbf{D}^{m1}$	⋯	$\mathbf{D}^{mr}$	⋯	$\mathbf{D}^{ms}$	⋯	$\mathbf{D}^{mm}$	$\mathbf{f}^{m1}$	⋯	$\mathbf{f}^{mr}$	⋯	$\mathbf{f}^{ms}$	⋯	$\mathbf{f}^{mm}$	$\mathbf{z}^{m}$
VA	$(\mathbf{v}^{1})'$	⋯	$(\mathbf{v}^{r})'$	⋯	$(\mathbf{v}^{s})'$	⋯	$(\mathbf{v}^{m})'$								
Total	$(\mathbf{z}^{1})'$	⋯	$(\mathbf{z}^{r})'$	⋯	$(\mathbf{z}^{s})'$	⋯	$(\mathbf{z}^{m})'$								

$$\mathbf{D} = \begin{bmatrix} \mathbf{D}^{11} & \cdots & \mathbf{D}^{1r} & \cdots & \mathbf{D}^{1s} & \cdots & \mathbf{D}^{1m} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{D}^{r1} & \cdots & \mathbf{D}^{rr} & \cdots & \mathbf{D}^{rs} & \cdots & \mathbf{D}^{rm} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{D}^{s1} & \cdots & \mathbf{D}^{sr} & \cdots & \mathbf{D}^{ss} & \cdots & \mathbf{D}^{sm} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{D}^{m1} & \cdots & \mathbf{D}^{mr} & \cdots & \mathbf{D}^{ms} & \cdots & \mathbf{D}^{mm} \end{bmatrix}, \mathbf{z} = \begin{pmatrix} \mathbf{z}^{1} \\ \vdots \\ \mathbf{z}^{r} \\ \vdots \\ \mathbf{z}^{s} \\ \vdots \\ \mathbf{z}^{m} \end{pmatrix}$$

$$\mathbf{F} = \begin{bmatrix} \mathbf{f}^{11} & \cdots & \mathbf{f}^{1r} & \cdots & \mathbf{f}^{1s} & \cdots & \mathbf{f}^{1m} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{f}^{r1} & \cdots & \mathbf{f}^{rr} & \cdots & \mathbf{f}^{rs} & \cdots & \mathbf{f}^{rm} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{f}^{s1} & \cdots & \mathbf{f}^{sr} & \cdots & \mathbf{f}^{ss} & \cdots & \mathbf{f}^{sm} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{f}^{m1} & \cdots & \mathbf{f}^{mr} & \cdots & \mathbf{f}^{ms} & \cdots & \mathbf{f}^{mm} \end{bmatrix}, \mathbf{v} = \begin{pmatrix} \mathbf{v}^{1} \\ \vdots \\ \mathbf{v}^{r} \\ \vdots \\ \mathbf{v}^{s} \\ \vdots \\ \mathbf{v}^{m} \end{pmatrix}$$

Element d_{ij}^{rs} of the $n \times n$ matrix $\mathbf{D}^{rs}$ gives the money value (say in million dollars, m$) of intermediate deliveries from industry *i* in country *r* to industry *j* in country *s*, element f_i^{rs} of the *n*-element vector $\mathbf{f}^{rs}$ gives the deliveries from industry *i* in country *r* for final demands in country *s*, element z_i^r of the *n*-element vector $\mathbf{z}^r$ gives the output of industry *i* in country *r*, and element v_i^r of the *n*-element vector $\mathbf{v}^r$ gives the value-added generated in industry *i* in country *r*. The $mn \times mn$ matrix with input coefficients is given by $\mathbf{A} = \mathbf{D}\hat{\mathbf{z}}^{-1}$, implying $\mathbf{A}^{rs} = \mathbf{D}^{rs}(\hat{\mathbf{z}}^s)^{-1}$ or $a_{ij}^{rs} = d_{ij}^{rs}/z_j^s$ which gives the intermediate inputs per unit of the receiving industry's output. In the same fashion, the value-added coefficients are given by $\mathbf{g}' = \mathbf{v}\hat{\mathbf{z}}^{-1}$, implying $(\mathbf{g}^r)' = (\mathbf{v}^r)'(\hat{\mathbf{z}}^r)^{-1}$ or $g_i^r = v_i^r/z_i^r$ which gives the value-added in industry *i* in country *r* per unit of its output.

From the WIOT in Table 3.1 it follows that $\sum_{s=1}^{m} \mathbf{D}^{rs}\mathbf{e} + \sum_{s=1}^{m} \mathbf{f}^{rs} = \mathbf{z}^r$, where $\mathbf{e}$ is a summation vector (consisting of ones) of appropriate length. Using the definition of the input coefficients ($\mathbf{D}^{rs} = \mathbf{A}^{rs}\hat{\mathbf{z}}^s$) yields $\sum_{s=1}^{m} \mathbf{A}^{rs}\mathbf{z}^s + \sum_{s=1}^{m} \mathbf{f}^{rs} = \mathbf{z}^r$, or $\mathbf{z} = \mathbf{Az} + \mathbf{Fe}$. Its solution is given by $\mathbf{z} = \mathbf{LFe}$, where the $mn \times mn$ matrix $\mathbf{L} \equiv (\mathbf{I} - \mathbf{A})^{-1}$ is the Leontief inverse, which – in its partitioned form – is given by

$$\mathbf{L} = \begin{bmatrix} \mathbf{L}^{11} & \cdots & \mathbf{L}^{1r} & \cdots & \mathbf{L}^{1s} & \cdots & \mathbf{L}^{1m} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{L}^{r1} & \cdots & \mathbf{L}^{rr} & \cdots & \mathbf{L}^{rs} & \cdots & \mathbf{L}^{rm} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{L}^{s1} & \cdots & \mathbf{L}^{sr} & \cdots & \mathbf{L}^{ss} & \cdots & \mathbf{L}^{sm} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{L}^{m1} & \cdots & \mathbf{L}^{mr} & \cdots & \mathbf{L}^{ms} & \cdots & \mathbf{L}^{mm} \end{bmatrix}$$

For any final demand vector, we can calculate the outputs in each country and next how much value-added is involved. Take the final demands in country s (i.e., $\mathbf{f}^{ts}$, with $t = 1, \ldots, m$). The production in country r that is necessary to satisfy these (and only these) final demands is $\sum_{t=1}^{m} \mathbf{L}^{rt}\mathbf{f}^{ts}$. Premultiplying this production in country r with the value-added coefficients gives the vector $\sum_{t=1}^{m} \hat{\mathbf{g}}^{r}\mathbf{L}^{rt}\mathbf{f}^{ts}$. Its ith element gives the value-added generated in industry i in country r that is embodied in the final demands in country s. The total value-added generated in country r that is embodied in the final demands in country s then is $\sum_{t=1}^{m}(\mathbf{g}^{r})'\mathbf{L}^{rt}\mathbf{f}^{ts}$. If $r \neq s$, it gives the value-added of country r that is ultimately absorbed by the final users in country s or, in other words, the exports of value-added from r to s. For the value-added exports we thus have $VAX^{rs} = \sum_{t=1}^{m}(\mathbf{g}^{r})'\mathbf{L}^{rt}\mathbf{f}^{ts}$.

We can now create an $m \times m$ matrix with VAX^{rs} (including the diagonal elements with $r = s$). It can be shown that its rowsums equal the GDP of the corresponding country (i.e., $\sum_{s=1}^{m} VAX^{rs} = GDP^{r}$). Taking the downstream perspective, the answer to the question "where does the value-added of country r go to?" is: VAX^{rr} is for the own final users, $\sum_{s\neq r} VAX^{rs}$ is exported and is for final users abroad. Normalizing the rows of the matrix with VAX^{rs} gives percentages or ratios. The exports of value-added indicator is defined as

$$XVA^{rs} = \frac{VAX^{rs}}{GDP^{r}} \tag{3.1}$$

It expresses the share of country r's GDP that is exported to country s and is embodied in its final demands. The share of GDP^{r} that is exported yields (by summing over all destination countries) $XVA^{r} = \sum_{s\neq r} XVA^{rs}$.

In the same fashion, it can be shown that the column-sums equal the total value of final demands of the corresponding country (i.e., $\sum_{r=1}^{m} VAX^{rs} = \sum_{r=1}^{m}\sum_{i=1}^{n} f_{i}^{rs} = FD^{s}$). Note that all final demands consist of pieces of value-added that are consumed by final users. The upstream perspective thus asks "where does the consumed value-added in country s come from?" and the answer is: VAX^{ss} is by the own producers, $\sum_{r \neq s} VAX^{rs}$ is imported (and is thus generated by producers abroad). Normalizing the columns of the matrix with VAX^{rs} gives the shares again. The imports of value-added indicator is defined as:

$$MVA^{rs} = \frac{VAX^{rs}}{FD^{s}} \tag{3.2}$$

It expresses the share of country s's total value of final demand (FD) that is imported from and generated by country r. In other words, the value-added imports from r as a share of total final demands in country s.

To assess whether services travel further than manufactured goods (Section 3.4.2), it is necessary to distinguish between dependence on intraregional and interregional trade. In the empirical application we will focus on three regions: EU, which consists of all 28 members of the European Union; North America, which consists of the three NAFTA countries Canada, Mexico and the United States; and East Asia, which consists of China, Japan, Korea and Taiwan. These are also the regions analysed in the two studies most closely related to this paper, Los et al. (2015) and Baldwin and Lopez-Gonzalez (2015).

The XVA and MVA indicators are split into intraregional and interregional components. Let us indicate a region with a capital letter. Then, the intraregional XVA for region R is obtained by summing the value-added exports of all members of R to all other countries in R, and taken as a share of regional GDP. Hence, for the intraregional XVA we have:

$$INXVA^{R} = \frac{\sum_{r \in R} \sum_{s \in R} (VAX^{rs} - VAX^{rr})}{\sum_{r \in R} GDP^{r}} \tag{3.3}$$

The interregional XVA (IRXVA) measures the value-added exports to countries outside the region. We have:

$$IRXVA^{R} = \frac{\sum_{r \in R} \sum_{s \notin R} VAX^{rs}}{\sum_{r \in R} GDP^{r}} \tag{3.4}$$

Note that $INXVA^{R} + IRXVA^{R} = XVA^{R}$, with:

$$XVA^{R} = \frac{\sum_{r \in R} \sum_{s} (VAX^{rs} - VAX^{rr})}{\sum_{r \in R} GDP^{r}} \tag{3.5}$$

The split of the MVA indicator into an intraregional and an interregional component is similar. That is, $INMVA^R = \sum_{r\in R}\sum_{s\in R}(VAX^{rs} - VAX^{rr}) \,/\, \sum_{s\in R} FD^s$ and $IRMVA^R = \sum_{r\notin R}\sum_{s\in R} VAX^{rs} \,/\, \sum_{s\in R} FD^s$.

When discussing the results, we will distinguish between the contributions of three sectors to trade flows in value-added and dependency shares. These are: manufacturing, services and other production. Recall that $\sum_{t=1}^{m} \hat{\mathbf{g}}^r \mathbf{L}^{rt}\mathbf{f}^{ts}$ is an n-element vector and its ith element gives the value-added generated in industry *i* in country *r* that is embodied in the final demands in country *s*. Denote this by VAX_i^{rs}. Then, we can split XVA^R for region R as: $XVA_{Manuf}^R + XVA_{Services}^R + XVA_{Other}^R$, with, for example,

$$XVA_{Manuf}^R = \frac{\sum_{r\in R}\sum_s \sum_{i\in Manuf}(VAX_i^{rs} - VAX_i^{rr})}{\sum_{r\in R} GDP^r} \quad (3.6)$$

There is a set of Appendix tables (Tables 3.A2–A7) that contain the results at industry level.

We use the 2016 release of the World Input-Output Database (WIOD) (Timmer et al., 2015). This database contains annual time-series of WIOTs for the period 2000–14. The consistent and harmonised tables include detailed data for 43 countries (including all 28 EU members and the major advanced and emerging economies) and 56 industries. In this paper, services are defined in a broad sense and include financial services; real estate; business services; transport services; post and telecommunications; education; public administration; health and social work; and wholesale trade and retail trade services. According to this broad definition, 29 of the 56 industries in the database are considered services industries. These 29 industries—numbered 28–56 in Table 3.A1—are considered part of the services sector in this analysis.[65] The 2016 release of the WIOD is an update of the 2013 version of the database, which covered 40 countries and a slightly earlier timeframe. The 2016 version offers more industry-level detail than the initial WIOD release. For example, the new version includes a disaggregation of business services. Reliable and detailed data for business services are useful, because business services are known to play a key role in global value chains (Berry et al., 2016).

Services data are the weakest part of current trade databases. This is because of the intangible characteristic of services output and the resulting challenge in capturing services trade flows. These challenges also hold for the WIOD and certain balancing procedures and

[65] Industries numbered 5–23 in Appendix Table 3.A1 are considered part of the manufacturing sector; and industries numbered 1–4 and 24–27 are considered part of the other production sector.

assumptions were necessary for the construction of internally consistent tables. Services data in the WIOD use alternative data sources than standard balance of payments statistics (customs information) because the database builds on international supply-use tables, which are sometimes regarded as providing more reliable data for services (Miroudot and Shepherd, 2016). For these reasons, the WIOD is regarded as a comprehensive, reliable and consistent database.

3.4 Empirical results

This section investigates evolving dependencies of the European Union, North American and East Asian regions on trade in value-added by applying the XVA and MVA indicators. Section 3.4.1 examines the extent to which trade of value-added in services industries is (or is not) becoming more important relative to trade of value-added in manufactured goods industries over time. This involves deriving sectoral shares of both value-added based indicators. Section 3.4.2 considers whether services or manufactured goods travel "further" in value-added trade. The results based on gross exports (from the same database) serve as a benchmark.

3.4.1 Identifying the relative importance of services over time

Table 3.2 reports the indicators XVA and MVA for the European Union's, North American and East Asian trade in value-added. The exports of value-added as a share of regional GDP were given by Equation (3.6), and the imports of value-added as a share of regional final demand are obtained from using a similar equation. The results are given for the years 2000 and 2014, and by sector. The sectors (that account for the entire economy) are: manufacturing (M), services (S) and other production (O), which includes agriculture, mining and quarrying, electricity and construction. The two years are the first and last year in the database.[66]

Using Equation (3.5), we have (note that XVA is a weighted average of the XVAs of the individual countries):

$$XVA^R = \sum_{r \in R} [\sum_s (VAX^{rs} - VAX^{rr}) / GDP^r] \frac{GDP^r}{\sum_{r \in R} GDP^r} = \sum_{r \in R} XVA^r \frac{GDP^r}{\sum_{r \in R} GDP^r} \qquad (3.7)$$

Table 3.2 shows that the average EU country exported 23.3% of its GDP in 2000, which rose to 27.6% in 2014, an increase of 4.3 percentage points (p.p.). That is, foreign final users

[66] Only the results for 2000 and 2014 are displayed and the results are aggregated on a regional level to illustrate the most important trends. However, results for individual countries within each region and for all 15 years are available upon request.

(responsible for household consumption, private investments and government expenditures) generate approximately one quarter of an EU country's GDP. The "earnings" triggered by foreign final demand is further split into the value-added generated in each sector. The exports of value-added generated by services amounted for the average EU country to 11.3% of its GDP in 2000 but to 15.0% in 2014, an increase of 3.7 percentage points. The results for all 56 industries are given in Appendix Table 3.A2. From these tables, it appears that approximately two-thirds of the overall increase (of 4.3 p.p.) in XVA was attributable to business services (1.8 p.p.) and wholesale/retail trade (0.9 p.p.).[67] The export of value-added has remained more or less constant for the sectors manufacturing and other production in the average EU country. Services have thus become more important over time for the generation of value-added triggered by foreign final demand.

Table 3.2. Trade in value-added and gross exports for three regions (European Union, North America and East Asia) and sectors

		European Union				North America				East Asia			
		M	S	O	T	M	S	O	T	M	S	O	T
XVA	2000	10.0	11.3	2.1	23.3	3.7	4.3	0.9	9.0	7.4	5.0	1.0	13.3
	2014	10.2	15.0	2.4	27.6	3.6	5.5	1.8	10.8	9.6	7.1	2.3	19.0
	Change	0.2	3.7	0.4	4.3	-0.2	1.2	0.9	1.9	2.2	2.2	1.2	5.7
MVA	2000	9.3	9.9	3.3	22.5	5.1	4.1	1.8	11.1	4.3	4.0	2.4	10.8
	2014	8.7	11.5	4.3	24.6	5.0	4.8	2.7	12.6	5.2	5.5	4.7	15.4
	Change	-0.6	1.6	1.0	2.0	-0.1	0.7	0.9	1.5	0.9	1.5	2.3	4.6
XGT	2000	23.7	8.4	1.8	33.9	7.9	3.3	0.9	12.0	13.8	3.0	0.2	17.1
	2014	27.2	14.0	2.3	43.5	8.0	4.5	1.7	14.1	21.5	4.2	0.3	26.1
	Change	3.5	5.6	0.5	9.6	0.0	1.2	0.8	2.1	7.7	1.2	0.1	9.0

Notes: The European Union includes all 28 EU members, North America includes Canada, Mexico and the United States, and East Asia consists of China, Japan, Korea and Taiwan. The sectors are: M = manufacturing; S = services; O = other production; and T = total/sum of all sectors. XVA refers to value-added exports as a share of GDP, averaged over the countries in the region. MVA refers to value-added imports as a share of total final demand, averaged over the countries in the region. XGT refers to total gross exports as a share of GDP, averaged over the countries in the region. Note that all data are rounded to the nearest tenth.

Whereas the XVAs indicate the foreign dependence on EU production, inputs and value-added, the MVAs indicate the EU dependence on foreign value-added. Of the total final demand in the average EU country, 22.5% was accounted for by foreign value-added in 2000, increasing

[67] The following industries make up business services: "Legal and accounting activities, activities of head offices, management and consultancy activities" (M69/M70); "Architectural and engineering activities, technical testing and analysis" (M71); "Scientific R&D" (M72); "Advertising and market research" (M73); "Other professional, scientific and technological activities, veterinary activities" (M74/M75); "Administrative and support service activities" (N), and "Computer programming, consultancy and related activities; information service activities" (J62/63). See Appendix Table 3.A1 for the classification of all services industries.

to 24.6% in 2014. Observe that the dependence on manufacturing value-added declined (with 0.6 p.p.) and the largest increase was for services (with 1.6 p.p.). Also the increase in other production was substantial (1.0 p.p.), and it turns out that this was largely due to mining and quarrying. It was the industry responsible for the single largest percentage point increase in dependence (0.6 p.p.). This reflects a greater reliance of EU's final demands on natural resource imports. The growing importance of the other production sector (and of the mining and quarrying industry in particular) might be partly explained by higher commodity prices and not only by volume changes.

Returning to Question 1 ("Has trade of value-added in services industries become more important relative to trade of value-added in manufactured goods industries between 2000 and 2014?"), the answer is clearly affirmative for the European Union. The rising contributions of services industries to trade in value-added could be a reflection of the growing importance of services overall in the EU and other developed regions. This development may systematically boost the trade triggered by services industries. Another explanation may be the liberalisation of services trade during the time period, such as via services trade negotiations, which have led to the rise of services-related GVCs (Heuser and Mattoo, 2017).

The bottom part of Table 3.2 gives the results for the gross export figures. These data have the advantage of providing the industry of the products actually crossing the border (both intermediates and final). The products exported by these industries may contain value-added created in other industries or sectors, but only the industry of the actually exported products is reflected in the data. Let $\mathbf{p}^{rs} = \sum_{s \neq r} \mathbf{D}^{rs}\mathbf{e} + \sum_{s \neq r} \mathbf{f}^{rs}$ indicate the vector of gross exports from country r to country s, and define $\mathbf{p}^{rr} = 0$ for all r. For example, $XGT_{Manuf}^{R} = \sum_{r \in R} \sum_{s} \sum_{i \in Manuf} p_i^{rs} / \sum_{r \in R} GDP^r$ then gives, for the average EU country, its gross exports as a share of its GDP. Observe in Table 3.2 that the role of manufacturing is much more important than the role of services when exports are measured directly (as is the case with XGT). The role of services is to a large extent indirect. Still, also when using the direct export figures it is true that exports in services have become more important relative to exports in manufactured goods.

For North America, the findings are similar but not as pronounced as for the EU. The trade in value-added has grown more for value-added created in the services sector than in manufacturing (which has even fallen). The same applies to the services trade itself (see XGT). However, the changes were not very large. For instance, total exports of value-added nudged up from 9.0% to 10.8% as a share of GDP between 2000 and 2014. Furthermore, the sector other production (agriculture, mining and quarrying, construction, and electricity) contributed almost equally to this change. This is almost exclusively due to mining and quarrying, which was the single industry that had the greatest impact on the increases in trade in value-added. Rising commodity prices in the mining and quarrying industry may play a role, which reinforces the decision to focus the comparison on the services and manufacturing sectors. Both the XVA and the MVA of mining and quarrying grew by +0.7 p.p. over the time period. In explaining the increased importance of services, business services and wholesale trade were particularly influential, just as they were for the EU.

In East Asia, exports of value-added are still dominated by manufacturing although services catches up. The percentage point changes in XVA were 2.2 for both sectors. Value-added abroad triggered by final demands in the East Asian countries sketches a different picture. Imports of foreign value-added (MVA) increased considerably (on average with 4.6 p.p.), but the increase was the largest for value-added created in other production and the smallest for manufacturing. The findings with regards to the XVA indicator are in line with the idea of Factory East Asia. The region is still dependent for its value-added creation on exporting manufactured goods, although the indirect contribution of services grows steadily.

Business services played a relative large role in explaining rising dependencies of the three regions on trade. On the import side, this may be related to the increased domestic offshoring of business services activities in developed countries to emerging and developing countries. Balance of payments data provides some information on disaggregated trade flows in the business services industries, which corroborates what we find using WIOD. For example, the United States and Germany outsourced especially in the computer services, business consulting, advertising and market research, R&D, and legal services sectors (Berry et al., 2016). Emerging and developing countries have increased their world export share in these business services categories between 2002 and 2012. At the same time, however, business services exports by developed countries have also increased in importance. This indicates that countries may be increasingly specialising in different types of business services.

Finally, two remarks are relevant. First, the results highlight the increasing disparities between indicators for trade in value-added and for gross exports. In Table 3.2, the XVA outcomes for services are always larger than the XGT outcomes. For manufacturing, the differences are in the opposite direction and larger than for services. Indicators largely based on direct trade (like XGT) overestimate manufactured goods (which embody more services) compared to indicators that fully account for indirect trade (like XVA).

Second, almost all indicators are the largest for the EU and the smallest for North America. One should be careful to give too much weight to this observation, as it depends on the number of countries that are included in a region.

3.4.2 Did services travel further than manufactured goods?

This section addresses the question whether trade of value-added in services industries travelled further than trade of value-added in manufactured goods industries in 2014. This is measured by the share of services vis-a-vis manufacturing in intraregional and interregional trade in value added. The intraregional XVA ($INXVA^R$) was defined in Equation (3.3). Just like the XVA^R in (5) was split into $XVA^R = XVA^R_{Manuf} + XVA^R_{Services} + XVA^R_{Other}$, we now have $INXVA^R = INXVA^R_{Manuf} + INXVA^R_{Services} + INXVA^R_{Other}$. The results in Table 3.3 then report the shares, that is, $INXVA^R_{Services}/INXVA^R$ for example. Of the total value-added (created in the average EU country) that was embodied in the final demands of all other EU countries, 50.6% was created in the services sector and 39.2% in the manufacturing sector. Similar calculations and interpretations apply to interregional trade in value-added. For example, 57.1% of the value-added in the average EU country that was embodied in final demands outside the EU was created in the services sector. The services sector in the EU thus had a larger share in the interregional exports of value-added than in the intraregional exports of value-added (i.e., IR > IN) and the opposite held for the manufacturing sector (IR < IN). We conclude that exports of value-added in EU services industries travelled further than exports of value-added in EU manufacturing industries. It should be noted that this is a de facto, aggregated result because the findings may vary depending on the geographic and structural orientation of countries in trade.

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is a de facto, aggregated result because the findings may vary depending on the geographic and structural orientation of countries in trade.

Table 3.3. Shares for sectors in total, intraregional, and interregional trade in value-added for three regions in 2014

		European Union				North America				East Asia			
		M	S	O	T	M	S	O	T	M	S	O	T
XVA	IN	39.2	50.6	10.2	100	42.3	32.4	25.3	100	58.9	30.6	10.4	100
	IR	35.4	57.1	7.6	100	28.5	59.1	12.4	100	48.9	39.0	12.1	100
	TOT	37.0	54.2	8.7	100	32.8	50.7	16.5	100	50.6	37.6	11.8	100
MVA	IN	39.2	50.6	10.2	100	42.3	32.4	25.3	100	58.9	30.6	10.4	100
	IR	31.4	43.2	25.4	100	39.1	40.8	20.1	100	27.6	36.8	35.6	100
	TOT	35.4	47.0	17.6	100	40.0	38.6	21.5	100	34.0	35.7	30.3	100
XGT	IN	66.8	26.6	6.5	100	74.4	7.7	17.9	100	94.0	5.2	0.8	100
	IR	57.5	38.5	4.0	100	45.0	47.2	7.9	100	79.3	19.2	1.4	100
	TOT	62.5	32.1	5.4	100	56.4	31.8	11.8	100	82.5	16.2	1.3	100

Notes: Calculations are based on the World Input-Output Database. The European Union includes all 28 EU members, North America includes Canada, Mexico and the United States, and East Asia consists of China, Japan, Korea and Taiwan. Shares are rounded to the nearest tenth. XVA refers to VA exports of a particular sector (M = manufacturing; S = services; O = other production) as a share of all VA exports contributions (T = total/sum of all sectors = 100). MVA refers to VA imports as share of all VA import contributions. XGT refers to regional gross exports as a share of regional GDP. IN = intraregional trade in value-added (or gross exports), IR = interregional trade in value-added (or gross exports), TOT = total trade in value-added (or gross exports).

The row TOT gives the shares of the sectors in XVA^R. For example, for the services sector, we have $XVA^R_{services}/XVA^R = 15.0/27.6 = 0.542$, where the 15.0 and 27.6 are from Table 3.2. The results are only for 1 year (2014) because the outcomes for other years sketch a similar picture.[68]

The observation for the EU's exports of value-added (i.e., services travelled further than manufactured goods) also holds for the exports of value-added of the other two regions. For the imports of value-added (MVA), the story is slightly different in the case of the EU even if the conclusions are the same. Both for the services and the manufacturing sector, the share of interregional trade is smaller than the share of intraregional trade (IR < IN). This is due to the role of the sector other production. Comparing IR with IN, we find IR/IN = 43.2/50.6 = 0.85 for services and IR/ IN = 31.4/39.2 = 0.80 for manufacturing. Also for imports of value-added by the EU, it is thus true that services value-added travelled further than manufacturing value-added. For North America and East Asia, the findings for the imports (through MVA) are similar to the findings for exports of value-added (through XVA).[69] Hence, for every region and indicator (including the EU MVA indicator), the result held that trade in value-added

[68] The results for 2014 for the full 56-industry classification are provided in Appendix Tables 3.A5–A7.

[69] Note that intraregional imports of value-added (MVA) by definition sum up to the intraregional exports of value-added (XVA) for each region. Hence, INXVA and INMVA values are identical in Table 3.3.

created by services industries travelled further than trade in value-added created by manufacturing industries. We add that transport services, which could be expected to increase the share of services in interregional trade, only explain a small share of the more global nature of services. The four transport industries together (land, water and air transport, and support activities) accounted for less than a quarter of the increased importance of services in the EU's interregional exports of value-added relative to intraregional exports of value-added. The 2000 figures (not shown in the table) reveal similar patterns.

The distributions of the intraregional and interregional shares of the sectors in XVA and MVA appear to be time invariant. The only observable difference over time was that services grew as a share of total trade. One possible explanation for the lack of a stronger interregional pattern over time for services could be that the ICT revolution increased more generally the services content of manufactured goods. Given that the majority of exports of value-added created in services industries are embodied in products traded by other sectors (e.g., in manufacturing), there is less reason to believe an interregional trend in services would predominate relative to manufactured goods over time. This is because changes in the geographic orientation of manufactured goods trade would trigger (corresponding) changes in the geographic orientation of services trade. Another explanation could be that the effect of an expanded geographic scope of production fragmentation on services might have been offset by regulatory convergence in services if convergence has been the strongest within regions.

Observe that the sector other production plays a substantial role in the case of imports of value added (MVA). The industry-level results (see Appendix Tables 3.A5–A7) reveal that this was overwhelmingly due to mining and quarrying, for which interregional imports of value-added embodied in final demand were much more important than intraregional imports (except for North America). This shows that Europe and East Asia were relatively dependent on raw materials imported from outside the own region.

The sectoral embodiments of gross exports (intraregional, interregional and total) of the three regions were also calculated for total gross exports (XGT). The trade of value-added in services is typically indirect, because services are embodied in the gross exports of manufactured goods (Heuser and Mattoo, 2017). The XVA and MVA indicators capture both the direct and indirect services linkages. Direct export figures using the XGT approach may provide additional insights because these data only report services and manufactured goods that cross the border, aggregated by sector, and are not embodied indirectly in products traded by other sectors. Two conclusions can be drawn when comparing the results for XGT with those for XVA. First, gross exports were dominated by manufacturing. Services were considerably more important in value-added terms relative to gross exports in each of the regions. Second, also for gross exports it was the case that services travelled further than manufacturing.

Observe that there are significant differences in the intraregional vs. interregional shares of services. The services share in intraregional exports of value-added was between two and six times higher than the services share in gross intraregional exports in each region. However, discrepancies between the share of services in interregional value-added exports and gross interregional exports were considerably less. This provides an additional motivation for an analysis of services trade based on value-added. The role of services is already understated when gross exports are considered, but it is even more underrepresented when gross intraregional exports are employed.

3.5 Conclusion and discussion

This study employed several trade indicators and different levels of industry aggregation to study the role of services in globalisation patterns. This was done by examining the cases of the European Union, North America and East Asia between 2000 and 2014, and distinguishing between intraregional, interregional and total trade. There are two key findings. First, in Europe and North America trade of value-added in services industries rose more than trade of value-added in manufactured goods industries. In relative terms, this was also the case in East Asia. Second, by comparing intraregional and interregional trade in value-added on a sectoral level, value-added created in services industries always travelled further than value-added created in manufacturing industries.

Our results also underscored the increasing disparity between gross exports and exports of value-added over time (supporting the original finding of Johnson and Noguera, 2012), which is especially acute for services. This greater discrepancy for services reflects the fact that gross trade only captures direct but not indirect services exports—understating their importance. That could cause one to misinterpret where value is created. Disparities between the services share in gross exports and the services share in value-added exports were considerably larger within regions than between regions. The results also indicated that world trade is more global when measured in value-added terms than in gross exports. Although analysing trade in value-added is extremely useful in exposing indirect dependencies, actual trade is the action that takes place. Thus, gross export statistics remain important themselves and are also necessary to determine the trade in value-added figures.

The importance of services is even greater in interregional trade than in intraregional trade. This has policy implications. First, trade policy should explicitly be aimed at lifting services barriers (Berry et al., 2016; Saez et al., 2014). The Trade in Services Agreement (TiSA) that is currently being negotiated by 23 members of the World Trade Organization (representing 50 countries) is a positive step in this direction. Research based on firm-level data finds that allowing for the participation of foreign services providers improves the performance of downstream manufacturing firms (Arnold et al., 2011; Duggan et al., 2013). Second, it is important to improve the regulatory environment for domestic services because services are embodied in the output of other sectors. Regulatory reform in the services sector can contribute in establishing comparative advantage for firms relying on services inputs (Van der Marel, 2016). Improved access to services, which may accompany trade liberalisation and domestic policy reform efforts, raises competitiveness and productivity of manufacturing industries (Arnold et al, 2008; Arnold et al., 2016) and contributes to economic growth (Mattoo et al., 2006).

Appendix Chapter 3

Table 3.A1

Nr.	Industries	(in WIOD release 2016 according to ISIC Rev. 4, see also Timmer et al., 2016)
1	A01	Crop and animal production hunting and related service activities
2	A02	Forestry and logging
3	A03	Fishing and aquaculture
4	B	Mining and quarrying
5	C10-C12	Manufacture of food products, beverages and tobacco products
6	C13-C15	Manufacture of textiles, wearing apparel and leather products
7	C16	Manufacture of wood and of products of wood and cork, except furniture; etc.
8	C17	Manufacture of paper and paper products
9	C18	Printing and reproduction of recorded media
10	C19	Manufacture of coke and refined petroleum products
11	C20	Manufacture of chemicals and chemical products
12	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
13	C22	Manufacture of rubber and plastic products
14	C23	Manufacture of other non-metallic mineral products
15	C24	Manufacture of basic metals
16	C25	Manufacture of fabricated metal products, except machinery and equipment
17	C26	Manufacture of computer, electronic and optical products
18	C27	Manufacture of electrical equipment
19	C28	Manufacture of machinery and equipment n.e.c.
20	C29	Manufacture of motor vehicles, trailers and semi-trailers
21	C30	Manufacture of other transport equipment
22	C31, C32	Manufacture of furniture; other manufacturing
23	C33	Repair and installation of machinery and equipment
24	D	Electricity, gas, steam and air conditioning supply
25	E36	Water collection, treatment and supply
26	E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; etc.
27	F	Construction
28	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
29	G46	Wholesale trade, except of motor vehicles and motorcycles
30	G47	Retail trade, except of motor vehicles and motorcycles
31	H49	Land transport and transport via pipelines
32	H50	Water transport
33	H51	Air transport
34	H52	Warehousing and support activities for transportation
35	H53	Postal and courier activities
36	I	Accommodation and food service activities
37	J58	Publishing activities
38	J59, J60	Motion picture/video/TV programme production, sound recording/music publishing activities; etc.
39	J61	Telecommunications
40	J62, J63	Computer programming, consultancy and related activities; information service activities
41	K64	Financial service activities, except insurance and pension funding
42	K65	Insurance, reinsurance and pension funding, except compulsory social security
43	K66	Activities auxiliary to financial services and insurance activities
44	L	Real estate activities
45	M69, M70	Legal and accounting activities; activities of head offices; management consultancy activities
46	M71	Architectural and engineering activates: technical testing and analysis
47	M72	Scientific research and development
48	M73	Advertising and market research
49	M74, M75	Other professional, scientific and technical activities; veterinary activities
50	N	Rental and leasing activities, Employment activities, Travel services, security and services to building
51	O	Public administration and defence; compulsory social security
52	P	Education
53	Q	Human health and social work activities
54	R-S	Creative, Arts, Sports, Recreation and entertainment activities and all other personal service activities
55	T	Activities of households as employers; undifferentiated goods/services-producing activities - own use
56	U	Activities of extra-territorial organisations and bodies

Table 3.A2

European Union: decomposition of dependency indicators by industry (2000-2014)
(in percent; change between 2000 and 2014 in percentage points and percent change)

	XVA				MVA			
Industry / ISIC rev. 4	2000	2000	2000	2000	2000	2014	14-00	Δ (%)
Crop and animal production	0.5	0.6	0.0	9.2	0.8	1.0	0.2	26.9
Forestry and logging	0.1	0.1	0.0	19.8	0.1	0.1	0.0	-11.9
Fishing and aquaculture	0.0	0.0	0.0	-15.0	0.1	0.1	0.0	10.4
Mining and quarrying	0.5	0.5	-0.1	-12.0	1.4	2.1	0.6	45.1
Food products	0.6	0.8	0.2	33.1	0.6	0.8	0.2	30.3
Textile products	0.6	0.4	-0.2	-26.6	0.7	0.6	-0.1	-13.5
Wood products	0.2	0.1	0.0	-11.6	0.2	0.1	0.0	-12.6
Paper products	0.3	0.2	-0.1	-28.8	0.3	0.2	-0.1	-33.8
Printing products	0.2	0.1	-0.1	-37.5	0.1	0.1	-0.1	-39.9
Refined petroleum products	0.1	0.1	0.0	-4.9	0.2	0.3	0.1	50.1
Chemical products	0.9	0.8	0.0	-4.5	0.8	0.7	-0.1	-8.2
Pharmaceutical products	0.5	0.7	0.2	43.3	0.4	0.6	0.2	44.6
Rubber and plastics	0.5	0.5	0.0	7.4	0.4	0.4	0.0	-5.6
Other nonmetallic minerals	0.3	0.2	-0.1	-18.4	0.2	0.2	0.0	-17.5
Basic metals	0.5	0.4	-0.1	-17.3	0.5	0.5	-0.1	-16.5
Fabricated metals	0.8	0.9	0.1	10.7	0.6	0.6	0.0	-8.0
Computer, electronic and optical products	1.0	0.7	-0.4	-36.4	1.3	0.9	-0.4	-28.3
Electronic equipment	0.6	0.6	0.0	0.1	0.5	0.5	-0.1	-11.6
Machinery and equipment n.e.c.	1.1	1.4	0.3	24.1	0.8	0.8	0.0	2.0
Motor vehicles, trailers and semi-trailers	1.0	1.2	0.2	19.2	0.8	0.7	-0.1	-6.8
Other transport equipment	0.4	0.4	0.0	4.7	0.4	0.3	-0.1	-14.2
Furniture; other manufacturing	0.4	0.4	0.1	15.3	0.4	0.4	0.0	0.0
Repair, installation of machinery/equipment	0.2	0.3	0.1	32.9	0.1	0.1	0.0	15.2
Electricity and gas	0.4	0.5	0.1	24.7	0.5	0.6	0.0	8.1
Water	0.0	0.0	0.0	23.6	0.0	0.0	0.0	-1.4
Waste and water management	0.2	0.3	0.1	63.8	0.2	0.2	0.1	34.0
Construction	0.3	0.4	0.1	51.0	0.2	0.3	0.1	38.1

Table 3.A2 (continued)

	XVA				MVA			
Industry / ISIC rev. 4	2000	2014	14-00	Δ (%)	2000	2014	14-00	Δ (%)
Wholesale and retail trade/repair of vehicles	0.2	0.4	0.2	84.5	0.2	0.3	0.1	35.4
Wholesale trade, except of vehicles	1.6	2.3	0.7	46.1	1.6	2.0	0.4	27.3
Retail trade, except of vehicles	0.8	0.6	-0.2	-28.5	0.7	0.5	-0.1	-18.7
Inland transport	0.7	0.9	0.2	24.6	0.7	0.8	0.1	15.3
Water transport	0.2	0.2	0.0	1.8	0.1	0.1	0.0	-15.8
Air transport	0.2	0.2	0.0	3.1	0.2	0.1	0.0	-12.6
Support activities for transportation	0.6	0.8	0.2	42.3	0.4	0.6	0.1	31.5
Post	0.2	0.2	0.0	-1.1	0.1	0.1	0.0	-12.5
Hotels and restaurants	0.2	0.3	0.1	41.0	0.3	0.3	0.0	-4.7
Publishing activities	0.2	0.2	0.0	14.4	0.2	0.2	0.0	-6.6
Video, television, music, and casting	0.1	0.2	0.0	8.9	0.1	0.1	0.0	3.2
Telecommunications	0.3	0.3	0.0	-0.9	0.3	0.3	0.0	-5.0
Computer programming, consultancy, IT	0.4	0.9	0.5	121.5	0.3	0.5	0.2	77.7
Fin services, not insurance/pension funding	0.9	1.1	0.2	28.4	0.8	0.9	0.1	16.6
Insurance, reinsurance and pension funding	0.2	0.2	0.1	54.3	0.1	0.1	0.0	4.4
Other fin. services activities	0.2	0.3	0.1	47.5	0.1	0.2	0.0	30.4
Real estate activities	0.6	0.8	0.2	40.9	0.5	0.6	0.1	17.9
Legal and accounting; consultancy	0.9	1.4	0.5	55.7	0.7	1.0	0.3	37.8
Architectural and engineering activities	0.4	0.5	0.1	32.0	0.3	0.3	0.1	20.5
Scientific research and development	0.3	0.1	-0.2	-58.5	0.2	0.2	-0.1	-29.7
Advertising and market research	0.2	0.2	0.0	10.0	0.2	0.2	0.0	2.9
Other prof./scientific/technical activities	0.2	0.2	0.1	45.2	0.2	0.2	0.0	22.4
Admin and support service activities	1.1	1.7	0.5	44.1	1.1	1.3	0.2	19.2
Public admin	0.2	0.3	0.1	42.7	0.2	0.2	0.0	11.5
Education	0.2	0.2	0.1	34.4	0.1	0.1	0.0	13.9
Health and social work	0.0	0.1	0.1	119.5	0.0	0.1	0.0	30.1
Other services	0.2	0.3	0.1	27.0	0.3	0.3	0.0	15.9
Household consumption	0.0	0.0	0.0	-5.3	0.0	0.0	0.0	-56.0
Extraterritorial organizations and bodies	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing	10.0	10.2	0.2	2.3	9.3	8.7	-0.6	-6.4
Services	11.3	15.0	3.7	32.6	9.9	11.5	1.6	16.1
Other	2.1	2.4	0.4	17.7	3.3	4.3	1.0	31.1
Total	23.3	27.6	4.3	18.3	22.5	24.6	2.0	9.0

Source: Own calculations based on the World Input-Output Database. Shares are rounded to the nearest tenth.
Notes: All 28 members of the European Union are aggregated. Industries are assigned to sectors. XVA refers to VA-exports as share of total regional value-added production. MVA refers to VA-imports as share of total regional final demand.

Table 3.A3

North America: decomposition of dependency indicators by industry (2000-2014)
(in percent; change between 2000 and 2014 in percentage points and percent change)

	XVA				MVA			
Industry / ISIC rev. 4	2000	2014	14-00	Δ (%)	2000	2014	14-00	Δ (%)
Crop and animal production	0.2	0.3	0.1	71.0	0.3	0.5	0.2	77.7
Forestry and logging	0.0	0.0	0.0	-2.8	0.1	0.1	0.0	-18.2
Fishing and aquaculture	0.0	0.0	0.0	72.4	0.0	0.0	0.0	67.7
Mining and quarrying	0.5	1.2	0.7	156.4	1.0	1.7	0.7	65.1
Food products	0.2	0.2	0.1	34.2	0.2	0.3	0.1	60.6
Textile products	0.1	0.1	-0.1	-57.1	0.4	0.4	-0.1	-16.4
Wood products	0.1	0.0	0.0	-30.3	0.1	0.1	0.0	5.7
Paper products	0.1	0.1	0.0	-35.2	0.1	0.1	0.0	-24.0
Printing products	0.1	0.0	0.0	-28.7	0.1	0.0	0.0	-44.3
Refined petroleum products	0.1	0.2	0.1	211.4	0.1	0.2	0.1	59.7
Chemical products	0.3	0.4	0.1	38.9	0.4	0.4	0.1	14.0
Pharmaceutical products	0.1	0.2	0.0	32.7	0.2	0.2	0.0	17.8
Rubber and plastics	0.1	0.1	0.0	-6.1	0.2	0.2	0.0	5.0
Other nonmetallic minerals	0.1	0.1	0.0	-14.9	0.1	0.1	0.0	-16.2
Basic metals	0.2	0.2	0.0	24.2	0.3	0.4	0.0	4.1
Fabricated metals	0.2	0.2	0.0	-7.6	0.3	0.3	0.0	0.1
Computer, electronic and optical products	0.8	0.5	-0.3	-34.3	0.9	0.7	-0.2	-18.3
Electronic equipment	0.1	0.1	0.0	-13.9	0.3	0.2	0.0	-10.1
Machinery and equipment n.e.c.	0.3	0.3	0.0	-5.1	0.4	0.5	0.0	5.8
Motor vehicles, trailers and semi-trailers	0.4	0.3	-0.1	-19.3	0.6	0.6	0.0	-6.3
Other transport equipment	0.3	0.3	0.0	1.7	0.1	0.1	0.0	0.3
Furniture; other manufacturing	0.2	0.1	0.0	-11.0	0.3	0.2	0.0	-14.5
Repair, installation of machinery/equipment	0.0	0.0	0.0	-23.0	0.0	0.0	0.0	-11.6
Electricity and gas	0.1	0.1	0.0	-13.6	0.3	0.3	0.0	11.2
Water	0.0	0.0	0.0	81.0	0.0	0.0	0.0	-4.1
Waste and water management	0.0	0.1	0.0	68.4	0.1	0.1	0.0	23.3
Construction	0.0	0.1	0.0	23.2	0.1	0.1	0.0	35.7

Table 3.A3 (continued)

Industry / ISIC rev. 4	XVA 2000	XVA 2014	XVA 14-00	XVA Δ (%)	MVA 2000	MVA 2014	MVA 14-00	MVA Δ (%)
Wholesale and retail trade/repair of vehicles	0.1	0.1	0.0	-8.4	0.1	0.1	0.0	-3.7
Wholesale trade, except of vehicles	1.0	1.2	0.2	18.6	0.7	0.8	0.2	23.0
Retail trade, except of vehicles	0.1	0.1	0.0	4.1	0.3	0.3	0.0	-4.7
Inland transport	0.3	0.3	0.1	22.5	0.3	0.3	0.0	13.6
Water transport	0.0	0.0	0.0	-16.0	0.1	0.0	0.0	-24.6
Air transport	0.1	0.1	0.0	23.4	0.1	0.1	0.0	-9.1
Support activities for transportation	0.1	0.1	0.0	28.7	0.1	0.1	0.0	29.7
Post	0.1	0.1	0.0	-9.6	0.0	0.0	0.0	-8.1
Hotels and restaurants	0.1	0.1	0.0	11.0	0.1	0.1	0.0	22.4
Publishing activities	0.1	0.2	0.1	44.2	0.0	0.0	0.0	-5.0
Video, television, music, and casting	0.1	0.1	0.0	49.0	0.0	0.0	0.0	14.1
Telecommunications	0.1	0.1	0.0	0.9	0.1	0.1	0.0	-5.9
Computer programming, consultancy, IT	0.1	0.2	0.1	108.0	0.1	0.2	0.1	68.2
Fin services, not insurance/pension funding	0.3	0.4	0.1	43.9	0.3	0.4	0.1	39.8
Insurance, reinsurance and pension funding	0.1	0.1	0.1	55.4	0.1	0.2	0.1	64.9
Other fin. services activities	0.1	0.2	0.1	71.3	0.0	0.0	0.0	26.3
Real estate activities	0.2	0.2	0.0	15.2	0.2	0.2	0.0	18.5
Legal and accounting; consultancy	0.4	0.5	0.1	37.4	0.2	0.4	0.1	56.2
Architectural and engineering activities	0.1	0.2	0.1	43.8	0.1	0.1	0.0	35.3
Scientific research and development	0.1	0.1	0.0	54.2	0.1	0.1	0.0	-22.8
Advertising and market research	0.1	0.1	0.0	59.6	0.0	0.0	0.0	12.8
Other prof./scientific/technical activities	0.0	0.0	0.0	37.4	0.1	0.1	0.1	73.5
Admin and support service activities	0.5	0.6	0.1	22.6	0.7	0.7	-0.1	-7.2
Public admin	0.1	0.2	0.0	20.4	0.1	0.1	0.0	13.9
Education	0.0	0.0	0.0	59.6	0.0	0.0	0.0	28.4
Health and social work	0.0	0.0	0.0	54.0	0.0	0.0	0.0	16.6
Other services	0.1	0.1	0.0	5.5	0.1	0.1	0.0	31.9
Household consumption	0.0	0.0	0.0	-18.1	0.0	0.0	0.0	-51.4
Extraterritorial organizations and bodies	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing	3.7	3.6	-0.2	-5.1	5.1	5.0	-0.1	-2.4
Services	4.3	5.5	1.2	27.4	4.1	4.8	0.7	17.0
Other	0.9	1.8	0.9	94.8	1.8	2.7	0.9	51.6
Total	9.0	10.8	1.9	20.7	11.1	12.6	1.5	13.5

Source: Own calculations based on the World Input-Output Database. Shares are rounded to the nearest tenth.
Notes: The 3 North American countries (Canada, Mexico, and US) are aggregated. Industries are assigned to sectors. XVA refers to VA-exports as share of total regional value-added production. MVA refers to VA-imports as share of total regional final demand.

Table 3.A4

East Asia: decomposition of dependency indicators by industry (2000-2014)
(in percent; change between 2000 and 2014 in percentage points and percent change)

	XVA				MVA			
Industry / ISIC rev. 4	2000	2014	14-00	Δ (%)	2000	2014	14-00	Δ (%)
Crop and animal production	0.3	0.7	0.5	184.9	0.4	0.7	0.3	63.8
Forestry and logging	0.0	0.1	0.0	42.9	0.1	0.1	0.0	14.5
Fishing and aquaculture	0.0	0.1	0.0	31.8	0.0	0.0	0.0	-15.9
Mining and quarrying	0.3	0.9	0.6	218.8	1.4	3.1	1.7	120.3
Food products	0.2	0.4	0.2	137.0	0.3	0.3	0.0	13.5
Textile products	0.6	0.9	0.3	44.0	0.3	0.3	-0.1	-16.4
Wood products	0.0	0.1	0.1	201.6	0.1	0.1	0.0	12.9
Paper products	0.1	0.1	0.0	7.2	0.0	0.0	0.0	-16.9
Printing products	0.1	0.1	0.0	-13.5	0.0	0.0	0.0	-22.9
Refined petroleum products	0.2	0.3	0.1	77.8	0.1	0.2	0.1	35.6
Chemical products	0.6	0.8	0.1	19.6	0.4	0.5	0.1	12.9
Pharmaceutical products	0.0	0.1	0.0	100.2	0.1	0.2	0.1	93.8
Rubber and plastics	0.3	0.4	0.0	13.6	0.2	0.2	0.0	16.4
Other nonmetallic minerals	0.2	0.3	0.1	56.1	0.1	0.1	0.0	12.7
Basic metals	0.6	0.8	0.2	32.5	0.4	0.4	0.1	14.7
Fabricated metals	0.4	0.5	0.1	16.8	0.2	0.3	0.0	13.0
Computer, electronic and optical products	1.8	2.2	0.4	24.3	0.9	1.1	0.2	21.9
Electronic equipment	0.5	0.6	0.1	16.4	0.3	0.3	0.0	8.5
Machinery and equipment n.e.c.	0.6	0.8	0.2	43.0	0.4	0.5	0.1	23.9
Motor vehicles, trailers and semi-trailers	0.7	0.7	0.0	1.0	0.1	0.3	0.2	120.3
Other transport equipment	0.2	0.3	0.1	80.5	0.1	0.2	0.1	47.1
Furniture; other manufacturing	0.2	0.3	0.1	40.3	0.2	0.2	0.1	35.9
Repair, installation of machinery/equipment	0.0	0.0	0.0	-31.4	0.0	0.0	0.0	34.3
Electricity and gas	0.3	0.4	0.1	29.2	0.3	0.4	0.2	58.0
Water	0.0	0.0	0.0	-8.6	0.0	0.0	0.0	12.1
Waste and water management	0.0	0.0	0.0	91.0	0.0	0.1	0.0	108.7
Construction	0.1	0.1	0.0	36.7	0.1	0.1	0.1	101.0

Table 3.A4 (continued)

Industry / ISIC rev. 4	XVA 2000	XVA 2014	XVA 14-00	XVA Δ (%)	MVA 2000	MVA 2014	MVA 14-00	MVA Δ (%)
Wholesale and retail trade/repair of vehicles	0.1	0.1	0.0	-27.3	0.1	0.1	0.0	36.6
Wholesale trade, except of vehicles	1.4	2.2	0.8	57.6	0.7	1.1	0.3	41.0
Retail trade, except of vehicles	0.3	0.5	0.2	90.0	0.3	0.3	0.1	25.9
Inland transport	0.4	0.6	0.2	46.5	0.3	0.4	0.1	49.0
Water transport	0.3	0.2	0.0	-12.0	0.1	0.1	0.0	-19.6
Air transport	0.1	0.1	0.0	-20.7	0.1	0.1	0.0	25.2
Support activities for transportation	0.2	0.2	0.0	21.3	0.1	0.2	0.1	46.3
Post	0.0	0.0	0.0	-5.0	0.0	0.0	0.0	5.6
Hotels and restaurants	0.2	0.2	0.0	18.9	0.2	0.2	0.0	-14.3
Publishing activities	0.0	0.0	0.0	-27.3	0.0	0.0	0.0	-0.5
Video, television, music, and casting	0.1	0.0	0.0	-26.6	0.0	0.0	0.0	4.1
Telecommunications	0.1	0.2	0.0	8.8	0.1	0.1	0.0	4.6
Computer programming, consultancy, IT	0.1	0.1	0.0	4.3	0.1	0.2	0.1	68.1
Fin services, not insurance/pension funding	0.5	0.9	0.4	67.4	0.3	0.5	0.2	73.1
Insurance, reinsurance and pension funding	0.1	0.1	0.0	3.9	0.1	0.1	0.0	5.8
Other fin. services activities	0.0	0.0	0.0	13.6	0.0	0.1	0.0	27.8
Real estate activities	0.1	0.3	0.2	114.8	0.2	0.2	0.1	48.6
Legal and accounting; consultancy	0.1	0.4	0.3	318.8	0.3	0.5	0.2	91.2
Architectural and engineering activities	0.0	0.1	0.0	47.0	0.1	0.1	0.0	32.5
Scientific research and development	0.1	0.1	0.0	6.7	0.1	0.1	0.0	10.5
Advertising and market research	0.1	0.0	0.0	-65.4	0.0	0.0	0.0	-11.3
Other prof./scientific/technical activities	0.3	0.3	0.0	13.6	0.1	0.1	0.0	7.7
Admin and support service activities	0.1	0.2	0.0	14.2	0.3	0.4	0.1	30.2
Public admin	0.1	0.1	0.0	16.7	0.1	0.1	0.0	27.5
Education	0.0	0.0	0.0	106.6	0.0	0.1	0.0	40.4
Health and social work	0.0	0.0	0.0	29.6	0.0	0.0	0.0	66.1
Other services	0.1	0.2	0.1	74.2	0.1	0.2	0.1	69.4
Household consumption	0.0	0.0	0.0	-77.4	0.0	0.0	0.0	15.8
Extraterritorial organizations and bodies	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing	7.4	9.6	2.2	30.4	4.3	5.2	0.9	20.8
Services	5.0	7.1	2.2	44.4	4.0	5.5	1.5	36.4
Other	1.0	2.3	1.2	119.5	2.4	4.7	2.3	93.9
Total	13.3	19.0	5.7	42.4	10.8	15.4	4.6	43.0

Source: Own calculations based on the World Input-Output Database. Shares are rounded to the nearest tenth.
Notes: 4 East Asian countries (China, Japan, Korea, and Taiwan) are aggregated. Industries are assigned to sectors. XVA refers to VA-exports as share of total regional value-added production. MVA refers to VA-imports as share of total regional final demand.

Table 3.A5

European Union: Share of each industry in total, intraregional, and interregional trade (2014)

(*Percentage*)

Industry / ISIC rev. 4	XVA			MVA		
	IN	IR	TOT	IN	IR	TOT
Crop and animal production	3.0	1.3	2.0	3.0	5.1	4.0
Forestry and logging	0.3	0.3	0.3	0.3	0.3	0.3
Fishing and aquaculture	0.1	0.0	0.1	0.1	0.4	0.2
Mining and quarrying	1.9	1.6	1.7	1.9	15.6	8.5
Food products	4.2	2.0	3.0	4.2	1.9	3.1
Textile products	1.6	1.4	1.5	1.6	3.1	2.3
Wood products	0.6	0.4	0.5	0.6	0.5	0.6
Paper products	1.0	0.7	0.8	1.0	0.5	0.8
Printing products	0.3	0.4	0.4	0.3	0.3	0.3
Refined petroleum products	0.4	0.3	0.4	0.4	1.7	1.0
Chemical products	3.1	2.9	3.0	3.1	2.8	3.0
Pharmaceutical products	2.8	2.2	2.5	2.8	1.7	2.3
Rubber and plastics	2.2	1.6	1.8	2.2	1.1	1.6
Other nonmetallic minerals	1.0	0.8	0.9	1.0	0.7	0.8
Basic metals	1.5	1.6	1.5	1.5	2.2	1.8
Fabricated metals	3.1	3.1	3.1	3.1	1.3	2.3
Computer, electronic and optical products	2.4	2.4	2.4	2.4	5.2	3.8
Electronic equipment	2.3	2.1	2.2	2.3	1.4	1.9
Machinery and equipment n.e.c.	4.3	5.3	4.9	4.3	2.3	3.4
Motor vehicles, trailers and semi-trailers	4.3	4.1	4.2	4.3	1.6	3.0
Other transport equipment	1.0	1.8	1.4	1.0	1.5	1.2
Furniture; other manufacturing	1.9	1.4	1.6	1.9	1.5	1.7
Repair, installation of machinery/equipment	0.9	1.0	0.9	0.9	0.1	0.5
Electricity and gas	2.0	1.7	1.9	2.0	2.8	2.4
Water	0.2	0.1	0.2	0.2	0.2	0.2
Waste and water management	1.2	1.0	1.1	1.2	0.5	0.8
Construction	1.6	1.5	1.6	1.6	0.7	1.2

Table 3.A5 (continued)

Industry / ISIC rev. 4	XVA			MVA		
	IN	IR	TOT	IN	IR	TOT
Wholesale and retail trade and repair of vehicles	1.6	1.5	1.5	1.6	0.5	1.1
Wholesale trade, except of vehicles	8.7	8.2	8.4	8.7	7.5	8.2
Retail trade, except of vehicles	2.2	2.0	2.1	2.2	2.2	2.2
Inland transport	3.1	3.2	3.2	3.1	3.4	3.3
Water transport	0.3	1.3	0.9	0.3	0.6	0.4
Air transport	0.5	0.7	0.6	0.5	0.7	0.6
Support activities for transportation	2.9	3.1	3.0	2.9	1.6	2.3
Post	0.5	0.6	0.6	0.5	0.3	0.4
Hotels and restaurants	0.7	1.1	0.9	0.7	1.6	1.2
Publishing activities	0.6	0.9	0.8	0.6	0.7	0.7
Video, television, music, and casting	0.5	0.6	0.6	0.5	0.6	0.6
Telecommunications	1.3	1.1	1.2	1.3	1.2	1.2
Computer programming, consultancy, IT	2.2	3.9	3.1	2.2	1.9	2.0
Fin services, except insurance and pension funding	3.1	4.8	4.1	3.1	4.1	3.6
Insurance, reinsurance and pension funding	0.5	1.1	0.9	0.5	0.7	0.6
Other fin. services activities	0.8	1.5	1.2	0.8	0.5	0.6
Real estate activities	2.9	3.1	3.0	2.9	1.5	2.2
Legal and accounting; consultancy	5.0	5.0	5.0	5.0	3.4	4.2
Architectural and engineering activities	1.6	2.0	1.8	1.6	0.9	1.2
Scientific research and development	0.6	0.4	0.5	0.6	0.8	0.7
Advertising and market research	0.9	0.8	0.9	0.9	0.4	0.7
Other professional, scientific and technical activities	0.9	0.8	0.8	0.9	0.9	0.9
Admin and support service activities	6.0	6.0	6.0	6.0	4.2	5.2
Public admin	1.0	1.2	1.1	1.0	1.0	1.0
Education	0.7	0.8	0.8	0.7	0.3	0.5
Health and social work	0.3	0.4	0.3	0.3	0.2	0.3
Other services	1.1	1.0	1.1	1.1	1.3	1.2
Household consumption	0.0	0.0	0.0	0.0	0.0	0.0
Extraterritorial organizations and bodies	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing	39.2	35.4	37.0	39.2	31.4	35.4
Services	50.6	57.1	54.2	50.6	43.2	47.0
Other	10.2	7.6	8.7	10.2	25.4	17.6
Total	100	100	100	100	100	100

Source: Own calculations based on the World Input-Output Database. Shares are rounded to the nearest tenth.
Notes: All 27 members of the European Union are aggregated. Industries are assigned to sectors. XVA refers to VA-exports as share of all value-added exports contributions. MVA refers to VA-imports as share of all value-added import contributions.

Table 3.A6

North America: Share of each industry in total, intraregional, and interregional trade (2014)

(Percentage)

Industry / ISIC rev. 4	XVA			MVA		
	IN	IR	TOT	IN	IR	TOT
Crop and animal production	3.6	2.4	2.8	3.6	3.8	3.7
Forestry and logging	0.5	0.3	0.3	0.5	0.6	0.6
Fishing and aquaculture	0.2	0.2	0.2	0.2	0.3	0.3
Mining and quarrying	18.5	7.2	10.8	18.5	11.2	13.1
Food products	3.0	1.5	2.0	3.0	1.8	2.1
Textile products	1.2	0.3	0.6	1.2	3.6	3.0
Wood products	0.7	0.3	0.4	0.7	0.6	0.6
Paper products	1.2	0.6	0.8	1.2	0.7	0.8
Printing products	0.4	0.3	0.4	0.4	0.3	0.3
Refined petroleum products	1.9	1.9	1.9	1.9	1.1	1.3
Chemical products	3.7	3.7	3.7	3.7	3.4	3.5
Pharmaceutical products	1.3	1.7	1.6	1.3	1.6	1.5
Rubber and plastics	2.2	0.8	1.2	2.2	1.6	1.8
Other nonmetallic minerals	1.0	0.4	0.6	1.0	0.9	0.9
Basic metals	3.2	1.6	2.1	3.2	2.7	2.8
Fabricated metals	2.8	1.7	2.1	2.8	2.2	2.4
Computer, electronic and optical products	4.4	4.7	4.6	4.4	6.0	5.6
Electronic equipment	1.7	0.9	1.1	1.7	1.9	1.8
Machinery and equipment n.e.c.	3.9	2.4	2.9	3.9	3.5	3.6
Motor vehicles, trailers and semi-trailers	6.0	1.2	2.7	6.0	4.1	4.6
Other transport equipment	1.8	3.3	2.9	1.8	0.9	1.2
Furniture; other manufacturing	1.8	1.1	1.3	1.8	2.0	1.9
Repair, installation of machinery/equipment	0.0	0.0	0.0	0.0	0.3	0.2
Electricity and gas	1.4	1.0	1.1	1.4	2.7	2.3
Water	0.1	0.0	0.1	0.1	0.2	0.2
Waste and water management	0.5	0.8	0.7	0.5	0.5	0.5
Construction	0.5	0.5	0.5	0.5	0.8	0.7

Table 3.A6 (continued)

Industry / ISIC rev. 4	XVA			MVA		
	IN	IR	TOT	IN	IR	TOT
Wholesale and retail trade and repair of vehicles	1.1	0.5	0.7	1.1	0.7	0.8
Wholesale trade, except of vehicles	5.8	13.1	10.8	5.8	7.0	6.6
Retail trade, except of vehicles	2.1	0.7	1.1	2.1	2.2	2.2
Inland transport	2.3	3.2	2.9	2.3	2.6	2.5
Water transport	0.1	0.4	0.3	0.1	0.5	0.4
Air transport	0.6	1.4	1.1	0.6	0.7	0.7
Support activities for transportation	0.6	1.4	1.2	0.6	1.2	1.0
Post	0.3	0.9	0.7	0.3	0.2	0.2
Hotels and restaurants	1.0	0.9	1.0	1.0	0.9	0.9
Publishing activities	0.2	2.2	1.6	0.2	0.3	0.3
Video, television, music, and casting	0.5	1.3	1.0	0.5	0.3	0.4
Telecommunications	0.7	1.4	1.2	0.7	0.8	0.8
Computer programming, consultancy, IT	0.7	2.1	1.7	0.7	1.7	1.5
Fin services, except insurance and pension funding	1.9	4.2	3.5	1.9	3.8	3.3
Insurance, reinsurance and pension funding	0.7	1.7	1.4	0.7	1.8	1.5
Other fin. services activities	0.3	2.0	1.5	0.3	0.3	0.3
Real estate activities	1.2	2.3	2.0	1.2	1.5	1.4
Legal and accounting; consultancy	3.2	5.2	4.6	3.2	2.7	2.8
Architectural and engineering activities	1.2	2.1	1.8	1.2	1.1	1.2
Scientific research and development	0.6	1.2	1.0	0.6	0.5	0.5
Advertising and market research	0.3	1.1	0.8	0.3	0.4	0.4
Other professional, scientific and technical activities	0.3	0.4	0.4	0.3	1.2	1.0
Admin and support service activities	4.4	5.8	5.4	4.4	5.9	5.5
Public admin	1.0	2.0	1.7	1.0	0.6	0.7
Education	0.2	0.4	0.3	0.2	0.4	0.4
Health and social work	0.3	0.2	0.2	0.3	0.2	0.2
Other services	0.6	0.8	0.7	0.6	1.0	0.9
Household consumption	0.0	0.0	0.0	0.0	0.0	0.0
Extraterritorial organizations and bodies	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing	42.3	28.5	32.8	42.3	39.1	40.0
Services	32.4	59.1	50.7	32.4	40.8	38.6
Other	25.3	12.4	16.5	25.3	20.1	21.5
Total	100	100	100	100	100	100

Source: Own calculations based on the World Input-Output Database. Shares are rounded to the nearest tenth.
Notes: The 3 North American countries (Canada, Mexico, and US) are aggregated. Industries are assigned to sectors. XVA refers to VA-exports as share of all value-added exports contributions. MVA refers to VA-imports as share of all value-added import contributions.

Table 3.A7

East Asia: Share of each industry in total, intraregional, and interregional trade (2014)
(*Percentage*)

Industry / ISIC rev. 4	XVA			MVA		
	IN	IR	TOT	IN	IR	TOT
Crop and animal production	3.7	3.8	3.8	3.7	4.9	4.6
Forestry and logging	0.3	0.4	0.3	0.3	0.9	0.7
Fishing and aquaculture	0.3	0.3	0.3	0.3	0.3	0.3
Mining and quarrying	3.3	4.8	4.5	3.3	24.9	20.4
Food products	2.3	1.8	1.9	2.3	2.2	2.2
Textile products	3.9	4.7	4.5	3.9	1.1	1.7
Wood products	0.5	0.7	0.7	0.5	0.6	0.6
Paper products	0.8	0.7	0.7	0.8	0.6	0.0
Printing products	0.4	0.4	0.4	0.4	0.2	0.2
Refined petroleum products	1.8	1.6	1.6	1.8	1.2	1.3
Chemical products	5.3	3.7	4.0	5.3	2.6	3.2
Pharmaceutical products	0.5	0.4	0.4	0.5	1.1	1.0
Rubber and plastics	2.2	2.0	2.0	2.2	0.9	1.2
Other nonmetallic minerals	1.6	1.3	1.3	1.6	0.6	0.8
Basic metals	4.8	4.1	4.2	4.8	2.3	2.8
Fabricated metals	2.8	2.5	2.5	2.8	1.5	1.8
Computer, electronic and optical products	18.8	10.0	11.5	18.8	3.8	7.1
Electronic equipment	4.0	3.1	3.2	4.0	1.3	1.9
Machinery and equipment n.e.c.	4.9	4.1	4.2	4.9	3.1	3.5
Motor vehicles, trailers and semi-trailers	2.4	4.3	3.9	2.4	1.8	2.0
Other transport equipment	0.8	1.8	1.7	0.8	1.1	1.0
Furniture; other manufacturing	1.1	1.7	1.6	1.1	1.4	1.4
Repair, installation of machinery/equipment	0.1	0.1	0.1	0.1	0.3	0.2
Electricity and gas	2.0	2.0	2.0	2.0	3.1	2.9
Water	0.2	0.1	0.1	0.2	0.2	0.2
Waste and water management	0.3	0.2	0.2	0.3	0.4	0.4
Construction	0.4	0.5	0.4	0.4	1.0	0.8

Table 3.A7 (continued)

Industry / ISIC rev. 4	XVA			MVA		
	IN	IR	TOT	IN	IR	TOT
Wholesale and retail trade and repair of vehicles	0.5	0.3	0.3	0.5	0.6	0.6
Wholesale trade, except of vehicles	7.7	12.2	11.5	7.7	6.6	6.8
Retail trade, except of vehicles	2.6	2.7	2.7	2.6	1.9	2.1
Inland transport	2.4	3.1	3.0	2.4	3.0	2.9
Water transport	0.6	1.4	1.3	0.6	0.6	0.6
Air transport	0.5	0.5	0.5	0.5	0.9	0.8
Support activities for transportation	0.9	1.0	1.0	0.9	1.3	1.3
Post	0.1	0.1	0.1	0.1	0.3	0.2
Hotels and restaurants	1.2	1.3	1.3	1.2	1.4	1.4
Publishing activities	0.2	0.1	0.1	0.2	0.3	0.3
Video, television, music, and casting	0.3	0.2	0.2	0.3	0.2	0.3
Telecommunications	0.7	0.8	0.8	0.7	0.9	0.8
Computer programming, consultancy, IT	0.5	0.6	0.6	0.5	1.4	1.2
Fin services, except insurance and pension funding	3.9	4.8	4.6	3.9	3.3	3.4
Insurance, reinsurance and pension funding	0.3	0.4	0.4	0.3	0.6	0.5
Other fin. services activities	0.1	0.1	0.1	0.1	0.4	0.3
Real estate activities	1.3	1.8	1.7	1.3	1.5	1.5
Legal and accounting; consultancy	1.4	2.4	2.2	1.4	3.8	3.3
Architectural and engineering activities	0.3	0.3	0.3	0.3	0.6	0.6
Scientific research and development	0.4	0.4	0.4	0.4	0.5	0.5
Advertising and market research	0.2	0.1	0.1	0.2	0.3	0.3
Other professional, scientific and technical activities	2.0	1.6	1.6	2.0	0.7	1.0
Admin and support service activities	1.0	0.8	0.8	1.0	2.7	2.3
Public admin	0.4	0.4	0.4	0.4	0.8	0.7
Education	0.2	0.2	0.2	0.2	0.4	0.4
Health and social work	0.2	0.1	0.1	0.2	0.1	0.1
Other services	0.9	1.1	1.1	0.9	1.5	1.3
Household consumption	0.0	0.0	0.0	0.0	0.3	0.2
Extraterritorial organizations and bodies	0.0	0.0	0.0	0.0	0.0	0.0
Manufacturing	58.9	48.9	50.6	58.9	27.6	34.0
Services	30.6	39.0	37.6	30.6	36.8	35.7
Other	10.4	12.1	11.8	10.4	35.6	30.3
Total	100	100	100	100	100	100

Source: Own calculations based on the World Input-Output Database. Shares are rounded to the nearest tenth.
Notes: 4 East Asian countries (China, Japan, Korea, and Taiwan) are aggregated. Industries are assigned to sectors. XVA refers to VA-exports as share of all value-added exports contributions. MVA refers to VA-imports as share of all value-added import contributions.

Chapter 4

Who's afraid of Virginia WU? The labor composition and labor gains of trade

ABSTRACT

There are various ways to indicate the importance of international trade. In this paper, we use the 'labor footprint' concept to gain new insights into the implications of trade for employment. We focus on the US, but also provide information on 39 other, mostly developed, countries for the period 1995-2008. We show that US consumption increasingly depends on foreign workers. At the same time, US labor has benefited from new jobs generated by the world economy, especially in the services sector. Next we compare labor footprints with labor endowments to evaluate the capacity of countries to be self-sufficient in terms of labor in a hypothetical situation of autarky and perfect labor mobility. This counterfactual exercise reveals that most countries in our study are able to produce all output for consumption themselves. However, once the assumption that labor is perfectly mobile across skill levels and that all unemployed workers accept a job when offered one is relaxed, most countries can no longer be self-sufficient. That is, these countries would not be able to sustain their current consumption pattern.

This chapter is based on Bohn et al. (2019).

4.1 Introduction

The famous play “Who’s afraid of Virginia Woolf” by Edward Albee is about a married couple that take refuge in illusion and addresses the question “who’s afraid of living life without false illusions?”. This paper is about the fear of foreign workers, or a proverbial Chinese Virginia Wu, taking away domestic jobs, which for some countries turns out to be a false illusion. In this paper we investigate the issue whether foreign workers are a threat to domestic workers by using an empirical model that has become possible with the availability of global input-output tables: global labor footprints.

A country’s global labor footprint measures the global amount of labor that is embodied in the final products that this country consumes. The idea behind labor footprints is simple. Trade enables countries to use foreign labor, as embodied in imported goods and services. Not only the foreign labor that is embodied *directly* in the import of a – final or intermediate − product should be accounted for, but also the foreign labor that goes into the inputs that go into the production of this particular product. And the labor that goes into the inputs that go into the inputs, and so forth. This is the labor that is *indirectly* embodied. The international fragmentation of production processes has increased in importance (Baldwin, 2006), which had two consequences. First, the contribution to the footprint of labor that is indirectly embodied has probably increased. Second, calculating labor footprints is difficult because international fragmentation has led to longer global supply chains. However, using global input-output tables allows us to include all indirectly embodied labor. We can thus trace global supply chains and calculate the labor footprint more precisely than is possible without these data.

As Rodrik (2017) indicates, the analysis is also related to the often observed worries that foreign workers take away domestic jobs. The perceived threat to domestic jobs has increased, now that production processes and value chains have become global (Hummels et al., 2001). These developments have been associated with well-publicized outsourcing and offshoring concerns in advanced economies. Many policymakers fear the consequences of the increased international trade for ‘local jobs’. The negative effects of offshoring of US jobs to low income countries was a major topic in the 2016 US presidential election. After the election in 2016, the US has initiated a renegotiation of NAFTA, withdrew from the Trans-Pacific Partnership (TPP), and put the negotiations on the Transatlantic Trade and Investment Partnership (TTIP) on hold. Also the import penetration from China has revived the question ‘are the gains of trade positive for the US?’. Recent studies document possible negative effects of Chinese import exposure on the US labor market (Acemoglu et al., 2016; Autor et al., 2014; Ebenstein et al., 2012; Pierce and Schott, 2016). Autor et al. (2013), for instance, find that Chinese supply shocks accounted for 44% of total decline in US manufacturing jobs between 1990 and 2007. Import exposure also led to higher unemployment, lower wages in non-manufacturing sectors, and sizable transfer payments.

The labor footprint concept provides an alternative way of looking at the trade effects of import competition. The analysis covers 14 consecutive years from 1995 to 2008 and we focus mostly on the labor footprint of the US. We define the labor footprint as the number of workers, worldwide, required to produce the entire bundle of final products (goods and services) consumed in a certain country (e.g., the US) and year. This method allows us to calculate how much labor (of different skill-types and different origins) are currently at work. We measure the number of domestic workers that go into US consumption and the number of workers that are imported. On the flip side, we consider the number of US workers that are exported, i.e., are embodied in foreign consumption of final products. We compare this situation with the amount and type of workers required in autarky and take labor endowments into account (using unemployment data).

The analysis then answers the question whether 'lost' jobs would have been saved in case there was no trade with the condition that the country would still sustain its current level of consumption. This approach is (partially) linked to the gains-of-trade literature (see Dixit and Norman, 1980, or Feenstra, 2016, for comprehensive surveys of the concept). The standard gains-of-trade analyses show that countries are better off with trade than without. Our analysis should not be interpreted as a complete picture of the gains of trade because we focus only on one component: labor. Labor gains of trade occur if the consumption of a country would need more workers under autarky than current employment. In other words, the currently employed workers would only allow a reduced consumption under autarky. The reduction reflects the labor gains of trade.

We provide three measures related to what we call the labor benefits of trade. Firstly, we define the worker surplus as the labor endowments minus the footprint. A negative surplus indicates that a country "consumes" more workers than it actually endows. This has become possible through trade, so that a negative worker surplus (as a share of the labor force) is seen as a benefit from trade. We introduce worker productivity differences across countries in order to assess the self-sufficiency prospects of the US and other countries more properly (under a strong ceteris paribus assumption). Secondly, we calculate the footprint in autarky and the corresponding worker surplus. A negative surplus indicates that a country has a labor force that is not large enough to sustain its current consumption level and pattern in autarky. Also this can be viewed as a benefit of trade for the current, actual situation (because absence of trade would hamper consumption). Thirdly, we define the labor gains of trade as the footprint in autarky minus the number of employed workers, as a share of the employed workers. For example, an outcome of 0.1 indicates that the same consumption bundle would require 10% more workers in autarky than in the actual situation. The same number of workers can thus reach in autarky (10/11=) 91% of the consumption that workers in the actual situation can.

Our findings indicate that nearly half of all workers embodied in US consumption were foreign workers in 2008. The share of foreign workers in the US labor footprint grew 7.8 percentage points between 1995 and 2008. This may seem like a heavy dependence of domestic consumption on foreign labor. However, labor productivity differences have to be taken into account. Whereas the 'raw' share of Chinese workers in the 2008 US labor footprint was 14.2%, it was 1.5% after adjusting for efficiency differences between US and foreign workers. At the same time, nearly one million new jobs in services were created in the US to serve foreign demand – mitigating the negative effect of import competition.

Our main finding is that domestic US workers could have produced the entire US consumption bundle (which applies to every year in the period 1995-2008) in a situation of autarky. This, however, only holds if we assume: (i) perfect substitutability between domestic workers of different skill-types; and (ii) all unemployed workers are able and willing to accept a job if offered. If imperfect substitutability is allowed, the US would have showed a shortage of low-skilled workers in most years. Medium- and high-skilled workers would have needed to be re-allocated to low-skilled tasks. This implies that the US could not have been self-sufficient in autarky under realistic assumptions. We also find positive labor gains of trade for the US throughout the time period. The US consumed between 1.3% and 4.2% more in the actual trade structure between 1995 and 2008 than what would be possible in autarky with the same number of workers - even before accounting for imperfect labor mobility.

We use the US as an illustration, but the analysis covers 40 different countries. The paper is organised as follows. First, we provide the context and literature in Section 4.2, then we present the methodology in Section 4.3 and the data sources in Section 4.4. Subsequently, we discuss the results in Sections 4.5 and 4.6, and finalize our analysis with a conclusion in Section 4.7.

4.2 Literature

Footprint indicators are becoming increasingly popular in research, policy- and decision-making (Gomez-Paredes et al., 2015). They have been used in a diverse context including for the analysis of issues related to ecology, energy, water usage, land, biodiversity, wages and inequality. The concept captures both direct and indirect repercussions along production and distribution chains (Cucek et al., 2012). Not only the direct impact of a particular final product is calculated, but also the indirect impact of supplying (foreign) intermediate products and supplying the intermediates for producing the intermediates *et cetera*. Footprints are computed by using input-output analysis (Gomez-Paredes et al., 2015; Arto et al., 2014; Wiedmann et al., 2006). The labor footprint builds on this concept and can be used to track the global flows of labor that ends up in the consumption of final products (i.e., final demand) of a particular country.

4.2.1 The labor footprint

The labor footprint is constructed by linking employment accounts to trade flows using international input-output tables. It accounts for all workers, in whatever country, engaged in producing the final consumption bundle of country *R*, e.g., the US. All labor footprints together yield the global use of labor. Our empirical analysis can be split into two parts.

First, we use labor footprints to calculate the different types and origins of labor embodied in final consumption. We measure the exports of domestic labor (i.e., domestic labor embodied in foreign final demand) and the imports of foreign labor (i.e., foreign labor embodied in domestic final demand). We consider whether the imports of labor (reflecting the dependency of a country on foreign workers) increased between 1995 and 2008. Second, we compare the structure of the labor footprint in actual trade to the corresponding labor footprint in autarky. We check whether labor endowments were sufficient to sustain actually observed consumption levels, using various assumptions. We include both temporal and country-level comparisons.

We consider a country to gain from trade in terms of labor if its overall levels of consumption in the actual trade structure could not be obtained in a situation of autarky (with the same number of employed workers). Hence, autarky then implies residents must sacrifice part of their current consumption. The magnitude of the labor gains of trade in our measurements is given by the extra labor a country would need in a counterfactual situation of autarky to sustain the same consumption levels as in the actual situation (including the actual trade structure). To compare the labor gains of trade across time in the US, the number of workers the US would be in surplus of (or be short of) in autarky is taken as a percentage of the actually employed workers.

4.2.2 Factor content of trade

This paper fits into the recent discussion on trade in factor services, which is an approach that has been used for counterfactual analysis and to measure the gains from trade (Costinot and Rodriquez-Clare, 2018). The approach is based on the framework proposed by Adao et al. (2017). Trade in factor services includes all factors such as labor, capital, land, and so on that are embodied in the production of goods and services that are traded. Our analysis focusses on a specific element of trade in factor services: labor.[70]

The calculations for the labor footprints are also related to the extensive literature on the factor content of trade. Studies on this topic have long provided a method to compute the factors embodied in trade. Just like the labor footprint concept, also the factor content of trade analyses are based on input-output (IO) models.[71] This literature goes back to the Hecksher-Ohlin (HO) prediction, extended by Vanek (1968), which hypothesizes that countries export (import) their relatively abundant (scarce) factors. Numerous studies attempted to empirically confirm the Heckscher-Ohlin-Vanek theorem (HOV) but their models performed poorly when confronted with the data. The most famous example is the 'Leontief paradox' (1953). Subsequent studies extended HOV by relaxing certain assumptions to allow for technology differences, intermediate trade, and alternative assumptions on the preferences across countries.

One of the challenges in extensions to HOV was to account for cross-country productivity differences, which is an issue highly relevant to our study. Leontief (1953) and other early work had insufficient data on the production techniques of foreign trading partners and resorted to US technology to estimate labor and capital embodied in imports from abroad. A widely cited study by Trefler (1993) introduced factor-augmenting productivity differences across countries into the HOV model. He imputed international productivity differences to make the HOV theorem perfectly fit the data on trade and endowments, then determined they strongly correlated to cross-country variation in factor prices. However, there were two limitations in his study. First, Trefler (1993) used the US IO-matrix to measure the factor content of trade globally for all countries. Reliance on technology coefficients of a highly developed and capital-abundant country to serve as a reference is problematic as it leads to a (downward) bias in the

[70] The analysis is limited to labor because our focus is on the labor footprint; hence the counterfactual analysis can be considered a partial analysis of the gains of trade.
[71] For an overview, see Foster and Stehrer (2010).

factor content of exports by countries with less efficient technologies (Davis and Weinstein, 2001). That is, most countries would need less of each factor to produce their exported output using the US technology matrix than what they employ in reality. Second, Trefler (1993) did not account for trade in intermediate products, which became important with the global integration of production and the ongoing international fragmentation.

Subsequent studies have addressed the shortcomings, both through improved methodologies and better data. Davis and Weinstein (2001) used the OECD database to introduce the use of intermediates into the theoretical HOV model and to take into account productivity differences. Reimer (2006) extended the approach of Davis and Weinstein (2001) by using a world IO-matrix to measure the factor content of trade when production technologies differ across countries and intermediate inputs are traded. A more recent contribution that employs international IO tables is Trefler and Zhu (2010). They used the global GTAP database and a method consistent with Vanek's factor content predictions to determine a high correlation between relative factor endowments and the factor content of trade. Stehrer et al. (2012) found similar results using WIOD data. However, some authors (Fisher and Marshall, 2015; Zhang 2015) have criticized the approach of Trefler and Zhu (2010) as being "logically correct but economically misleading" due to double-counting of re-exported intermediates in complex trade structures.

4.2.3 Our approach

Our approach draws upon the insights of the factor content literature to account for both intermediate goods trade and differing production techniques across countries. To do so we use an IO-method and the same global database as in Stehrer et al. (2012) and H. Zhang (2015). However, our study differs from the factor content research in three respects. First, our focus is on labor footprints, not on testing the validity of the HOV model. Second, in order to avoid the double-counting of labor inputs in trade, we draw upon the 'trade in value-added' concept (Johnson, 2014). This means we trace the domestic factors embodied in domestic production that is directly or indirectly contained in the final consumption of partner countries (even in the absence of direct bilateral trade between them). This demand based perspective distinguishes our method from related studies such as Groshen et al. (2005) and Stehrer and Stöllinger (2014), both of whom used IO tables to compare the number of jobs embodied in exports with the hypothetical number of jobs required to produce imports.[72] Third, rather than focussing on the factor content of trade (which is –by definition– zero if there is no trade between two countries), we are interested in the trade in factors (i.e., how much factor content is embodied in the entire consumption bundle of another country). In this respect, we draw upon the footprints approach and want to know *all* the origins (including 'home') of the factors embodied in final consumption. We describe the data we use after the methodology section.

4.3 Methodology

The analysis is global and we work with a world IO table (also known as a Global Multiregional Input-Output table, see Tukker and Dietzenbacher, 2013, for an overview). For the ease of exposition but without loss of generality, suppose that the world consists of only three countries (*R*, *S*, and *T*). In this case, the world IO table looks as follows.[73]

Table 4.1. The world input-output table

	Intermediate use in:			Final use in:			Total output
	R	*S*	*T*	*R*	*S*	*T*	
Product flows from							
country *R*	$\mathbf{Z}^{RR}$	$\mathbf{Z}^{RS}$	$\mathbf{Z}^{RT}$	$\mathbf{f}^{RR}$	$\mathbf{f}^{RS}$	$\mathbf{f}^{RT}$	$\mathbf{x}^{R}$
country *S*	$\mathbf{Z}^{SR}$	$\mathbf{Z}^{SS}$	$\mathbf{Z}^{ST}$	$\mathbf{f}^{SR}$	$\mathbf{f}^{SS}$	$\mathbf{f}^{ST}$	$\mathbf{x}^{S}$
country *T*	$\mathbf{Z}^{TR}$	$\mathbf{Z}^{TS}$	$\mathbf{Z}^{TT}$	$\mathbf{f}^{TR}$	$\mathbf{f}^{TS}$	$\mathbf{f}^{TT}$	$\mathbf{x}^{T}$
Value added	$(\mathbf{v}^{R})'$	$(\mathbf{v}^{S})'$	$(\mathbf{v}^{T})'$				
Total inputs	$(\mathbf{x}^{R})'$	$(\mathbf{x}^{S})'$	$(\mathbf{x}^{T})'$				
Labor inputs	$(\mathbf{l}^{R})'$	$(\mathbf{l}^{S})'$	$(\mathbf{l}^{T})'$				

Assuming *n* industries in each country, $\mathbf{Z}^{RS}$ is the $n \times n$ matrix with intermediate deliveries and its element z_{ij}^{RS} gives the delivery of goods and services (expressed in million US$) that industry *i* in country *R* sells to industry *j* in country *S*. The element f_i^{RS} of the vector $\mathbf{f}^{RS}$ gives the delivery of goods and services from industry *i* in country *R* for household consumption and other domestic final demand purposes (including private investments, government consumption and investments, and changes in stocks) in country *S*. These are the exports from *R* to *S* in industry i. For simplicity, we use the term consumption in this paper to refer to the total of all final demand categories. The element x_i^R of the vector $\mathbf{x}^R$ gives the total output (or value of

[72] See also Steher (2012) who compares the demand-based measure of value added flows ('trade in value added') with the supply-based approach ('value added in trade') and applies them using the WIOD.

[73] This follows standard IO methodology (see Miller and Blair, 2009). Bold-faced lower-case letters are used to indicate vectors, bold-faced capital letters indicate matrices, italic lower-case letters indicate scalars (including elements of a vector or matrix). Subscripts indicate industries and superscripts indicate countries. Vectors are columns by definition, row vectors are obtained by transposition, denoted by a prime (e.g., $\mathbf{x}'$). Diagonal matrices are denoted by a circumflex (e.g., $\hat{\mathbf{x}}$).

production) by industry i in country R. In country S, the element v_j^S of the (row) vector $(\mathbf{v}^S)'$ gives the value added (including wages and salaries, employers' contributions, capital depreciation, indirect taxes, price-decreasing subsidies, and operating surplus or other income) generated in industry j in country S. Additionally, the element l_j^S of the (row) vector $(\mathbf{l}^S)'$ gives the input of labor in industry j in country S. Labor is measured in thousands of workers (not corrected for productivity differences). Note that there are no separate column vectors with exports nor separate row vectors with imports included in Table 4.1. This is because there are no other countries in this world than R, S and T.

The labor footprint gives the amount of work worldwide that is necessary for the final demands of a country (say R). Define

$$\mathbf{A} = \begin{bmatrix} \mathbf{A}^{RR} & \mathbf{A}^{RS} & \mathbf{A}^{RT} \\ \mathbf{A}^{SR} & \mathbf{A}^{SS} & \mathbf{A}^{ST} \\ \mathbf{A}^{TR} & \mathbf{A}^{TS} & \mathbf{A}^{TT} \end{bmatrix}, \boldsymbol{\omega} = \begin{pmatrix} \boldsymbol{\omega}^R \\ \boldsymbol{\omega}^S \\ \boldsymbol{\omega}^T \end{pmatrix}$$

where $\mathbf{A}^{RS} = \mathbf{Z}^{RS}(\hat{\mathbf{x}}^S)^{-1}$ is the $n \times n$ matrix of input coefficients $a_{ij}^{RS} = z_{ij}^{RS}/x_j^S$, and $\boldsymbol{\omega}^R = \mathbf{l}^R(\hat{\mathbf{x}}^R)^{-1}$ is the vector of labor inputs per US\$ of output, i.e., $\omega_j^R = l_j^R/x_j^R$. The vector with (in this case three) labor footprints is then given by

$$\begin{aligned} &(\varphi^R \quad \varphi^S \quad \varphi^T) \\ &= ((\boldsymbol{\omega}^R)' \quad (\boldsymbol{\omega}^S)' \quad (\boldsymbol{\omega}^T)') \begin{bmatrix} \mathbf{M}^{RR} & \mathbf{M}^{RS} & \mathbf{M}^{RT} \\ \mathbf{M}^{SR} & \mathbf{M}^{SS} & \mathbf{M}^{ST} \\ \mathbf{M}^{TR} & \mathbf{M}^{TS} & \mathbf{M}^{TT} \end{bmatrix} \begin{bmatrix} \mathbf{f}^{RR} & \mathbf{f}^{RS} & \mathbf{f}^{RT} \\ \mathbf{f}^{SR} & \mathbf{f}^{SS} & \mathbf{f}^{ST} \\ \mathbf{f}^{TR} & \mathbf{f}^{TS} & \mathbf{f}^{TT} \end{bmatrix} \end{aligned} \tag{4.1}$$

where $\mathbf{M}$ is the multiplier matrix $(\mathbf{I} - \mathbf{A})^{-1}$, known as the Leontief inverse (or total requirements matrix). Element m_{ij}^{RS} of the matrix $\mathbf{M}^{RS}$ indicates how much output from industry i in country R is directly and indirectly required per unit of final demand for the products produced by industry j in country S. φ^R gives the labor footprint for country R, which gives the amount of labor worldwide that is necessary to sustain the consumption pattern of country R. Note that

$$\varphi^R = (\boldsymbol{\omega}^R)' \sum_{J=R,S,T} \mathbf{M}^{RJ}\mathbf{f}^{JR} + (\boldsymbol{\omega}^S)' \sum_{J=R,S,T} \mathbf{M}^{SJ}\mathbf{f}^{JR} + (\boldsymbol{\omega}^T)' \textstyle\sum_{J=R,S,T} \mathbf{M}^{TJ}\mathbf{f}^{JR} \tag{4.2}$$

The first term on the right-hand side gives the labor in country R that is embodied in the entire consumption bundle of country R. The second and third term give the labor in countries S and T, again, embodied in the consumption by R. The latter two terms give the imports of labor.

The question is whether the labor footprint φ^R in country R is larger (or smaller) than the actual labor force in this country. If larger, country R can be said to consume more labor than it actually has (given the current trade structure). The actual labor force is given by the number of workers employed in country R (i.e., $(\mathbf{l}^S)'\mathbf{e}$, with $\mathbf{e}$ the summation vector consisting of ones) and unemployment in workers. Unemployed workers are workers not currently engaged in productive activities but actively searching for a job. The difference between the labor footprint and the number of employees (excluding unemployed workers) is equivalent to the imports of labor minus the exports of labor. (In a follow-up analysis, we also take worker productivity into account. Differences in production technologies across countries are then assumed to be perfectly reflected by differences in factor costs.)

The next step is to assume that country R acts under autarky, i.e., without any trade relations. In that case, the labor footprint equals

$$(\boldsymbol{\omega}^R)'(\mathbf{I} - \bar{\mathbf{A}}^R)^{-1}\bar{\mathbf{f}}^R \tag{4.3}$$

where $\bar{\mathbf{A}}^R = \sum_{J=R,S,T} \mathbf{A}^{JR}$ is the matrix with technical input coefficients. For instance, it gives how many dollars of steel are necessary for one dollar of car production, irrespective of the origin of the steel. In a situation of autarky, a country has to produce everything itself, including the inputs that go into the production (and the inputs that go into the inputs, etcetera). Similarly, $\bar{\mathbf{f}}^R = \sum_{J=R,S,T} \mathbf{f}^{JR}$ gives the consumption in country R under the assumption that all goods and services are now produced at home. Note that in autarky all the labor involved in producing for other countries in the current trade structure is released. It is now available for domestic production, including production to substitute for 'lost' imports.

4.4 Data sources

Our primary data source is the 2013 version of the World-Input-Output Database (WIOD). This database contains a time-series of World Input-Output Tables (WIOTs) for the period 1995-2011.[74] There are 40 countries and 35 industries included, covering more than 85% of world GDP, in addition to the 'Rest of World'.[75] The WIOTs were compiled by harmonizing national supply-use tables (or national input-output tables) and combining them with detailed

[74] Although a new version of the WIOD was released in 2016 (with a time-period from 2000-2014, and which includes three more countries), we use the 2013 release because the socio-economic accounts accompanying the 2016 release did not update employment data by skill levels, which is crucial for our analysis.

[75] A list of all countries is provided in Table 4.A1 of the appendix. The 35 industries are based on the NACE revision 1, which corresponds to ISIC revision 3.

international trade data. This provides a single and consistent source of global trade linkages involving intermediate and final trade flows between all industries and countries.[76] The WIOD's socio-economic accounts (SEAs) give additional information on employment and wage shares of three skill categories of workers. Note that employment is defined as 'all persons engaged', which includes paid employees, the self-employed, part-time, and informal workers (the latter has been estimated). This disaggregated employment and factor payment data are available for every industry and country.[77] All data have been harmonized to ensure international comparability and compatibility with the WIOTs. Differences in labor productivity across countries will be proxied in our study by the factor cost data at the industry and skill level.

To estimate the labor force (or domestic labor endowment), we need data on unemployed workers, which are then added to the number of employees engaged. For unemployment data, we use the International Labor Organization (ILO) database. In most cases unemployment data was based on Labor Force Surveys (LFSs). Whenever the ILO provided multiple data sources for unemployment, the LFS was preferred over official national sources because LFSs use a consistent methodology across countries. The ILO also provides unemployment data as unemployment ratios, which we use later as a robustness check. In this way we were able to obtain data for nearly all countries and years in the WIOD database.

Although the data covers the years 1995-2011, our analysis focusses on the period until 2008 for two reasons. First, labor and capital compensation data are not available for non-EU countries in 2010 and 2011. This precludes productivity comparisons between EU and non-EU countries based on using factor costs as a proxy of worker productivity. Second, 2009 and 2010 were the years most influenced by the financial crisis and thus may taint our results because of the general contraction of trade. This could imply that the worker composition of the consumption bundle became less diversified, with a higher share of domestic workers compared to previous years.

Employment data in numbers of workers also reflect labor participation rates, which are to some extent culturally determined and may differ across countries. For this reason we considered using hours worked (instead of workers) as our unit of measurement. This

[76] The WIOD is available for free at www.wiod.org. For more details on its construction, see Dietzenbacher et al. (2013) and Timmer et al. (2015).

[77] Industry-level employment for the 'Rest of World' aggregate (making up 15% of world GDP but more in employment terms) is not included in the publicly released SEAs; however, confidential estimations, including a breakdown by skill-level, were gratefully provided by Gaaitzen de Vries. He was involved in the development of the WIOD satellite accounts. For more details on the construction of the satellite accounts, see Erumban et al. (2012).

information is also provided by the SEAs, but data in hours are incomplete because only the EU, US, Japan, and other advanced countries (with the exception of China) have reliable data on this variable. The SEA creators derived data on hours worked for all other countries contained in the WIOD directly from employment data in numbers of workers (which does thus provide the same information). In addition, data on hours worked in the 'Rest of World' is not provided by the SEAs and would be difficult to estimate. Therefore, we use workers – initially without any cross-country productivity adjustment – as our baseline unit of measurement.

4.5 Results: US case study

We begin our analysis with a case study of the United States. This includes determining the composition of the US labor footprint (i.e., answering the question "who contributes how much labor to the US consumption bundle?") and evaluating the self-sufficiency of US labor in autarky, followed by robustness and sensitivity checks. In Section 4.6, we move beyond the US and analyze the situation of 39 more countries by comparing each country's labor footprint with its labor endowment. In each case we also examine the labor gains of trade.

4.5.1 US labor footprint

We first employ the labor footprint concept to compute the number of workers directly and indirectly embodied in the consumption bundle of the United States (in 1995 and 2008). The calculation is similar to what is done in equation (4.2) for a world with three countries. The first term on the right-hand side gives the domestic workers embodied in the consumption bundle of country *R* (i.e., in this case US workers embodied in US consumption), the second and third terms give the embodied foreign workers (from *S* and *T*).

Table 4.2 displays the worker composition of the US labor footprint. The table shows the number (and share) of domestic (i.e., US) workers embodied in US consumption and the numbers (and shares) of 'imported workers'. In 1995, approximately 203 million workers were worldwide engaged, directly and indirectly, to produce the goods and services consumed in the US in that year. 124 million (61.1%) of them were domestic US workers and almost 79 million (38.9%) were foreign workers. Of all workers in the US labor footprint, only 9 million workers (4.5%) were from advanced nations (EU-27 and other advanced nations), while the remaining nearly 70 million foreign workers (34.3%) were from all other countries (including mostly developing and emerging countries).[78] China alone provided more than 25 million workers or 12.6% of all the labor required to produce the US consumption bundle.

In 2008, the year just preceding the economic crisis, 264 million workers were embodied in US consumption (+61 million workers). The share of workers originating from developing countries (i.e., China, Other emerging, and 'Rest of World') rose. The total share of foreign workers increased by 7.8 percentage points, but the share of workers from emerging and developing countries increased by 8.4 percentage points. This implies that the share of workers from all advanced countries decreased by 8.4 percentage points (7.8 percentage points in the US itself, 0.6 percentage points in the EU-27 and Other advanced countries). While the number of domestic US workers increased in absolute terms, from 124 to 140 million, the share of US workers in all embodied workers decreased to 53.3% in 2008. This is indicative of large and increasing net labor imports.[79] The share of US workers increased a few percentage points during the financial crisis (2009-2011; not shown here). World trade contracted and the trend towards greater US dependence on foreign labor temporarily reversed.

Table 4.2. US labor footprint, by region

A. Workers embodied in US consumption (in thousands of workers)

	1995	2008	Change
US workers (1)	124106	140874	16768
All foreign workers (2)	78931	123472	44541
EU-27 workers	4066	5004	938
Other advanced	5157	5428	271
China	25562	37607	12046
Other emerging	15638	22283	6644
Rest of World	28508	53150	24642
Footprint (3) = (1) + (2)	203037	264346	61309

B. Workers embodied in US consumption (as percentage of all embodied workers)

	1995	2008	Change
US workers (1)	61.1	53.3	-7.8
All foreign workers (2)	38.9	46.7	7.8
EU-27 workers	2.0	1.9	-0.1
Other advanced	2.5	2.1	-0.5
China	12.6	14.2	1.6
Other emerging	7.7	8.4	0.7
Rest of World	14.0	20.1	6.1
Total	100	100	0

[78] Other advanced countries include Australia, Canada, Japan, Korea, and Taiwan; Other emerging countries (i.e., other than China) include Brazil, India, Indonesia, Mexico, Russia, and Turkey; the 'Rest of World' aggregate combines all other countries in the world not included in any of the other categories, such that the labor footprint covers all countries.

[79] As shown in Table 4.3, net imports were greatest in manufacturing and 'other' categories.

There are two observations. First, the workers involved in producing for US consumption diversified over the period because reliance on domestic workers declined (in relative terms). This is consistent with the increasing international specialization patterns in trade in that period. Although the US 'lost' jobs overseas, it 'gained' jobs because more US workers were involved in producing foreign consumption (not captured in Table 4.2). What matters in this respect is the net trade of workers. In addition, foreign workers, while large in number, may be less productive than domestic US workers. We return to this issue in the counterfactual exercises, in Section 4.5.2. The second observation is that the share of Chinese workers did not increase substantially in the period of observation.

The current debate on US job losses is focused on lost jobs in manufacturing. Table 4.3 therefore splits the workers according to the industry group (manufacturing, services, other) they are working in. It gives the US manufacturing workers embodied in the US consumption bundle, the imports of manufacturing workers (i.e., foreign manufacturing workers embodied in US consumption), and the export of manufacturing workers (i.e., US manufacturing workers embodied in foreign consumption).

The number of US manufacturing jobs in US consumption shrank by 4 million between 1995 and 2008. This large reduction in US manufacturing jobs was only marginally compensated by new US manufacturing jobs in foreign consumption. At the same time, 15 million manufacturing jobs were created overseas to directly or indirectly serve US consumption. The number of services jobs in US consumption increased by almost 33 million. Nearly 20 million of them were newly created US jobs and 13 million were newly offshored services jobs.

Focusing on the number of US workers embodied in foreign consumption bundles, the results show that in 2008 nearly 11 million US workers were involved in this – more than 6 million of which in services. The changes in these numbers over time indicate that nearly 1 million new services jobs were induced by exporting related activities between 1995 and 2008. These 1 million new jobs could contribute to (partially) replace domestic jobs that may have been lost to globalization and import competition. Thus, the perspective of lost jobs in manufacturing is – in the debate – incomplete because in a GVC context these can (and are) offset by gains in other sectors. The data strongly suggest that this is propelled by a transition from manufacturing to services jobs. This supports a study by Timmer et al. (2013), which found that advanced nations were increasing their competitiveness by transitioning to (high-skilled) services activities. Note that the numbers do not yet reveal anything about the skill-type (quality) of jobs gained or lost by US and foreign workers. We discuss skill-distributions next to check the activities in which advanced nations specialize within production networks.

Table 4.4 splits all workers embodied in the US consumption bundle into two groups: domestic workers and foreign workers. For each of the workers we distinguish three skill levels. They are defined by educational attainment categories using skill-shares provided in the SEAs (medium and high-skilled workers typically correspond to workers having at least a secondary education, e.g., High School and vocational training). In 1995, 89% of US workers involved in US consumption were either medium or high skilled, compared to only 29% of the foreign workers. The numbers 2008 were 91% and 37%, respectively. Among all workers embodied in US consumption, domestic US workers were highly educated relative to their foreign peers. Highly skilled workers typically have better salaries, and in Ricardian theory cross-country income differences are expected to reflect differences in labor productivity. This suggests that there may be significant productivity discrepancies between domestic and foreign workers. These discrepancies may, when properly accounted for, influence the capacity of US labor to be self-sufficient in autarky. We use this insight to take a deeper look at the impact of productivity in Section 4.5.2.

Table 4.3. Who works for whom? (in thousands of workers)

		1995	2008	Change
Manufacturing	US workers for US consumption	14873	10674	-4200
	Import of foreign workers	26307	41405	15098
	Export of US workers	3744	3852	107
Services	US workers for US consumption	98919	118405	19485
	Import of foreign workers	15351	28770	13420
	Export of US workers	5364	6305	942
Other	US workers for US consumption	10313	11795	1482
	Import of foreign workers	37273	53297	16024
	Export of US workers	766	712	-53
Total	US workers for US consumption	124106	140874	16768
	Import of foreign workers	78931	123472	44541
	Export of US workers	9873	10869	996

Table 4.4. US domestic and foreign workers in US consumption by skill-level (as percent of all domestic and foreign employment, respectively, embodied in US consumption)

	1995	2008	Change
Domestic workers			
Low-skilled (1)	10.9	9.0	-1.9
Medium-skilled (2)	64.0	60.1	-3.9
High-skilled (3)	25.1	30.9	5.8
Total	100	100	
Foreign workers			
Low-skilled (1)	70.6	62.8	-7.8
Medium-skilled (2)	25.0	29.5	4.5
High-skilled (3)	4.5	7.7	3.3
Total	100	100	

4.5.2 Counterfactual exercises

Next we compare the labor that is necessary to sustain the US consumption bundle with the US labor endowments (or labor force). Table 4.5 displays the US labor endowment and the total number of workers embodied in US consumption (i.e., the US labor footprint). The difference (endowment minus footprint) gives the worker surplus and equals the difference between US exports of labor (US workers embodied in foreign consumption) plus all unemployed US workers in the labor force on the one hand and US imports of labor (foreign workers embodied in US consumption) on the other hand. For 1995, for example, we find: endowment (141383) minus footprint (203037) equals –61654 for the worker surplus. This is the same as exports of US labor (9873, in Table 4.3) plus unemployment (7404) minus imports of labor (78931, also in Table 4.3).

The footprints for 1995 and 2008 are the same as the ones in the previous section, but now we consider additional years. In 1995, there was a discrepancy between endowment and footprint of 62 million workers. In other words, there was a negative worker surplus, which was –43.6% of the US labor force. This labor deficit grew to –80.8% by 2006, meaning that US consumers became even more dependent on imports of labor over time. Clearly, the US consumed more labor than it had available and could not be self-sufficient in terms of labor if workers have the same productivity across countries. Thus, there were positive benefits from trade in both cases (of 43.6% and 80.8%, respectively). However, given our insights from standard trade theory and the literature, the assumption that all workers have the same productivity across countries is an overly simplistic assumption because there are productivity differences.

In the first scenario we consider the case of autarky. We assume the US produces everything it consumes using its own technology and labor. This includes the production of the current imports and all foreign indirect inputs into the US production process. On the other hand, all US workers that were previously embodied in foreign consumption bundles are freed up now. We use equation (4.3) for the calculations. The US labor footprint in this case shows that almost 136 million US workers would be required in 1995, which is about 6 million less than the US labor endowment of that year. The results imply that if the US used all of its workers in an optimal way, including unemployed workers, the US would have a slight 4.0% labor surplus (as a share of its labor force). In other words, unemployment would have fallen to 4.0% and the US could have sustained the same consumption levels it actually achieved that year. This worker surplus declined to 0.5% in 2006. This means that in a situation of autarky, the US would only manage to be self-sufficient if at least 90% of all unemployed workers would accept a job.[80] This would assume little to no frictional unemployment.

In the second scenario we return to the actual trade structure and take a closer look at the foreign workers embodied in US consumption and account for productivity differences. The socio-economic accounts in the WIOD database allow us to calculate the wage rates by dividing the labor payments and the number of workers. We have done this for all 35 industries in 41 countries (including the 'Rest of World') and for three skill types. Using these wage rates we 'translate' the imports of foreign workers into so-called US-efficient workers. To illustrate how this works, suppose that we find that US consumption requires 360 high-skilled local workers in the Indian automobile industry. Suppose also that the wage rate of high-skilled workers in the US automobile industry is twice the corresponding wage rate in India. Then, the amount of money that is paid for the 360 Indian high-skilled workers would have paid for only 180 US workers. We thus assume that the output produced by two high-skilled Indian workers in the automobile industry (using Indian technology) can be replaced by output produced by one US worker (using US technology). Dividing the number of high-skilled Indian workers in the automobile industry by two gives the number of US-efficient workers. This procedure is repeated for the foreign workers of all skill types, industries and countries. It is expected to work well if labor payments perfectly reflect differences in labor productivity.[81]

[80] The worker surplus reduces to 729 thousand workers, which is 10.4% of the number of unemployed workers. Hence, 89.6% of the currently unemployed workers would have to accept a job offer.

[81] As an alternative, we also used overall average wages (i.e., not distinguishing between high-, medium-, and low-skilled workers) to proxy productivity. The results using this more aggregated data did not differ much from the results in Table 4.5 (which are more precise).

In Table 4.5 we see that the US had a labor surplus of 3.5% in 1995 (declining to 0.3% in 2006) when using US-efficient workers. The imports of 78931 thousand workers (Table 4.3) is equivalent to only 12273 US-efficient workers. This implies that US workers are found to be on average 6.4 times as productive as foreign workers. The import of US-efficient workers was only a little larger than the export of US workers, implying that trade was fairly balanced (when compared to the unadjusted numbers of workers).

As percentage of the US labor endowment, the US import of workers in 2008 was 10.5% when measured in US-efficient workers instead of 46.7% in unadjusted workers. The share of Chinese workers in 2008 was only 1.5% when measured in US-efficient workers, rather than 14.2% in case the numbers had not been adjusted for efficiency or productivity differences. In absolute numbers, the import of Chinese workers in 2008 was equivalent to 2.3 million US workers whereas the export of US workers to China was 0.8 million workers. US-China trade created 548 thousand *new* US jobs (i.e., the increase in US exports) between 1995 and 2008. The number of jobs created in China was equivalent to 1656 thousand new US-efficient workers. Hence, while trade with China may have cost net US jobs, the numbers are not as impressive as conventional studies like Autor et al. (2013) suggest.

Table 4.5. Labor footprints and endowments (top part, in thousands of workers), the worker surpluses (as percentage of the labor force, middle part), and the labor gains of trade (bottom part)

	1995	2000	2005	2006	2007	2008
(1) Employed workers	133979	147717	148903	151319	152567	151743
(2) Unemployed workers	7404	5692	7591	7001	7078	8924
(3) Labor endowment *(employed + unemployed)*	141383	153409	156494	158320	159645	160667
(4) US labor footprint *(using the actual trade structure)*	203037	256722	282337	286191	274698	264346
(5) US labor footprint under autarky	135753	152547	155188	157591	158066	157151
(6) US labor footprint *(after efficiency adjustments)*	136379	152236	155944	157909	158268	157528
Worker surpluses (as share of (3))						
(7) Actual trade structure (no adjustments)	-43.6	-67.3	-80.4	-80.8	-72.1	-64.5
(8) Autarky	4.0	0.6	0.8	0.5	1.0	2.2
(9) Actual trade structure *(incl. efficiency adjustments)*	3.5	0.8	0.4	0.3	0.9	2.0
(10) Labor gains of trade	1.3	3.3	4.2	4.1	3.6	3.6

Notes: (3) = (1) + (2); (7) = 100×[(3) - (4)]/(3); (8) = 100×[(3) - (5)]/(3); (9) = 100×[(3) - (6)]/(3); (10) = 100×[(5) - (1)]/(1).

The last row in Table 4.5 gives the labor gains of trade which are defined as the footprint in autarky minus the number of employed workers, as a share of the employed workers. The 1995 consumption bundle requires in the actual situation with the current trade structure 134 million US workers. Some of these workers are exported and traded for foreign workers. Through this trade in embodied workers, the US is able to consume its 1995 bundle. In autarky, however, the same bundle would require 136 million workers. The current 134 million employed workers would generate a consumption bundle is only 98.7% (≈ 134/136). The labor gains of trade then state that the current bundle is 1.3% larger than the bundle that would be possible in autarky. The labor gains of trade were even larger in later years – as high as 4.2% in 2005, meaning the same consumption bundle would require 4.2% more workers in autarky than in the actual situation.

4.6 Extensions

The key finding of our counterfactual exercises is that the labor force (or labor endowment) in the US is large enough to enable the country to achieve the same consumption levels in autarky as in the current situation with trade. This result rests on a strong ceteris paribus clause and two key assumptions however. First, any unemployed worker is assumed to be available for the labor market and, second, there is perfect substitutability of workers across industries and skill-types. In particular the assumption that a high-skilled worker can be replaced by a low-skilled worker is implausible. This section will assume no substitutability across skill-types, which implies that we redo the counterfactual exercises for each skill level. A second extension in this section is to consider the results for the other countries in the WIOD database.

4.6.1 Sectoral substitutability and worker endowments

The assumption of perfect worker substitutability between industry and skill-types is unlikely to be satisfied in the short-term. Restructuring takes time and efforts (e.g., retraining or re-educating workers), which will have consequences. If workers have different aptitudes (comparative advantages) for jobs of different skill levels and are not easily retrained, then moving them around is not possible or will seriously reduce productivity. Transitioning between skill-specific tasks requires a lot of time and is costly so it is plausible to expect less than full substitutability, at least in the short term (e.g., Borjas et al., 2008).

Instead of assuming perfect worker substitutability between industries *and* skill levels (in autarky), we now posit that in the short-term workers are mobile only between industries, but not between skills. This implies that – for each skill-type – we have labor endowments and that we calculate how many US workers are necessary under autarky for the US consumption bundle. The labor endowment is obtained by summing the employed and unemployed workers in each industry for each skill-type. The unemployed workers have been estimated by allocating the total amount of unemployed workers in an industry proportionally to skill categories. This implies that for each industry we assume identical unemployment rates across skill-types.

Table 4.5 in the previous section showed that the worker surplus was 862 thousand workers in 2000 (i.e., row (3) minus row (5)). So, if a large part (i.e., 84.9%) of the 5692 thousand unemployed workers would have been willing and able to accept a job, the US could have sustained its consumption. The question, however, is whether this also holds if workers cannot (or will not) switch to a job with another skill-level. Table 4.6 shows that in 2000 the US would have lacked 169 thousand low-skilled workers if it had produced its own consumption under autarky. This shortage rose to 233 thousand workers by 2006. At the same time, the US would have had a surplus of medium- and high-skilled workers throughout the period (fluctuating but generally decreasing over time). For instance, there would have been a surplus of 568 thousand medium-skilled workers and 394 thousand high-skilled workers in 2006. As the US generally had a surplus in highly skilled workers and a deficit in low-skilled workers, there was a skills-mismatch in terms of workers available and required. Because the low-skilled worker deficit was small compared to the surpluses of medium- and high-skilled workers in all years, the more highly qualified workers could have been able to compensate the low-skilled worker shortage (if redeployed to low-skilled tasks) - even when factoring in a small productivity loss.

Table 4.6. United States - employment, endowments, and labor footprints by skill-level (in thousands of workers)

	1995	2000	2005	2006	2007	2008
Low-skilled workers						
employed (1)	14636	15265	15083	15234	14655	13723
unemployed (2)	809	588	769	705	680	807
US labor footprint under autarky (3)	15085	16022	15989	16172	15482	14521
surplus of workers (4)	360	-169	-137	-233	-147	9
Medium-skilled workers						
employed (1)	85757	92163	90683	91401	92014	91232
unemployed (2)	4739	3551	4623	4229	4269	5365
US labor footprint under autarky (3)	86733	95093	94370	95062	95233	94408
surplus of workers (4)	3763	621	936	568	1050	2189
High-skilled workers						
employed (1)	33587	40289	43137	44685	45898	46789
unemployed (2)	1856	1552	2199	2067	2129	2752
US labor footprint under autarky (3)	33935	41432	44828	46358	47350	48223
surplus of workers (4)	1508	409	508	394	677	1318

Notes: (4) = (1) + (2) – (3).

The second assumption that we have made and that is not realistic is that all unemployed workers are willing and able to accept a job if so required. This is overly optimistic because there will always be at least some frictional unemployment. The numbers in row (1) of Table

4.5 show that 152 million workers (of all skill-types) were employed in the US in 2008, but it follows from row (5) that 157 million workers would have been required to be self-sufficient in autarky. This implies that more than 5 million (of the 9 million, see row (2)) unemployed workers would have needed to take up a job. That would be no problem under the assumptions that we have made. If, however, we assume a natural unemployment rate of 5% as most economists do, only 1 million workers would be able to accept a job.[82] Consequently, there would have been a true shortage of 4 million workers in 2008, implying that the US would not have been able to produce its consumption bundle.

The data shows that for all years between 1995 and 2008, the number of US workers required in autarky was always larger than the number of employed workers. The difference (between currently employed workers and required workers under autarky, i.e., row (5) minus row (1) in Table 4.5), however, was also always smaller than the number of unemployed workers. We have already seen that this is not true for low-skilled jobs if they cannot be carried out by medium- or high-skilled workers. For medium- and high-skilled jobs we see that the number of workers required in autarky almost matched the number of actually employed workers.[83] The gross worker deficit of medium- and high-skilled workers in autarky would never have been more than four million and two million, respectively, in any year. The deficits were always smaller than the number of unemployed workers. However, there was a significant shortage of low-skilled workers employed relative to the low-skilled workers required under autarky. In other words, the US would not have been able to perform enough low-skill functions as required to sustain the consumption bundle. So, in the absence of substitutability between skill-types, a reversion to autarky would be impossible.

4.6.2 Sensitivity analysis

In this section we modify the way unemployment data are obtained and cross-country productivities are measured. So far, we have used ILO unemployment estimates in persons. Now we draw upon unemployment rates, which are also readily available from the ILO. We derive unemployed workers by combining the rates with data on the number of employed workers provided by the WIOD's satellite accounts.[84] Note that employment data from the

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[82] That is, (160,667 thousand)*0.05 = 8 million persons remain unemployed under autarky, where 160,667 thousand is from (3) in Table 4.5. This indicates only 1 million of the 9 million currently unemployed workers are employed under autarky, leaving a 5 – 1 = 4 million worker shortage under autarky in 2008.

[83] That is, (3) – (1) in Table 4.6.

[84] Specifically, let e = employed workers, u = unemployed workers, L = labor force = e + u, and α = unemployment ratio = u/L. Then $u = \alpha(e+u)$, which yields $u = [\alpha/(1-\alpha)]e$.

satellite accounts is not identical to the ILO employment data due to the former being harmonized with the world IOTs. Hence the new estimates for unemployment in persons and resulting labor endowments differ somewhat from the original estimates. For example, for 2008, we now find 9.3 million unemployed workers in the US instead of 8.9 million (see Table 4.5). The alternative estimate is less than 5% higher than the original number. The modification only slightly increases resulting labor endowment levels and does not meaningfully affect the results. The 2008 case for the US is indicative for other countries and years, suggesting that the results are robust to this alternative measure of unemployment.

Next, we use an alternative estimation for the productivity of the 'Rest of World' (ROW) for the scenario based on the actual trade structure with efficiency adjustments (i.e., used to produce rows (6) and (9) in Table 4.5). It is important to check for robustness because the US labor footprints showed large shares of embodied ROW workers (before any efficiency adjustments). This indicates the role of ROW in this respect. The productivity was measured by the per-person wage-rate. In the analysis so far, the wage rates in ROW were obtained in the same way they were obtained for the other countries: by dividing the labor payments in ROW by the number of workers (for low-, medium-, and high-skilled workers, respectively). Then these wage rates were used to 'translate' the imports of foreign workers from ROW into US-efficient workers. However, employment figures for ROW were obtained confidentially from the WIOD creators and are based on estimation techniques. This data was not part of the officially released satellite accounts. As so many countries and workers are reflected in the aggregated number of ROW workers, the employment data for ROW could be expected to be more approximated than for the individual countries included in the WIOD.

Now we take the unweighted average per-person labor payment of the 7 largest emerging countries included in WIOD (Brazil, China, India, Indonesia, Mexico, Russia, and Turkey) to proxy ROW productivity (that is, the per-person labor payments in each country are summed up and divided by 7) and use this to replace the productivity of ROW workers in the original specification. The discrepancy between the original worker surplus shares for the US (i.e., row (9) in Table 4.5) and the modified surplus shares based on adjustments to ROW worker productivity was less than 1.5 percentage points in all years before 2005. For example, The US worker surplus in the original specification was 6.4 million workers in 1995 (or 3.5% of the labor force) compared to 5.6 million workers using the alternative proxy for ROW's productivity in the same year (2.9% of the labor force).

The situation is slightly different in later years. Table 4.5 reported a surplus (endowment in row (3) minus footprint after efficiency adjustments in row (6)) of 3.1 million workers (or

2.0% of the labor force) in 2008. Using the alternative proxy for ROW productivity, however, would have yielded a *shortage* of 1.6 million workers (-1.0% of the labor force) in 2008. This larger discrepancy in more recent years is because the new estimates for the wage rate in ROW are based on the wage rates in emerging countries. These have grown more rapidly than the original estimates of ROW's wage rates. Because the wage rate is used to proxy productivity, the productivity gaps between ROW workers using emerging country wage rates and US workers narrowed. This caused the US labor surplus to decline and even change into a shortage. Similar findings were observed for other years and other advanced countries. We feel that the original ROW estimates seem more suitable than the alternative. This is because ROW includes many developing countries that are not yet emerging countries. Their productivity (i.e., wage rate) did not increase as much and as fast as the wage rate of the largest emerging countries. We feel that the alternative overestimates the wage rate in ROW. The alternative should therefore be viewed as a 'worst case scenario' (for the US).

4.6.3 Comparative perspective of the other countries in WIOD

Now we expand the analysis to track the hypothetical self-sufficiency prospects and labor gains of trade of all 40 countries in the WIOD database. We calculate a country's ability to sustain its consumption bundle in autarky using only domestic workers. This follows the same method as before for the US, using equation (4.3) leading to the results in row (5) in Table 4.5.[85] As in Section 4.5.2, we assume (*i*) perfect worker substitutability between skill-types and industries (based on effective use of each country's production technology), and (*ii*) that unemployed workers are able and willing to accept at any time a job if offered one. The exercise examines which countries are most dependent on foreign workers to sustain consumption levels and how this dependence changes over time in the period 1995-2008. This also puts the case of the US into a broader context.

Table 4.7 displays all 40 countries, 34 of which had complete data (with unemployment data available in 1995 and 2008). The surplus is displayed in the same way as in row (8) in Table 4.5 for the US. That is, the labor endowment (currently employed plus unemployed workers) minus the number of workers required under autarky, expressed as a percentage of the labor endowment. Serious sacrifices would be necessary in cases where a country's labor

[85] The counterfactual method employed in this section hypothetically modifies the underlying trade structure. The second counterfactual exercise in Section 4.5 corrected for efficiency differences of workers across countries and estimated efficiency equivalent workers based on labor payments. Results based on the application of this second counterfactual method to the 40 WIOD countries are similar to the results with the first method for the same country and are available upon request.

endowment is less than the number of workers required in autarky (i.e., a shortage). For instance, Bulgaria had an estimated surplus of 16.1% in 1995, meaning that its domestic labor endowment would have easily been sufficient to produce everything itself without trade that year. However, Bulgaria would have had a deficit of 6.1% in 2008, implying that autarky would necessarily entail reduced consumption, even in the most ideal circumstances (i.e., perfect substitutability and all unemployed workers can and will accept the jobs they are offered).

The results reveal two notable insights. First, nearly all countries in our analysis could have been self-sufficient in terms of producing everything for themselves using only their own domestic labor. In the year 1995, 32 of 35 countries had an excess in labor endowments (all except Estonia, Greece and Portugal); in 2008 still 28 out of 39 countries would have had a labor surplus. Second, a clear majority of countries became less able to be self-sufficient over time (25 of 34).

Table 4.7. Self-sufficiency measured by the labor 'surplus' or 'deficit' in hypothetical autarky

Country	Suplus 1995	Surplus 2008	Change (08-95)	Country	Surplus 1995	Surplus 2008	Change (08-95)
Bulgaria	16.1	-6.1	-22.2	Netherlands	12.0	10.0	-2.0
Lithuania	13.1	-2.8	-16.0	USA	4.0	2.2	-1.8
Spain	19.3	4.9	-14.4	Sweden	15.4	13.7	-1.8
Finland	22.7	9.2	-13.6	India	11.5	10.4	-1.1
Ireland	21.4	8.2	-13.1	Korea	5.0	5.0	0.0
Romania	6.0	-5.7	-11.8	Japan	3.8	4.0	0.3
Greece	-4.5	-15.7	-11.1	Hungary	6.5	7.7	1.2
Poland	17.7	6.6	-11.1	China	6.7	10.4	3.7
Mexico	7.8	0.0	-7.8	Indonesia	6.5	10.8	4.2
Italy	14.3	7.0	-7.3	Germany	9.5	14.6	5.1
France	13.3	6.0	-7.3	Austria	1.4	8.0	6.6
Canada	11.6	4.4	-7.2	Taiwan	6.8	16.2	9.4
Slovenia	4.7	-1.5	-6.2	Luxembourg	6.7	17.4	10.7
Denmark	12.3	6.5	-5.7	Estonia	-9.7	3.6	13.3
Belgium	15.9	10.2	-5.7	Brazil	6.5	n/a	n/a
Slovakia	13.4	8.3	-5.0	Australia	n/a	1.8	n/a
Great Britain	8.9	4.3	-4.6	Cyprus	n/a	-23.4	n/a
Turkey	9.0	4.6	-4.4	Czech Republic	n/a	10.3	n/a
Portugal	0.0	-4.2	-4.2	Latvia	n/a	-4.3	n/a
Russia	0.8	-2.6	-3.4	Malta	n/a	-1.8	n/a

Notes: The first two columns give the labor endowment (i.e., employed plus unemployed workers) minus the workers required to sustain the consumption bundle in autarky, expressed as percentage of the labor endowment. If the result is positive we have a 'surplus', if negative a 'deficit'. The third column gives the percentage point changes between 1995 and 2008. The countries are ranked by largest decrease (in percentage points) over time.

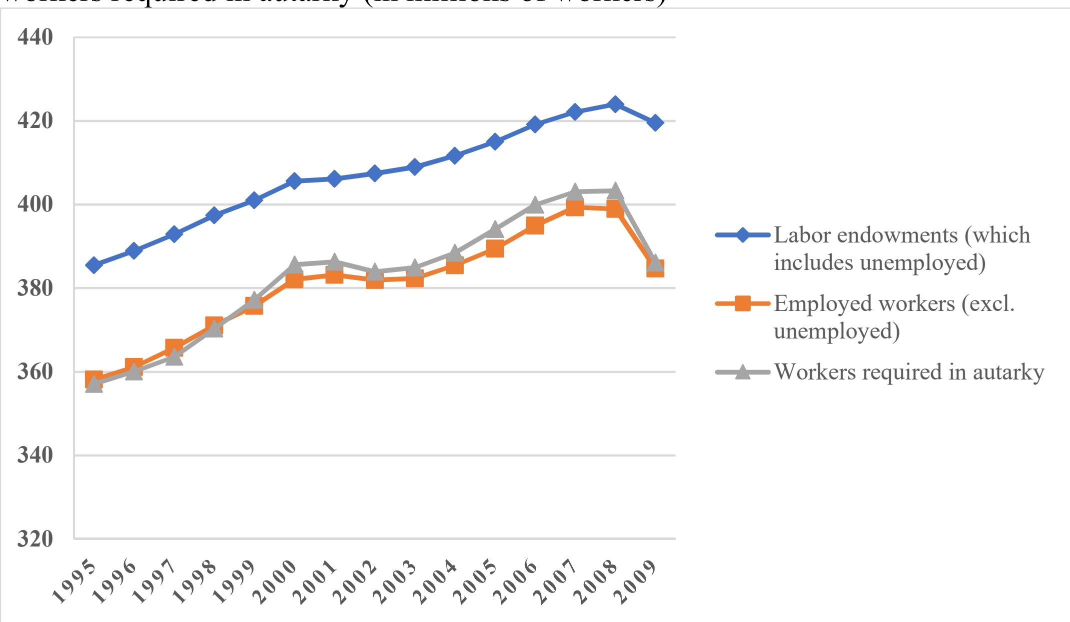
The number of countries still in position to be self-sufficient in 2008 may appear surprising. The next-best case scenario assumes that unemployed workers cannot immediately accept a job and that the number of unemployed workers cannot fall. In that scenario, only 24 of 35 countries had sufficient labor in 1995 and 18 of 39 in 2008 (which also means that unemployment had increased in these countries). Under realistic circumstances, the share of hypothetically self-sufficient countries would probably be lower. This is because worker substitutability between sectors and industries is not perfect, the unemployment is underreported in certain countries, and innumerable other factors are not fully captured (such as efficiency losses related to the lack of import competition). In addition, small open economies simply do not have certain industries. In autarky, they thus could not possibly produce the same diversity of inputs and products as they currently consume. This is an important caveat and makes this exercise appear more reasonable for large and independent countries like the US than for small and trade-dependent countries.

The labor gains of trade were also calculated for the WIOD countries (see Table 4.A2 of the Appendix for full results). As could be expected with the trend towards declining worker surpluses in the counterfactual autarky situation over time in most countries, the labor gains of trade increased in 27 of the 40 countries between 1995 and 2008. The labor gains of trade rose in nearly all countries that became less self-sufficient in the period, and countries that were not able to be self-sufficient in autarky (as shown in Table 4.7) enjoyed the highest overall labor gains of trade.

Figure 4.1 gives the labor endowment, the number of employed workers, and the number of workers that would be required under autarky. The numbers are for the 'Triad', i.e., the first 15 members of the EU, Japan, and the United States and are given for the years from 1995 to 2009. Our motivation to highlight these countries is two-fold. First, they are commonly perceived to be the countries that are at greatest risk of job loss through outsourcing arrangements and import competition. Second, their unemployment estimates are readily available for every year in all countries and their employment data in general are probably more reliable than that of emerging and developing countries (which tend to have major urban/rural divides). Note that although the results of the 17 countries have been aggregated it is still assumed that each separate country operates alone in autarky and does not trade with any country – whether inside or outside of the group. The total Triad labor endowment (including all employed and unemployed workers, and marked by the blue line in Figure 4.1) clearly exceeded the number of workers cumulatively required in the Triad countries to maintain their combined consumption bundle in any of the years (the grey line). However, comparing the employed workers (the orange line) with the number of workers required under autarky shows an almost perfectly parallel movement. The Triad countries were thus able to sustain their current consumption levels with the currently employed workers.

Finally, it is worth noting the sudden change in 2009 (Figure 4.1). This paper's analysis does not cover the crisis years, primarily because these years were a clear aberration from the norm. There was a general collapse of trade, higher levels of unemployment, and declining labor endowments. Little change occurred in 2009 in the relative abilities of countries to sustain consumption levels in autarky with the currently employed workers (as the orange and grey lines dipped in tandem). But when unemployment (which has seriously risen in 2009) is included as part of the labor endowment, we observe an increase in the labor surplus in 2009 (blue minus grey lines).

Figure 4.1. The Triad (European Union-15, Japan, and United States) – labor endowments (which includes unemployed), employed workers (excluding unemployed), and domestic workers required in autarky (in millions of workers)



Notes: The EU-15 (members prior to May 1, 2004) consists of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

4.7 Conclusions and Evaluation

In this paper, we began by describing a way of computing labor footprints based on standard input-output methodology. The aim was twofold: first, to explore how much labor of different types is embodied in the labor footprint of the US, and second, to provide an alternative perspective on the labor benefits of trade and the popular debate over lost jobs due to globalization. Labor footprints are defined as the total number of workers (domestic and foreign) directly or indirectly involved in producing all final goods and services consumed in a country. While the labor footprint concept is not novel by itself, this is to our knowledge the first time it has been combined with employment data to systematically evaluate the (hypothetical) self-sufficiency of domestic labor. These insights help shed new light into the employment implications of trade – including the dependence of countries on foreign labor and the threat of foreign workers for domestic jobs. The analysis was focused on the US but covered 40 countries and 14 consecutive years.

In the US case study, we showed that the share of foreign workers in the US labor footprint grew steadily over time. The trend was largely driven by workers induced in emerging and developing countries. This does not necessarily imply a net US job loss because new jobs were created in export-related activities. We find that many new jobs were gained especially in the services industries. Furthermore, most of the foreign workers were shown to be low-skilled. We considered two counterfactual exercises and determined that US labor would have been able to produce enough to sustain the domestic consumption bundle all by itself (i.e., in autarky) in most years between 1995 and 2008. Despite the worker surplus possible in autarky, there were still positive labor gains of trade for the US when these labor gains are defined as the footprint in autarky minus the number of employed workers as a share of the employed workers. Employed workers achieved a consumption bundle that was 1.3% larger in 1995 and 3.6% larger in 2008 in the actual situation than the consumption bundle that would be possible in autarky.

The second counterfactual exercise was based on the idea that wage rate differences between countries reflected differences in productivity. US workers and US production technology are more efficient than the foreign workers ending up in US consumption (in the current trade structure). Correcting for the differences in productivity levels showed that the enormous amounts of imports of foreign workers would be equivalent to much less US workers. The US labor footprint (in US-efficient workers) was thus fairly close to the autarkic US labor requirements. These results were upheld using different sources for unemployment data and, to a lesser extent, a different proxy for the productivity of the ‘Rest of World’ workers.

However, if we drop the assumption of perfect substitutability between sectors and skill-levels it becomes clear that US labor cannot be self-sufficient (which would also increase the labor gains of trade). In fact, the US would face an acute shortage of low-skilled workers in autarky, and the US was no longer able to be self-sufficient in any year.

Dropping additional assumptions in the analysis would almost certainly further emphasize that US labor cannot be self-sufficient (in terms of maintaining consumption levels). For instance, price effects are important. If the US did not import from China and Mexico, many consumer goods would have been much more expensive for US consumers. They would buy less and US employment would be lower. In other words, consumption is not exogenous to trade as implied in our analysis; employment and imports can also be positively correlated. Second, in a world with internationally fragmented production processes, US export competitiveness is also determined by finding the cheapest, most reliable, and most flexible suppliers of intermediate inputs, which are often not located in the US itself. Therefore, factor prices (and hence input coefficients) will differ in autarky due to the switch from foreign to possibly less efficient domestic suppliers of intermediate inputs. Domestic inputs may not be perfect substitutes of foreign inputs even if differences in the production technologies between countries are accounted for.[86] Of course, these caveats are even more applicable to smaller countries with higher dependencies on trade and foreign suppliers – in an extreme case when they lack certain industries or factor endowments entirely. Related to this point, consumption bundles in autarky may be less diverse in most if not all countries even if it were possible to produce the required industry-level output levels.[87] This implies less product varieties available to consumers.

We did not incorporate additional constraining factors in the analysis - such as the possible endogeneity of consumption to trade - for two reasons. First and foremost, our goal was not to simulate autarky. This would not be possible with our input-output approach; a different type of analysis would have been required and this would go beyond the scope of our paper. Further

[86] For instance, foreign suppliers may be able to produce more cheaply due to economies of scale or country-specific idiosyncrasies e.g., cultural factors, which are not accounted for by production technology. In addition, it has been shown that exporting firms are more productive and pay higher wages than non-exporters (Bernard et al. 2007). In autarky, all firms would be non-exporters. World IOTs are not currently detailed enough to distinguish between exporters and non-exporters, precluding any consideration of this in our analysis.

[87] We cannot test this because of database limitations. Labor payments, employment figures, and footprint contributions are aggregated to the industry level (35 industries in the case of WIOD) and it is not possible to differentiate between product varieties within these industries.

refinements and/or alternative approaches are avenues for future research, for instance through use of computable general equilibrium models. Second, the inability of the US to be self-sufficient after dropping the assumption of perfect labor market mobility for workers of different skill-levels already confirms the hypothesis. Additional evidence would hence corroborate but not overturn the main conclusions. The finding that the US cannot maintain the same consumption levels in autarky using only domestic workers already sends an important policy message: protectionism has clear drawbacks and some of the rhetoric in the public sphere from politicians and the popular press is misleading. At the same time, it should be noted that efficiency losses related to protectionism (due primarily to lack of competition and disincentives for innovation and optimal resource allocation) do still matter and would reinforce the findings (i.e., there would be even bigger sacrifices necessary in autarky).

Lastly, we return to the specific case of the perceived threat of China for US jobs. We highlighted this issue at the start as it was one of the motivating factors for the paper. Despite widespread fears of a growing China rapidly taking away US jobs, we found that the share of Chinese workers embodied in the US labor footprint increased by only 1.6 percentage points between 1995 and 2008 (from 12.6% of the labor force to 14.2%). Just shy of half of this increase involved manufacturing jobs, which potentially reflects import competition in that sector. While the overall share of 14.2% in 2008 is not insignificant, this number too may exaggerate the impact. To demonstrate this, we convert all Chinese workers reflected in the labor footprint to US efficiency equivalents. Our analysis based on wage differences (at industry- and skill-levels) between US and foreign workers as a proxy of productivity differences showed that the efficiency-adjusted share of Chinese workers in the US labor footprint amounted to only 1.5% in 2008!

Thus, while the evidence does suggest that some US jobs involved in producing for US consumption have been outsourced to China, we do not find that China had a particularly large negative impact on US jobs (and the same holds true for other developing countries). This is underscored by looking at the reverse perspective. US trade with China was responsible for the largest US job gains in terms of export-related activities between 1995 and 2008 (548,000 new jobs), providing nearly 800,000 US jobs overall in 2008. Therefore, it is equally important to consider how US labor has integrated in the world economy and the jobs that have been gained due to globalization. The threat of China is therefore exaggerated and the US has relatively little to fear.

Appendix Chapter 4

Table 4.A1

Names and abbreviations of all countries included in the World Input-Output Database

AUT = Australia	ITA = Italy
AUT = Austria	JPN = Japan
BEL = Belgium	KOR = South Korea
BGR = Bulgaria	LTU = Lithuania
BRA = Brazil	LUX = Luxembourg
CAN = Canada	LVA = Latvia
CHN = China	MEX = Mexico
CYP = Cyprus	MLT = Malta
CZE = Czech Republic	NLD = The Netherlands
DEU = Germany	POL = Poland
DNK = Denmark	PRT = Portugal
ESP = Spain	ROU = Romania
EST = Estonia	RUS = Russia
FIN = Finland	SVK = Slovak Republic
FRA = France	SVN = Slovenia
GBR = Great Britain	SWE = Sweden
GRC = Greece	TUR = Turkey
HUN = Hungary	TWN = Taiwan
IDN = Indonesia	USA = United States
IND = India	ROW = Rest of World
IRL = Ireland	

Table 4.A2

Labor gains (LG) of trade

(Percentage of employed workers)

Country	LG of trade 1995	LG of trade, 2008	Change (08-95)	Country	LG of trade 1995	LG of trade, 2008	Change (08-95)
Bulgaria	-2.7	11.7	14.4	Slovakia	0.0	2.0	2.1
Latvia	0.6	12.6	11.9	Great Britain	-0.8	1.0	1.8
Greece	14.2	24.7	10.6	Lithuania	7.2	8.7	1.5
Turkey	-1.9	7.1	9.0	Korea	-3.1	-1.9	1.2
Ireland	-10.8	-2.1	8.8	Russia	8.0	8.9	0.8
Romania	3.5	12.2	8.7	Japan	-0.7	0.0	0.7
Poland	-5.0	0.5	5.5	India	-2.9	-2.8	0.1
Portugal	7.4	12.6	5.2	Sweden	-7.3	-7.8	-0.5
Spain	2.5	7.1	4.6	Indonesia	-2.3	-3.2	-0.9
Mexico	-1.2	3.2	4.4	Netherlands	-5.5	-7.5	-1.9
Canada	-2.6	1.7	4.2	China	-5.6	-8.7	-3.1
Cyprus	23.8	28.0	4.2	Brazil	-1.2	-4.5	-3.3
Finland	-7.2	-3.0	4.2	Hungary	3.2	-0.3	-3.5
Belgium	-7.4	-3.5	3.9	Germany	-1.8	-8.0	-6.2
Slovenia	2.3	6.2	3.8	Austria	3.1	-4.3	-7.4
France	-2.1	1.4	3.5	Taiwan	-5.2	-12.6	-7.4
Italy	-4.0	-0.9	3.1	Czech Republic	3.3	-6.4	-9.7
Denmark	-5.5	-3.2	2.3	Luxembourg	-4.6	-15.0	-10.4
USA	1.3	3.6	2.2	Malta	19.4	8.1	-11.3
Australia	0.3	2.5	2.1	Estonia	21.5	1.9	-19.5

Notes: The labor gains of trade are defined as the footprint in autarky minus the number of employed workers, expressed as percentage of employed workers. The last columns give the percentage point changes between 1995 and 2008. The countries are ranked by largest increase (in percentage points) in their gains of trade over time.

Table 4.A3

Unemployment by country
(in thousands of persons)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	n/a	n/a	n/a	n/a	592	n/a	524	508	478	474
AUT	167	181	154	187	188	223	223	212	200	172
BEL	391	290	266	301	337	329	390	383	353	333
BGR	565	556	686	619	458	406	334	306	240	200
BRA	4198	n/a	7644	7724	8453	8083	8747	8024	7853	n/a
CAN	1394	1082	1162	1269	1283	1232	1169	1106	1077	1112
CHN	7900	19070	10870	12120	11750	10260	14730	13370	12100	14820
CYP	n/a	15	13	11	14	15	19	17	15	15
CZE	n/a	449	407	357	384	419	410	372	277	230
DEU	3179	3123	3078	3362	3894	4261	4571	4245	3601	3136
DNK	196	127	118	122	154	151	140	114	111	101
ESP	3664	2469	1856	2103	2216	2248	1934	1841	1846	2596
EST	68	90	88	66	76	69	54	41	32	38
FIN	413	297	276	280	281	275	220	204	183	172
FRA	2941	2631	2231	2276	2308	2488	2432	2432	2223	2064
GBR	2475	1606	1357	1470	1416	1363	1434	1642	1623	1753
GRC	381	519	493	474	454	507	493	448	418	388
HUN	417	267	232	230	241	241	302	318	312	326
IDN	3918	8005	9132	9531	10251	11899	10932	10011	9395	8963
IND	36742	41343	41996	41173	41390	40457	39348	41465	39974	39112
IRL	172	75	66	78	84	86	89	94	105	146
ITA	2639	2545	2268	2206	2146	1913	1877	1654	1481	1664
JPN	2100	3220	3390	3570	3510	3130	2950	2770	2570	2640
KOR	419	979	897	752	818	860	888	827	783	770
LTU	347	269	278	212	218	171	130	88	64	88
LUX	5	4	3	5	7	10	9	10	9	11
LVA	n/a	156	150	153	131	127	108	78	68	88
MEX	2379	989	981	1137	1188	1528	1470	1367	1495	1584
MLT	n/a	10	11	11	12	12	11	11	11	10
NLD	523	220	175	214	303	395	402	336	278	243
POL	2279	2830	3208	3432	3281	3225	3045	2344	1619	1211
PRT	336	199	203	243	333	342	414	421	441	418
ROU	968	816	758	862	700	776	704	728	641	576
RUS	6710	7699	6423	5700	5959	5676	5264	5311	4588	4793
SVK	324	491	509	486	448	491	430	355	296	256
SVN	68	66	55	58	62	60	66	61	50	46
SWE	396	239	215	227	256	309	351	337	298	305
TUR	1610	1498	1969	2466	2493	2498	2520	2329	2361	2605
TWN	165	291	452	515	503	454	429	410	417	450
USA	7404	5692	6801	8378	8774	8149	7591	7001	7078	8924

Source: International Labor Organization (ILOSTAT 2015), http://www.ilo.org/ilostat/

Table 4.A4

Labor endowments (or labor force) by country
(all workers gainfully employed, including informal workers, plus unemployed workers; in thousands of persons)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	n/a	n/a	n/a	n/a	10111	n/a	10552	10797	11036	11336
AUT	3884	4112	4113	4146	4159	4209	4255	4302	4361	4472
BEL	4258	4399	4431	4460	4498	4528	4648	4692	4731	4783
BGR	4083	3795	3900	3842	3775	3810	3830	3918	3967	3959
BRA	77744	n/a	87189	90353	92488	96335	99653	101271	102567	n/a
CAN	14987	16130	16361	16837	17185	17398	17574	17783	18124	18598
CHN	688550	739920	741120	749520	756070	762260	772980	777370	782000	789620
CYP	n/a	330	335	339	355	369	386	389	400	406
CZE	n/a	5389	5369	5348	5307	5359	5402	5460	5500	5579
DEU	40780	42267	42394	42458	42620	43141	43406	43320	43325	43586
DNK	2748	2840	2861	2868	2868	2848	2867	2897	2972	3009
ESP	17233	18880	18786	19441	20094	20757	21201	21863	22475	23172
EST	701	663	666	651	670	664	661	687	687	698
FIN	2466	2590	2600	2626	2628	2632	2609	2638	2669	2713
FRA	25635	26963	26995	27195	27259	27465	27547	27794	27952	28009
GBR	30388	31223	31281	31576	31824	32066	32524	33040	33225	33426
GRC	4512	4774	4754	4831	4862	5021	5044	5149	5201	5335
HUN	4442	4518	4464	4453	4468	4407	4458	4500	4481	4395
IDN	91189	101326	102569	103186	104574	106595	106396	107891	112744	114716
IND	417529	458226	474372	465379	490413	498357	509125	513233	500204	502491
IRL	1457	1772	1814	1857	1899	1957	2051	2142	2228	2322
ITA	24480	25475	25662	26000	26295	26169	26273	26528	26669	26942
JPN	68958	68473	68150	67318	67047	66807	66867	66967	67008	65685
KOR	20817	22115	22454	22904	22935	23394	23718	23960	24201	24331
LTU	1827	1668	1624	1607	1644	1596	1591	1575	1593	1619
LUX	220	268	282	293	300	309	317	329	342	381
LVA	n/a	1097	1103	1134	1131	1140	1140	1157	1186	1209
MEX	35507	40214	41085	42095	42844	44561	45171	46636	47575	51278
MLT	n/a	155	160	162	163	160	162	165	170	174
NLD	7678	8336	8457	8538	8586	8606	8654	8728	8884	8981
POL	17014	17847	17403	17199	16887	16998	17120	16874	16793	16994
PRT	4867	5229	5324	5395	5455	5459	5514	5621	5639	5636
ROU	10471	11587	11416	10436	10269	10187	9972	10059	10006	9942
RUS	81774	81425	81150	80628	81755	81950	82167	82687	82940	83481
SVK	2431	2516	2545	2525	2508	2547	2519	2488	2473	2518
SVN	986	971	964	981	981	983	986	995	1012	1040
SWE	4525	4539	4607	4620	4624	4647	4700	4759	4822	4847
TUR	22196	23078	23493	23820	23640	24230	24476	23421	23099	23799
TWN	9533	9888	9835	9969	10077	10238	10372	10523	10709	10854
USA	141383	153409	153619	153777	153963	155014	156494	158320	159645	160667

Source: International Labor Organization (ILOSTAT 2015) for unemployment; WIOD satellite accounts for employment data.

Table 4.A5

Current trade structure: labor footprints by country
(in thousands of persons; includes total number of domestic and foreign workers without efficiency adjustments)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	13906	15264	15058	16214	17262	19433	20421	20253	21700	21569
AUT	6580	6538	6576	6431	6850	7044	7123	7211	7308	7435
BEL	7413	8243	8254	8555	9525	9919	10112	10281	10310	10706
BGR	2950	2569	2619	2588	2729	2851	3055	3134	3307	3465
BRA	72860	76858	75177	75724	76502	78858	82877	86771	90269	93913
CAN	19327	22301	23154	23536	25308	25647	27596	29464	29682	29942
CHN	577903	628115	641626	639211	633498	630546	621570	617768	623743	645381
CYP	484	558	597	604	636	632	623	650	683	817
CZE	4782	4719	4879	5142	5231	5311	5297	5436	5625	5953
DEU	64686	65492	64364	62285	66056	66720	65647	66446	68160	68303
DNK	4552	4442	4531	4640	4815	5198	5263	5480	5573	5634
ESP	19750	24780	25861	26760	28799	31349	32972	34676	36302	34968
EST	504	624	662	767	837	818	779	867	906	858
FIN	3383	3533	3494	3545	3883	3998	4156	4329	4469	4847
FRA	34637	37810	39030	39747	41748	43114	43693	43460	44698	45432
GBR	40623	48614	49451	50584	51681	58127	59722	60579	60484	57059
GRC	5544	6484	6530	6917	7195	7402	7325	7642	8105	8858
HUN	3792	4155	4204	4394	4616	4580	4501	4400	4396	4318
IDN	80054	80145	80382	83397	83998	84093	83981	88434	93841	96146
IND	351789	376220	392496	381642	407842	411106	423897	420806	412902	416739
IRL	1719	2497	2581	2923	3087	3268	3360	3867	4031	4047
ITA	31936	35118	36505	37731	39794	40455	40479	41814	41670	41838
JPN	114618	106906	105275	101527	102555	104903	106047	103881	98147	96090
KOR	27423	30135	30113	32400	33029	33406	33579	34447	35138	33417
LTU	1305	1464	1436	1503	1607	1585	1644	1697	1798	1879
LUX	387	480	469	488	540	606	639	810	639	585
LVA	826	889	931	970	1014	1080	1088	1203	1323	1287
MEX	30053	38056	40044	41356	41855	43684	44911	46870	47559	50906
MLT	216	240	237	234	247	226	234	280	280	252
NLD	18039	19957	20370	21044	21095	20042	19874	19235	18652	19465
POL	13491	15133	14280	13947	13590	13932	14435	15126	16202	17615
PRT	5732	6489	6700	6654	6647	6860	6752	6751	6898	7094
ROU	8355	9303	9441	8219	8504	8502	8761	9155	9653	9613
RUS	72837	63009	67193	68805	71773	75021	78651	79782	88152	91550
SVK	1976	1929	2030	2059	2118	2383	2522	2631	2860	3026
SVN	1056	1103	1098	1152	1238	1205	1204	1226	1327	1573
SWE	6185	6856	6652	6993	7341	7526	7513	7678	8068	8108
TUR	21188	23342	21274	21907	22990	24379	25302	25011	25659	32489
TWN	11900	13023	12245	12451	12292	13047	13042	12759	12231	12468
USA	203037	256722	257448	260723	263466	272848	282337	286191	274698	264346

Source: Author’s calculations based on the World Input-Output Database (WIOD)

Table 4.A6

Current trade structure: labor endowment minus labor footprint
(without efficiency adjustments; surplus or deficit expressed as percent share of given country's labor force)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	n/a	n/a	n/a	n/a	-70.7	n/a	-93.5	-87.6	-96.6	-90.3
AUT	-69.4	-59.0	-59.9	-55.1	-64.7	-67.3	-67.4	-67.6	-67.6	-66.3
BEL	-74.1	-87.4	-86.3	-91.8	-111.8	-119.0	-117.5	-119.1	-117.9	-123.8
BGR	27.8	32.3	32.9	32.6	27.7	25.2	20.2	20.0	16.6	12.5
BRA	6.3	n/a	13.8	16.2	17.3	18.1	16.8	14.3	12.0	n/a
CAN	-29.0	-38.3	-41.5	-39.8	-47.3	-47.4	-57.0	-65.7	-63.8	-61.0
CHN	16.1	15.1	13.4	14.7	16.2	17.3	19.6	20.5	20.2	18.3
CYP	n/a	-69.0	-78.3	-78.1	-79.2	-71.4	-61.6	-66.8	-70.7	-101.4
CZE	n/a	12.4	9.1	3.9	1.4	0.9	1.9	0.4	-2.3	-6.7
DEU	-58.6	-54.9	-51.8	-46.7	-55.0	-54.7	-51.2	-53.4	-57.3	-56.7
DNK	-65.6	-56.4	-58.4	-61.8	-67.9	-82.5	-83.6	-89.2	-87.5	-87.2
ESP	-14.6	-31.2	-37.7	-37.6	-43.3	-51.0	-55.5	-58.6	-61.5	-50.9
EST	28.2	5.9	0.6	-17.9	-25.0	-23.2	-17.8	-26.3	-31.9	-22.9
FIN	-37.2	-36.4	-34.4	-35.0	-47.7	-51.9	-59.3	-64.1	-67.4	-78.6
FRA	-35.1	-40.2	-44.6	-46.2	-53.2	-57.0	-58.6	-56.4	-59.9	-62.2
GBR	-33.7	-55.7	-58.1	-60.2	-62.4	-81.3	-83.6	-83.4	-82.0	-70.7
GRC	-22.9	-35.8	-37.4	-43.2	-48.0	-47.4	-45.2	-48.4	-55.8	-66.1
HUN	14.6	8.0	5.8	1.3	-3.3	-3.9	-1.0	2.2	1.9	1.7
IDN	12.2	20.9	21.6	19.2	19.7	21.1	21.1	18.0	16.8	16.2
IND	15.7	17.9	17.3	18.0	16.8	17.5	16.7	18.0	17.5	17.1
IRL	-18.0	-40.9	-42.3	-57.4	-62.6	-67.0	-63.8	-80.5	-80.9	-74.3
ITA	-30.5	-37.9	-42.3	-45.1	-51.3	-54.6	-54.1	-57.6	-56.3	-55.3
JPN	-66.2	-56.1	-54.5	-50.8	-53.0	-57.0	-58.6	-55.1	-46.5	-46.3
KOR	-31.7	-36.3	-34.1	-41.5	-44.0	-42.8	-41.6	-43.8	-45.2	-37.3
LTU	28.6	12.2	11.6	6.5	2.2	0.7	-3.3	-7.8	-12.8	-16.1
LUX	-75.7	-79.0	-66.5	-66.9	-80.0	-95.9	-101.6	-146.4	-87.1	-53.3
LVA	0.0	19.0	15.5	14.5	10.3	5.2	4.6	-4.0	-11.6	-6.4
MEX	15.4	5.4	2.5	1.8	2.3	2.0	0.6	-0.5	0.0	0.7
MLT	n/a	-54.8	-48.2	-43.8	-52.0	-40.7	-44.6	-69.4	-64.7	-44.9
NLD	-134.9	-139.4	-140.9	-146.5	-145.7	-132.9	-129.7	-120.4	-109.9	-116.7
POL	20.7	15.2	17.9	18.9	19.5	18.0	15.7	10.4	3.5	-3.7
PRT	-17.8	-24.1	-25.8	-23.3	-21.9	-25.7	-22.4	-20.1	-22.3	-25.9
ROU	20.2	19.7	17.3	21.2	17.2	16.5	12.1	9.0	3.5	3.3
RUS	10.9	22.6	17.2	14.7	12.2	8.5	4.3	3.5	-6.3	-9.7
SVK	18.7	23.3	20.2	18.4	15.6	6.4	-0.1	-5.8	-15.7	-20.2
SVN	-7.1	-13.6	-13.9	-17.5	-26.1	-22.7	-22.1	-23.2	-31.1	-51.3
SWE	-36.7	-51.0	-44.4	-51.3	-58.8	-62.0	-59.9	-61.3	-67.3	-67.3
TUR	4.5	-1.1	9.4	8.0	2.8	-0.6	-3.4	-6.8	-11.1	-36.5
TWN	-24.8	-31.7	-24.5	-24.9	-22.0	-27.4	-25.7	-21.2	-14.2	-14.9
USA	-43.6	-67.3	-67.6	-69.5	-71.1	-76.0	-80.4	-80.8	-72.1	-64.5

Source / notes: Author's calculations based on the World Input-Output Database (WIOD). Difference between actual number of employees available and labor footprint: [(Export of Labor + Unemployed Workers) - (Imports of labor)] / [Workforce]

Table 4.A7

Autarky trade structure: labor footprints by country
(in thousands of persons)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	8316	9098	9247	9622	9774	10115	10396	10656	11041	11128
AUT	3832	3902	3928	3846	3890	3887	3912	3923	3975	4115
BEL	3583	3862	3889	3813	3843	3894	4008	4041	4115	4296
BGR	3425	3242	3279	3220	3363	3489	3696	3819	4056	4201
BRA	72671	77434	76466	77227	77694	80221	83308	86553	89246	91884
CAN	13246	14216	14420	14917	15429	15616	16077	16496	17005	17781
CHN	642630	681524	692438	691857	697421	701775	692826	689246	691088	707370
CYP	367	398	400	408	423	432	438	453	480	501
CZE	5317	5018	5030	5007	4942	4831	4743	4845	4891	5004
DEU	36914	38308	37916	36805	36680	36443	36396	36487	36611	37221
DNK	2411	2558	2568	2594	2549	2590	2635	2717	2813	2813
ESP	13914	17331	17770	18088	18705	19632	20639	21589	22302	22046
EST	769	599	605	625	628	639	638	696	708	673
FIN	1905	2113	2132	2146	2203	2221	2303	2343	2388	2465
FRA	22223	24037	24421	24499	24652	24834	25175	25501	25984	26320
GBR	27697	29763	30193	30512	30712	31134	31659	31904	32073	31989
GRC	4716	5114	5181	5280	5323	5379	5421	5655	5896	6170
HUN	4155	4502	4365	4334	4418	4331	4289	4269	4159	4057
IDN	85239	88172	89054	89655	89492	90390	90550	93343	99111	102363
IND	369640	394497	411906	401109	429735	438786	454481	453916	444607	450308
IRL	1146	1627	1648	1691	1685	1743	1866	1961	2055	2132
ITA	20975	22504	22871	23343	23781	23871	24145	24758	24958	25046
JPN	66357	64385	64384	63014	62645	62625	63201	63646	63723	63035
KOR	19769	19905	20498	21335	21166	21191	21694	22238	22513	23106
LTU	1587	1465	1388	1457	1479	1517	1542	1587	1645	1664
LUX	206	272	283	288	283	285	292	287	290	315
LVA	1547	1547	1547	1547	1547	1547	1547	1547	1547	1547
MEX	32740	39899	40773	41598	42386	43900	44466	46055	46972	51284
MLT	166	169	170	165	167	170	163	175	178	177
NLD	6758	7605	7759	7750	7744	7600	7554	7750	7905	8086
POL	14004	15509	14228	13766	13445	13514	13567	14184	15063	15866
PRT	4868	5666	5767	5699	5592	5661	5697	5731	5737	5875
ROU	9838	11094	11202	9922	10215	10087	10054	10258	10551	10512
RUS	81097	70560	74401	76782	77952	78193	79977	80339	84512	85666
SVK	2106	2054	2195	2157	2062	2081	2129	2172	2150	2309
SVN	940	948	933	926	943	960	953	964	1009	1056
SWE	3827	3986	4071	4076	4048	3966	3993	4048	4159	4185
TUR	20194	21859	20753	21279	21272	22071	22402	21753	21490	22703
TWN	8883	9006	8525	8461	8580	8994	9039	8988	9010	9097
USA	135753	152547	151549	150449	150543	152676	155188	157591	158066	157151

Source: Author’s calculations based on the World Input-Output Database (WIOD)

Table 4.A8

Autarky trade structure: labor endowment minus labor footprint
(surplus or deficit expressed as percent share of given country's workforce)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	n/a	n/a	n/a	n/a	3.3	n/a	1.5	1.3	0.0	1.8
AUT	1.4	5.1	4.5	7.2	6.5	7.7	8.1	8.8	8.8	8.0
BEL	15.9	12.2	12.2	14.5	14.6	14.0	13.8	13.9	13.0	10.2
BGR	16.1	14.6	15.9	16.2	10.9	8.4	3.5	2.5	-2.2	-6.1
BRA	6.5	n/a	12.3	14.5	16.0	16.7	16.4	14.5	13.0	n/a
CAN	11.6	11.9	11.9	11.4	10.2	10.2	8.5	7.2	6.2	4.4
CHN	6.7	7.9	6.6	7.7	7.8	7.9	10.4	11.3	11.6	10.4
CYP	n/a	-20.5	-19.4	-20.4	-19.2	-17.2	-13.4	-16.2	-19.9	-23.4
CZE	n/a	6.9	6.3	6.4	6.9	9.8	12.2	11.3	11.1	10.3
DEU	9.5	9.4	10.6	13.3	13.9	15.5	16.1	15.8	15.5	14.6
DNK	12.3	9.9	10.2	9.6	11.1	9.1	8.1	6.2	5.3	6.5
ESP	19.3	8.2	5.4	7.0	6.9	5.4	2.7	1.3	0.8	4.9
EST	-9.7	9.6	9.1	4.0	6.3	3.7	3.5	-1.3	-3.1	3.6
FIN	22.7	18.4	18.0	18.3	16.2	15.6	11.7	11.2	10.6	9.2
FRA	13.3	10.9	9.5	9.9	9.6	9.6	8.6	8.2	7.0	6.0
GBR	8.9	4.7	3.5	3.4	3.5	2.9	2.7	3.4	3.5	4.3
GRC	-4.5	-7.1	-9.0	-9.3	-9.5	-7.1	-7.5	-9.8	-13.4	-15.7
HUN	6.5	0.3	2.2	2.7	1.1	1.7	3.8	5.1	7.2	7.7
IDN	6.5	13.0	13.2	13.1	14.4	15.2	14.9	13.5	12.1	10.8
IND	11.5	13.9	13.2	13.8	12.4	12.0	10.7	11.6	11.1	10.4
IRL	21.4	8.2	9.2	8.9	11.3	10.9	9.0	8.4	7.8	8.2
ITA	14.3	11.7	10.9	10.2	9.6	8.8	8.1	6.7	6.4	7.0
JPN	3.8	6.0	5.5	6.4	6.6	6.3	5.5	5.0	4.9	4.0
KOR	5.0	10.0	8.7	6.9	7.7	9.4	8.5	7.2	7.0	5.0
LTU	13.1	12.2	14.5	9.3	10.0	5.0	3.1	-0.7	-3.2	-2.8
LUX	6.7	-1.6	-0.6	1.5	5.6	7.8	7.9	12.5	15.1	17.4
LVA	n/a	9.3	6.5	3.0	-1.8	-9.7	-17.3	-16.2	-14.2	-4.3
MEX	7.8	0.8	0.8	1.2	1.1	1.5	1.6	1.2	1.3	0.0
MLT	n/a	-9.0	-6.6	-1.3	-2.6	-6.1	-0.4	-6.1	-4.9	-1.8
NLD	12.0	8.8	8.3	9.2	9.8	11.7	12.7	11.2	11.0	10.0
POL	17.7	13.1	18.2	20.0	20.4	20.5	20.8	15.9	10.3	6.6
PRT	0.0	-8.4	-8.3	-5.6	-2.5	-3.7	-3.3	-2.0	-1.7	-4.2
ROU	6.0	4.3	1.9	4.9	0.5	1.0	-0.8	-2.0	-5.4	-5.7
RUS	0.8	13.3	8.3	4.8	4.7	4.6	2.7	2.8	-1.9	-2.6
SVK	13.4	18.3	13.8	14.5	17.8	18.3	15.5	12.7	13.0	8.3
SVN	4.7	2.4	3.2	5.6	3.9	2.3	3.4	3.1	0.3	-1.5
SWE	15.4	12.2	11.6	11.8	12.5	14.7	15.0	14.9	13.8	13.7
TUR	9.0	5.3	11.7	10.7	10.0	8.9	8.5	7.1	7.0	4.6
TWN	6.8	8.9	13.3	15.1	14.9	12.2	12.9	14.6	15.9	16.2
USA	4.0	0.6	1.3	2.2	2.2	1.5	0.8	0.5	1.0	2.2

Source: Author's calculations based on the World Input-Output Database (WIOD).

Chapter 5

From trade in value added to trade in income

ABSTRACT

This paper investigates how much value added generated in a country translates into income gains for this country's residents as opposed to income gains for foreign suppliers of capital and labor.

First, we deconstruct the GDP of 42 countries plus an aggregate for the rest of the world in the year 2014 into bilateral transfers of income by making novel use of the Balance of Payments, national accounts, and data on cross-border investment positions. The resulting matrix indicates the share of GDP that is contained in the same country's national income and indicates what shares end up as part of the national income of partner countries. The relation between GDP and GNI reveals that highly developed countries are the main beneficiaries of income transfers, receiving much income from developing and emerging countries.

Second, we use the constructed GDP-GNI matrix and supplemental trade in value added data to estimate the income of a country contained in the final demands of other countries. We compare the income generated by the final demands of all other countries, what we call exports of income, with the more conventional exports of value-added measure. We find that US exports of income (i.e., the contribution of foreign final demand to US GNI) were US$ 763 billion higher than US exports of value-added (i.e., the contribution of foreign final demand to US GDP). Furthermore, we find that the US had almost no trade deficit in income in the year 2014. The US trade balance of income was -0.2% as compared to the US trade balance of value-added of -2.5% (as shares of US GDP) and as compared to the US balance of gross trade of -2.8%.

The results across all countries show that the discrepancy between GDP and GNI matters for who ultimately gains from income transfers and from the final demand exerted by foreign countries. The national income implications of international integration should thus be given greater attention by trade economists and policymakers.

This chapter is co-authored with Steven Brakman and Erik Dietzenbacher.

5.1 Introduction

US President Trump frequently points to US trade deficits with China, Japan, Germany, and other countries in justifying new trade tariffs and his complaints of unfair trade practices. Trump proclaimed in May 2019 that the US "has been losing, for many years, 600 to 800 billion Dollars a year on Trade". [88] He has cited similar trade deficit figures more than 50 times since 2015 (Qiu, 2018). Although the numbers are exaggerated (reflecting the US trade deficit in goods but not the US trade surplus in services), it is true that the US has long had large trade deficits with its most important trading partners.[89] The overall US trade deficit and its bilateral deficits continue to play a prominent role in political discourse and US policymaking.

However, policymakers and the public can be misled by bilateral trade balances if they interpret the data as relating to the net income a country gains from its trade partners. This may not be correct. Consider the classic example of China's exports of iPhones to the US. China uses intermediate inputs from Japan and South Korea in the iPhones it assembles for export. This means that US imports from China do not only embody value added created in China. The money that China receives from the US for its exports overstates the actual value-added benefit of these exports to China's economy. Furthermore, part of the value added generated by the exports of iPhones or their components goes as profit to Apple, which may be repatriated to the US. Hence, there may be misleading inferences regarding China's iPhone exports and who gains the income. These developments are closely related to the well-documented rise of global supply chains, but so far, the resulting cross-border transfers of income have not been analyzed to the same degree (due to a lack of data). This is an important motivation for the paper.

In general, it is necessary to make two corrections to assess how much income the US truly loses to (or gains from) China and other countries due to trade. The first correction is assessing trade from the standpoint of value added instead of gross exports. The trade in value added literature has revealed that gross exports overstate to varying degrees the domestic value-added generated from trade (Johnson, 2014). This is attributed to the growing use of foreign inputs in the production process, double counting of intermediate inputs in global trade data, and globalization patterns, which have made the world more interconnected. As a result, bilateral trade balances based on trade in value added, measured by the domestic value-added contained

[88] https://twitter.com/realdonaldtrump/status/1125356705787850753
[89] The Department of Commerce reported a total trade deficit of more than $627 billion in 2018, which includes a trade surplus in services: https://www.bea.gov/data/intl-trade-investment/international-trade-goods-and-services

in the final demands of another country, differ from trade balances based on gross exports. The bilateral US trade deficit with China is reduced when this is calculated using value-added data.[90]

The second correction involves moving beyond value added to consider so-called exports of income. We define exports of income as income generated in a country that is attributed to purchases of final products in other countries. In motivating this next step, consider the more general, related issue: how much value added of a country translates into income gains for this country's residents as opposed to income gains for foreign suppliers of capital and labor? In the past, this distinction was not as consequential because factor incomes generated from value-added production generally corresponded to income for this country's residents. However, cross-border investment complicates this relationship. This is characterized by the growth of global value chains (to a large extent driven by multinational firms), foreign-owned capital, and profit-shifting strategies. Moreover, the increasing mobility of people and regional initiatives such as the EU's Schengen Area have resulted in more cross-border workers. The income earned by these workers does not stay in the country to which they are contributing value added. These developments result in income transferred abroad. Therefore, a country's gross domestic product (GDP) does not correspond to its gross national income (GNI).

Income transfers from one country to another may be related to trade, but not necessarily. Consider the iPhone example. China's exports of value-added related to the assembly of iPhones may generate US income via profit shifting by US multinational firms operating in China. However, if Apple sells iPhones produced in China to final consumers in China, there may be no exports of value-added, but China could still be transferring income to the US. This implies that final demand from China may generate US income in the absence of a direct or even indirect trade relationship between the two countries. In a second example, a cross-border worker may only be involved in the non-traded sector of another country but repatriate his/her income, which also generates transfers of income. Financial globalization and global interconnectedness could lead the US to depend more on the final demand of other countries in terms of generating its income than value added. It is also plausible that the US could have a lower trade deficit in terms of income than in terms of value-added when bilateral income linkages through the investment, employment, and trade channels are fully accounted for.

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[90] The bilateral US trade deficit with China was 15% lower in value-added terms than in gross terms in 2014. China's exports of value-added to the US does not include inputs from third countries that are embodied in China's bilateral gross exports. It does, however, include the value of Chinese inputs in other countries' bilateral gross exports to the US. The trade gap is narrowed in part because differences in the former exceed the latter. *Source*: World Input-Output Database (Timmer et al., 2015).

While this concept is simple, data on bilateral transfers of income do not currently exist and it is difficult to obtain the numbers on a country-by-country basis. The first part of this paper fills this gap by creating a matrix that relates countries' GDP to their GNI (the 'GDP-GNI' matrix). We decompose the GDP's of 42 countries and a 'Rest of World' aggregate for 2013 and 2014 into two components: a national income component and a bilateral income component, representing the transfers of income. Transfers of income are essentially what the System of National Accounts (SNA) defines as primary incomes payable to non-resident units. The GDP-GNI matrix answers the question "how much income generated domestically leaves a country?". This refers to the value added of a country that goes to the national income of another country. It also addresses the question "where does the income that leaves end up?" This helps to identify to whom income is transferred due to repatriation. The second part of this paper (the analysis) combines these insights with input-output analysis to derive and cast light on the income that is generated in a country due to foreign final demand. We ask: "how much income (as a share of GNI) do different countries export?".

To do the decomposition in the first part, we make novel use of the Balance of Payments (BoP) and national accounts data, focusing on the primary income accounts part of the current account. We also draw upon databases from the IMF and World Bank to proxy the bilateral shares of income transfers that are attributed to returns on direct investments, portfolio investment holdings, and employee compensation. As part of this process, we use a new type of foreign direct investment statistics (where available) that identifies the 'ultimate' investor. Data by ultimate investor captures the ultimate beneficiary of returns on FDI, including FDI that might otherwise be attributed to investors from tax havens in conventional bilateral FDI statistics. Hence, our analysis accounts for all MNE profit shifting activities, also including payments for the use of intellectual property. These data are available from central banks, national statistical offices, and the OECD International Direct Investment Statistics database.

To do the analysis in the second part, we construct a new matrix of trade in income (the 'GNIX' matrix), which we derive from the GDP-GNI matrix by using additional trade in value added data from world input-output tables. The GNIX matrix indicates the income that is earned by a country due to domestic and foreign final demand. As compared to transfers of income in the GDP-GNI matrix, exports of income involve linkages that are less tangible. Hence, French gross exports to final users in Japan generate Chinese value added and US income.

The GDP-GNI matrix reveals certain bilateral dependencies of countries. While income transferred by the European Union (EU15) and the US mainly ended up in the EU15 and the US themselves, other regions generated a lot of national wealth, via transfers of income, in the

EU15 and the US. Overall, while geographical proximity played a role in explaining where transfers of income went to, the EU15 and US received a disproportionate amount of income from other countries. About a third of all exported income transfers in 2014 worldwide were by emerging countries and the Rest of World aggregate, which mostly includes developing economies. More than half of this income ended up in the GNI of the EU15 or US. Hence, one can conclude that poorer countries are earning the money for rich, developed countries like the US.

The role of the US as a large net receiver of income is reflected by a higher dependence of the country on income induced by foreign final demand than on exports of value-added induced by foreign final demand. We estimate that the US earned US$ 763 billion more national income due to foreign final demand in 2014 than domestic value-added in the US generated by foreign final demand. The discrepancy may partly be attributed to US investment in foreign countries that leads to repatriated income even when no US exports of value-added are generated (e.g., value-added production by US subsidiaries in a foreign country that is consumed by the host-country). Another key finding is that the US was not an exception: every country in our sample exported a higher share of their GNI than their GDP. This suggests that the world is more globalized in terms of a country's dependence on foreign final demand from the new exports of income perspective than is the case for value-added exports. Finally, we show how (bilateral) trade balances of income differ from (bilateral) trade balances of value-added, which lead to a reconsideration of bilateral positions between countries. The results indicate that the US had almost no trade deficit in income (as compared to a considerable trade deficit in value-added). Although most countries exported more income than value added, the US alongside other highly developed countries benefited most from this new perspective in relative terms. Hence, while conventional trade balances might misleadingly suggest that the US loses (much) more income to other countries than it gains due to higher imports relative to exports, our balance of income measure shows that, when accounting for income transfers, this is much less the case.

The paper is structured as follows. Section 5.2 motivates the analysis by highlighting the current statistical challenges in greater detail and using the issue of trade in value added as an illustration. Sections 5.3 and 5.4 present the methodology and data sources for creating the GDP-GNI matrix. Sections 5.5.1 and 5.5.2 discuss and interpret the GDP-GNI matrix: the diagonal values of the matrix (i.e., the value added that goes to the national income of the same country), and the off-diagonal values of the matrix (i.e., value added of a country that becomes part of the national income of another country). Sections 5.5.3 and 5.5.4 build on the previous findings by formalizing the trade in income concept. First, we explain how the GNIX matrix of trade in income is derived and how exports of income differ from transfers of income. This is followed by an analysis of the income implications of foreign final demand with respect to countries' exports of incomes and trade balances of income.

5.2 Statistical challenges: three questions

One feature of globalization, which we characterize as the increasing cross-border movements of goods, services, labor, and capital, is the fragmentation of production. This was facilitated by greatly reduced transportation and communication costs in the last few decades and is related to the emergence of so-called global value chains (GVCs), which now dominate world trade. There are at least three empirical questions concerning trade that are raised by these new developments, which are briefly introduced in this section. These issues present statistical challenges that have only partially been addressed in previous research. They are an important motivation for creating the GDP-GNI and GNIX matrices to document income flows. Note that while the first part of this section is focused on the relationship between income and the trade of goods and services to illustrate key issues, transfers (and exports) of income involve not just trade related activities. For example, they may involve the income earned by cross-border workers for providing a non-tradable service. Or they may involve income earned by residents on portfolio investments abroad. The scope of the trade in income concept is thus broader.

The first question is: what are a country's exports of value-added (as opposed to its gross exports)? In part related to the rise of GVCs, a country's gross output contains a rising share of foreign inputs. A high dependence of a country on gross exports as a share of GDP is perceived as a sign of export success and a country's competitiveness in international trade. This is especially the case when the exports involve high-tech products, such as iPhones exported by China to the US. However, this can lead to misleading inferences if the share of foreign value-added in gross exports is large and domestic contributions, which could primarily involve low-skilled tasks, do not add much to the exporter's GDP. Moreover, production inputs passing through more than one country are double counted in the aggregate in international trade statistics. This poses a statistical problem and distorts the true nature of interconnectedness between countries. Input-output analysis and the recent development of global input-output databases provide researchers with tools to determine how much direct and indirect domestic value-added a country generates in the production for foreign final consumption (Johnson, 2014). These are known as the exports of value-added. A large and growing research field has emerged to consider these issues. For details on methodological aspects, we refer to Ahmad et al. (2017). This is a guide for measuring trade and fragmentation in global production networks using both gross export- and value-added-based approaches.

The second question is: how much income do countries gain from their domestic value-added production? This statistical challenge is subtler but none less important. Not all domestic value-added generated in a country becomes part of its national income and ultimately benefit its people. Consider for example the rise of GVCs, which tend to involve multinational enterprises (MNEs) that make large direct investments abroad. A recent report published by the OECD found that MNEs accounted for more than one-half of international trade, almost one-third of global output and GDP, and one-fourth of total employment in 2014 (Cadestin et al., 2019). Furthermore, it is estimated that MNE-coordinated GVCs in 2010 accounted for 80% of world trade in gross terms (OECD et al, 2013). At the same time, a large and growing share of MNE generated income involves intangible capital (e.g., intellectual property rights), which is less easily attributable to a specific country (Chen et al., 2018).

These developments raise the question of where the profits of MNE activities go to. About 50% of all returns earned by foreign affiliates are reinvested in foreign markets (UNCTAD, 2018). This occurs when income that is transferred home is sent back to the host country as FDI. Other profits may never leave the host country if there are strict capital controls. But the high presence of MNEs and foreign-owned capital in many countries suggests that profit shifting activities occur as well that result in income being repatriated or permanently transferred from one country to another. In the context of trade, a country may export value-added but gain little income or, conversely, gain income from the exports of value-added of another country. This is one way in which the domestic value-added in a country induced by foreign final demand may differ from the (GNI) income induced in the same country. This issue has not been resolved by the growing availability of statistics on trade in value added, which are all based on GDP, because data are lacking.

The third question is related to the first two: where does domestic value-added (including the share that is exported) that is not contained in the same country's national income due to repatriation of income end up? Tracing the income that a country does not retain from domestic production is not a trivial exercise due to limitations of BoP statistics. This issue is detailed below for the general case involving the distinction between GDP and GNI, which involves all value added - not just the part contained in another country's final demands.

GDP and GNI are used as benchmarks to summarize the performance and magnitude of an economy. GDP is typically defined according to the production approach, expenditure approach, and income approach (CBS, 2017). The production approach sums up the gross value added at each stage of production (at basic prices) from all institutional units residing in the economy, plus taxes and less subsidies on products. Value added refers to output minus intermediate use (the sum of required inputs of goods and services). The expenditure approach sums up all final uses of goods and services by resident institutional units (final consumption and gross capital formation), plus exports and minus imports of goods and services. The income approach compiles GDP as the sum of primary incomes generated in the production process that are distributed by resident producer units (EC et al., 2009). GNI is based on the location of owners of income. GNI indicates the sum of the primary incomes (wages and salaries, profits, net receipts of interest and dividend) earned by the residents of a country, whether originating within or outside of its borders (CBS, 2017). GNI equals GDP minus primary incomes payable to non-resident units plus primary incomes receivable from non-resident units (EC et al., 2009). That is, GNI is GDP plus the balance of net primary incomes received from and paid to residents in all other countries (the 'world').

GDP and GNI data are readily available for almost all countries. But data on primary incomes, which account for the discrepancy between GDP and GNI, are aggregated across all partner countries. This aggregation masks differences in incomes payable and receivable between counterpart economies and thus the relative importance of partner countries to the aggregated (net) primary income balance. This bilateral part is not typically provided by statistical agencies. Only a handful of countries provide publicly an official, geographical disaggregation of the BoP, including the primary income account component. These differ in coverage (in terms of geographical detail), years (typically only a few) and most importantly method (income sent to intermediary entities may play a role, creating issues with so-called pass-through income. Pass-through income is discussed in Section 5.3). Hence, even for the few countries that do release fragmentary data on the bilateral part, such as the Netherlands, it is based on different sources. The data are not easily comparable, and it is difficult to discern the assumptions and modelling that were employed. This is to some extent also confidential.

On the aggregate, global GDP equals gross world income (or global GNI). However, GDP and GNI only coincide on a country-level in two improbable cases. In the first case, this can occur if a country prevents all movement of capital across its borders. This would imply that there are no foreign investments and no cross-border workers. In the second case, this can occur when all income that residents earn in foreign countries and repatriate home (= primary income credits) precisely matches all income earned by non-residents domestically and repatriated abroad (= primary income debits). But even in the second case, it is still interesting to know where the transfers of income go to in order to shed light on the interconnectedness between countries. In addition, countries like Ireland have a large foreign MNE presence and pay considerably more income to non-residents than the incomes they receive from abroad. Hence Ireland's GNI was 14.7% smaller than its GDP in 2014 (according to World Bank World Development Indicators).

Therefore, this paper focusses on the bilateral part involving transfers of (primary) incomes. This involves splitting up the BoP data on a from-whom-to-whom basis to create a matrix that relates countries' GDP to their GNI. The novel GDP-GNI matrix of income transfers is used together with trade in value added data to derive a second matrix showing countries' trade in income. Note the important distinction between *transfers* of income (first matrix) and *exports* of income (second matrix). Transfers of income involve the tangible repatriation of income from one country to another and are not necessarily induced by foreign demand. Exports of income are less tangible and measure the income of a country embodied in the final demands of another country. Sections 5.3 and 5.4 focus on deriving bilateral transfers of income. The analysis in Section 5.5 addresses both transfers and exports of income.

5.3 Methodology

The novel aspect of this study is the relation of GDP to GNI by creating a matrix of bilateral trade in income containing a breakdown of GDP in the rows and GNI in the columns.

We consider a world that consists of N countries and the relation between GDP and GNI is shown in Table 5.1. The rows show "where does GDP go to?" and the columns show "where does income come from?". GDP_i is country i's gross domestic product; GNI_i is country i's gross national income; $\text{GDP}_{i,i}$ is the value added of i that is also part of i's GNI; and $\text{GDP}_{i,j}$ is the value added of i that goes to j becomes part of j's GNI. Note that $\text{WORLD} = \sum_i \text{GNI}_i = \sum_j \text{GDP}_j$.

Table 5.1. GDP embodied in home and foreign country GNI

		Destination country							
		1	…	i	…	j	…	N	Total
Origin country	1	$\text{GDP}_{1,1}$	…	$\text{GDP}_{1,i}$	…	$\text{GDP}_{1,j}$	…	$\text{GDP}_{1,N}$	GDP_1
	…	…		…		…		…	…
	i	$\text{GDP}_{i,1}$	…	$\text{GDP}_{i,i}$	…	$\text{GDP}_{i,j}$	…	$\text{GDP}_{i,N}$	GDP_i
	…	…		…		…		…	…
	j	$\text{GDP}_{j,1}$	…	$\text{GDP}_{j,i}$	…	$\text{GDP}_{j,j}$	…	$\text{GDP}_{j,N}$	GDP_j
	…	…		…		…		…	…
	N	$\text{GDP}_{N,1}$	…	$\text{GDP}_{N,i}$	…	$\text{GDP}_{N,j}$	…	$\text{GDP}_{N,N}$	GDP_N
	Total	GNI_1	…	GNI_i	…	GNI_j	…	GNI_N	WORLD

Data for GDP_i and GNI_i are publicly available. The first task is to calculate $\mathrm{GDP}_{i,i}$ with the help of publicly available Balance of Payments (BoP) data from the World Bank (WB) and by making an adjustment for so-called pass-through income. This is explained in step 1 (Section 5.3.3). This implies that we then have an estimate for $\sum_{j\neq i}\mathrm{GDP}_{i,j}$. The second task is to determine $\mathrm{GDP}_{i,j}$, which is the novel aspect and main aim of the exercise, separately. This will be done by making use of additional information on bilateral investment positions and employee compensation, as will be explained in step 2 (Section 5.3.4). Before proceeding with the two steps we provide background principles in Section 5.3.1 and discuss our general strategy, which involves two preliminary steps, in Section 5.3.2.

5.3.1 Background principles

From Table 5.1 we have:

$$\mathrm{GDP}_{i,i} = \mathrm{GDP}_i - \sum_{j\neq i}\mathrm{GDP}_{i,j} = \mathrm{GDP}_i - \mathrm{PID}_i \tag{5.1}$$

$$\mathrm{GDP}_{i,i} = \mathrm{GNI}_i - \sum_{j\neq i}\mathrm{GDP}_{j,i} = \mathrm{GNI}_i - \mathrm{PIC}_i \tag{5.2}$$

where PID_i (=$\sum_{j\neq i}\mathrm{GDP}_{i,j}$) are country i's total primary income debits and PIC_i (= $\sum_{j\neq i}\mathrm{GDP}_{j,i}$) are country i's total primary income credits. Primary income debits are incomes earned in country i and payable to residents in another country (i.e., "exported transfers of incomes"). Primary income credits are incomes received by residents of country i from another country (i.e., "imported transfers of incomes"). Combining (5.1) and (5.2) gives

$$\mathrm{GDP}_i - \sum_{j\neq i}\mathrm{GDP}_{i,j} = \mathrm{GNI}_i - \sum_{j\neq i}\mathrm{GDP}_{j,i} \tag{5.3}$$

which reflects the definitions in the System of National Accounts. That is, GNI_i equals GDP_i plus the balance of primary incomes ($\mathrm{GNI}_i = \mathrm{GDP}_i + \mathrm{PIC}_i - \mathrm{PID}_i$).

The estimation of $\mathrm{GDP}_{i,i}$ would be simple and would follow from (5.1) if data for PID_i were available. This is not the case. Information on primary incomes is available in the IMF's BoP and International Investment Position (IIP) statistics. We will indicate these data by PID_i^{IMF} and PIC_i^{IMF}. The main difference with PID_i and PIC_i is that the IMF data include possible pass-through incomes (described below). To account for this, our method in step 1 (Section 5.3.3) corrects IMF information on primary incomes for pass-through incomes.

Pass-through incomes are closely related to the internationalization of capital markets, which has made it easier for individuals and firms from country k to make investments in country j indirectly via intermediary entities in a third country i. This implies that the returns on these investments (which are primary incomes) run from j to k, via i. The transfer from i to k (which is included in PID_i^{IMF}) is not contained in GDP_i. It is therefore not included in $\text{GDP}_{i,k}$ and in PID_i. In the same fashion, the transfer from j to i is part of PIC_i^{IMF} but does not wind up in GNI_i. It thus should not be included in $\text{GDP}_{j,i}$ and in PIC_i. This is an example of income debits and income credits that pass through country i but have no effect on the real economy (i.e., the GDP and GNI) of i. They should thus be removed from the IMF data.

In general, pass-through income is defined as income that originates outside of the country and ultimately ends up outside of the country. Pass-through income shows up as income on both the credit (PIC_i^{IMF}) and debit (PID_i^{IMF}) sides of a country's primary income account. Their values are identical and offset each other.[91] For instance, suppose a German resident receives interest income on a Spanish bond held in an account in Luxembourg. For Luxembourg, the external nature of the source and destination of the transactions means that any income related to them are part of PID_{LUX}^{IMF} and PIC_{LUX}^{IMF}, but do not factor into GDP_{LUX} and GNI_{LUX}.

Therefore, the IMF information on primary incomes is corrected for pass-through incomes by subtracting pass-through incomes from the IMF data. That is,

$$\text{PID}_i = \text{PID}_i^{IMF} - \text{PT}_i \tag{5.4}$$

where PT_i is estimated pass-through income in country i.

5.3.2 Road map

In order to be able to calculate the diagonal ($\text{GDP}_{i,i}$) elements in Table 5.1, which are necessary to estimate the off-diagonal elements ($\text{GDP}_{i,j}$), we begin with two preliminary steps. The first preliminary step is to attribute all primary (factor) incomes to labor and capital on the basis of IMF data. The reason is that issues involving pass-through income mainly involve the capital part. Our second preliminary step is to estimate the capital and labor components of GDP_i and GNI_i.This means that Table 5.1 can be split into a version for labor and a version for capital. Also, the identities in Section 5.3.1 apply for labor and for capital. Step 1 (Section 5.3.3) uses information derived from these two preliminary steps to estimate the diagonal elements for

[91] For this reason, the net income credits and debits (i.e., the balance of primary incomes) is unaffected by pass-through income.

capital and labor separately. Step 2 (Section 5.3.4) explains how we estimate the off-diagonal elements, again separately for capital and labor. The last parts of steps 1 and 2 combine the capital and labor components (e.g., $\text{GDP}_{i,i} = \text{GDP}_{i,i}^{L} + \text{GDP}_{i,i}^{K}$).

Preliminary step 1

To calculate $\text{GDP}_{i,i}^{L} = \text{GDP}_{i}^{L} - \text{PID}_{i}^{L}$, our first preliminary step is to estimate $\text{PID}_{i}^{IMF,L}$ (and also $\text{PID}_{i}^{IMF,K}$) on the basis of IMF data. If we then correct this for pass-through income we have—according to (5.4)—our estimate for PID_{i}^{L} (and thus $\text{GDP}_{i,i}^{L}$).

The IMF distinguishes three categories of primary incomes. These are the raw data that we start with: primary capital income debits, denoted $\text{PID}_{i}^{IMF,K,raw}$; primary labor income debits, denoted $\text{PID}_{i}^{IMF,L,raw}$; and other primary income debits, denoted $\text{PID}_{i}^{IMF,OPI,raw}$.[92] Capital income debits relate to the returns on foreign investment. For example, this could be the income generated by US-owned capital in China that is repatriated. Labor income debits relates to the compensation of cross-border employees. (See Annex I for a more detailed discussion of the relevant subcomponents included in the primary income account).

The common strategy to compile estimates of GDP in national accounts data is to allocate all factor incomes to capital and labor. We use a similar strategy to estimate PID_{i}. Because no other information is available on $\text{PID}_{i}^{IMF,OPI,raw}$, the component other income is subsumed into the other two. This component is either zero or very small as a share of all debits for most countries. (See Annex II for the shares of $\text{PID}_{i}^{IMF,L,raw}$, $\text{PID}_{i}^{IMF,K,raw}$ and $\text{PID}_{i}^{IMF,OPI,raw}$ in their total, for 42 countries based on the reported IMF data.) Hence, $\text{PID}_{i}^{IMF,L,raw}$ and $\text{PID}_{i}^{IMF,K,raw}$ are increased proportionately to incorporate $\text{PID}_{i}^{IMF,OPI,raw}$ whenever $\text{PID}_{i}^{IMF,OPI,raw}$ is non-zero. This yields for the estimates of the primary labor and capital incomes from the IMF:

$$\text{PID}_{i}^{IMF,L} = \text{PID}_{i}^{IMF,L,raw}\left(\frac{\text{PID}_{i}^{IMF,L,raw} + \text{PID}_{i}^{IMF,K,raw} + \text{PID}_{i}^{IMF,OPI,raw}}{\text{PID}_{i}^{IMF,L,raw} + \text{PID}_{i}^{IMF,K,raw}}\right) \tag{5.5}$$

$$\text{PID}_{i}^{IMF,K} = \text{PID}_{i}^{IMF,K,raw}\left(\frac{\text{PID}_{i}^{IMF,L,raw} + \text{PID}_{i}^{IMF,K,raw} + \text{PID}_{i}^{IMF,OPI,raw}}{\text{PID}_{i}^{IMF,L,raw} + \text{PID}_{i}^{IMF,K,raw}}\right) \tag{5.6}$$

The same procedure also yields $\text{PIC}_{i}^{IMF,K}$, which is used in preliminary step 2.

[92] The category 'other income' is necessary because it exists in the data published by the IMF. Otherwise there is no full accounting of PID_{i}.

Preliminary step 2

Our second preliminary step is to estimate GDP_i^L and GNI_i^L, and GDP_i^K and GNI_i^K. The Conference Board (CB) publishes data for the ratio α_i^{CB}, which we use to derive these four components. Although this ratio is termed by the CB as 'labor share of GDP' (suggesting $\text{GDP}_i^L/\text{GDP}_i$) it actually is calculated as $\text{GNI}_i^L/\text{GDP}_i$. The separate information on the GNI_i^L and GDP_i used by CB is not available though. Therefore, we combine the ratios α_i^{CB} with GDP data from the World Bank (WB) to estimate the GNI components for labor and capital. That is,

$$\text{GNI}_i^L = \alpha_i^{CB}\text{GDP}_i^{WB} \text{ and } \text{GNI}_i^K = \text{GNI}_i^{WB} - \alpha_i^{CB}\text{GDP}_i^{WB} \quad (5.7)$$

Next we use the 'labor-version' and the 'capital-version' of equation (5.3) in connection with the estimates determined in preliminary step 1. This yields

$$\text{GDP}_i^K = \text{GNI}_i^K + \text{PID}_i^{IMF,K} - \text{PIC}_i^{IMF,K} \text{ and the residual } \text{GDP}_i^L = \text{GDP}_i^{WB} - \text{GDP}_i^K$$

5.3.3 Step 1: estimation of the diagonal elements of the matrix

Diagonal labor income elements

From equation (5.4) we know that the estimate $\text{PID}_i^{IMF,L}$ needs to be corrected for pass-through income (i.e., $\text{PID}_i^L = \text{PID}_i^{IMF,L} - \text{PT}_i^L$). We assume that there is no pass-through component in the case of labor incomes (i.e., $\text{PT}_i^L = 0$). This seems a reasonable assumption because labor income relates to the earnings of cross-border workers. The income debits that arise from German residents earning income in France is, by definition, part of the French GDP and cannot originate from another country's GDP. Similarly, income credits that arise from German residents earning income in France are unlikely to end up in another country's GNI than the German (because these are the earnings of private citizens and not MNE- or investment related). Given that labor income (compensation of employees, including the earnings of cross-border workers) typically only make up a small share of a country's primary income account, but a considerable share of its GDP, this component of GDP is mostly expected to stick to the local economy and become part of its GNI. Hence primary labor income is usually not pass-through even in countries with large capital movements. This implies that our estimate for the total primary labor income debits is given by $\text{PID}_i^L = \text{PID}_i^{IMF,L}$. The estimate for the diagonal elements (in the case of labor) is given by $\text{GDP}_{i,i}^L = \text{GDP}_i^L - \text{PID}_i^L$.

Diagonal capital income elements

The ‘capital-version’ of equation (5.3) is

$$\mathrm{GDP}_i^K + \mathrm{PIC}_i^K = \mathrm{GNI}_i^K + \mathrm{PID}_i^K \tag{5.8}$$

As was mentioned earlier, pass-through income shows up in equal size on both the credit and the debit side of a country’s primary income account. This means that we can add pass-through income on the left- and the right-hand side of (5.8), which yields

$$\mathrm{GDP}_i^K + \mathrm{PIC}_i^K + \mathrm{PT}_i = \mathrm{GNI}_i^K + \mathrm{PID}_i^K + \mathrm{PT}_i \tag{5.9}$$

Adding pass-through income to country *i*’s total primary income debits gives the primary income debits of the IMF. That is, $\mathrm{PID}_i^K + \mathrm{PT}_i = \mathrm{PID}_i^{IMF,K}$ and $\mathrm{PIC}_i^K + \mathrm{PT}_i = \mathrm{PIC}_i^{IMF,K}$. This yields

$$\mathrm{GDP}_i^K + \mathrm{PIC}_i^{IMF,K} = \mathrm{GNI}_i^K + \mathrm{PID}_i^{IMF,K} \tag{5.10}$$

The two sides of (5.10) give the total primary capital income flows of country *i* (TPCIF_i). The left-hand side takes the perspective of the capital inflows. That is, TPCIF_i consists of the capital that is earned on the territory (GDP_i^K) plus the capital inflow from abroad ($\mathrm{PIC}_i^{IMF,K}$, which includes pass-through income). The right-hand side takes the perspective of the capital outflows. That is, TPCIF_i consists of the capital that goes to domestic capital owners (GNI_i^K) plus the capital that flows abroad ($\mathrm{PID}_i^{IMF,K}$, which includes the same pass-through income).

The share of all capital flows (TPCIF_i) that goes to domestic capital owners is $\mathrm{GNI}_i^K/\mathrm{TPCIF}_i = \mathrm{GNI}_i^K/(\mathrm{GNI}_i^K + \mathrm{PID}_i^{IMF,K})$. We assume that the same share applies to the capital earnings that stay within the country (as a share of all the capital earnings GDP_i^K). That is, we assume

$$\frac{\mathrm{GDP}_{i,i}^K}{\mathrm{GDP}_i^K} = \frac{\mathrm{GNI}_i^K}{\mathrm{GNI}_i^K + \mathrm{PID}_i^{IMF,K}} \tag{5.11}$$

We therefore have now the diagonal element in the case of capital: $\mathrm{GDP}_{ii}^K = (\mathrm{GNI}_i^K \times \mathrm{GDP}_i^K)/(\mathrm{GNI}_i^K + \mathrm{PID}_i^{IMF,K})$.

Combined diagonal labor and capital elements

Combining the two cases yields

$$\text{GDP}_{i,i} = \text{GDP}_{i,i}^{L} + \text{GDP}_{i,i}^{K} = (\text{GDP}_{i}^{L} - \text{PID}_{i}^{L}) + \frac{\text{GNI}_{i}^{K}}{\text{GNI}_{i}^{K} + \text{PID}_{i}^{IMF,K}} \text{GDP}_{i}^{K} \quad (5.12)$$

Its complement (which is distributed in the next subsection over the countries of destination) is given by

$$\text{PID}_{i} = \sum\nolimits_{j \neq i} \text{GDP}_{i,j} = \text{GDP}_{i} - \text{GDP}_{i,i} = \text{PID}_{i}^{L} + \frac{\text{PID}_{i}^{IMF,K}}{\text{GNI}_{i}^{K} + \text{PID}_{i}^{IMF,K}} \text{GDP}_{i}^{K} \quad (5.13)$$

5.3.4 Step 2: estimation of the off-diagonal elements of the matrix

The next task is to obtain the off-diagonal elements $\text{GDP}_{i,j}$ of the matrix relating GDP to GNI. Each is divided into labor and capital components, $\text{GDP}_{i,j} = \text{GDP}_{i,j}^{L} + \text{GDP}_{i,j}^{K}$. We know that $\sum_{j \neq i} \text{GDP}_{i,j}^{L} = \text{PID}_{i}^{IMF,L}$ as estimated in (5.6) and from (5.13) it follows that

$$\sum\nolimits_{j \neq i} \text{GDP}_{i,j}^{K} = \text{PID}_{i}^{K} = \frac{\text{PID}_{i}^{IMF,K}}{\text{GNI}_{i}^{K} + \text{PID}_{i}^{IMF,K}} \text{GDP}_{i}^{K} \quad (5.14)$$

The next task is to allocate $\sum_{j \neq i} \text{GDP}_{i,j}^{L}$ and $\sum_{j \neq i} \text{GDP}_{i,j}^{K}$ to the separate countries of destination (i.e., determine $\text{GDP}_{i,j}^{L}$ and $\text{GDP}_{i,j}^{K}$).

<u>Off-diagonal labor income elements</u>

For labor, the allocation is done on the basis of data on compensation of employees. The share of the total compensation paid by country *i* that is received by country *j* is given by $\text{CE}_{ij} / \sum_{j \neq i} \text{CE}_{ij}$, where CE_{ij} denotes compensation of employees residing in country *j* and paid for by country *i*. This implies

$$\text{GDP}_{i,j}^{L} = \frac{\text{CE}_{ij}}{\sum_{j \neq i} \text{CE}_{ij}} \text{PID}_{i}^{IMF,L} \quad (5.15)$$

Data on CE_{ij} are drawn from a bilateral database on remittances. These remittances include: compensation of employees (= primary labor incomes); worker' remittances; and migrants' transfers. (Further details are given in Annex III).

<u>Off-diagonal capital income elements</u>

For capital, (5.14) states that $\sum_{j \neq i} \text{GDP}_{i,j}^{K} = \text{PID}_{i}^{K}$, where PID_{i}^{K} is estimated using $\text{PID}_{i}^{IMF,K}$. In its turn, $\text{PID}_{i}^{IMF,K}$ is estimated in (5.6), using $\text{PID}_{i}^{IMF,K,raw}$. These are data on capital primary incomes and are obtained directly from the IMF. $\text{PID}_i^{IMF,K,raw}$ consists of three components: income from returns on direct investments (DI), on portfolio investment (POI), and on other investments (OI). That is, $\text{PID}_i^{IMF,K,raw} = \text{PID}_i^{IMF,DI} + \text{PID}_i^{IMF,POI} + \text{PID}_i^{IMF,OI}$. We split $\text{PID}_i^{IMF,K,raw}$ into a DI-part and a POI-part on the basis of their sizes and we assume that the same split also applies to PID_i^{K}. That is,

$$\text{PID}_i^{DI,adapt} = \frac{\text{PID}_i^{IMF,DI}}{\text{PID}_i^{IMF,DI} + \text{PID}_i^{IMF,POI}} \text{PID}_i^{K}$$

$$\text{PID}_i^{POI,adapt} = \frac{\text{PID}_i^{IMF,POI}}{\text{PID}_i^{IMF,DI} + \text{PID}_i^{IMF,POI}} \text{PID}_i^{K}$$

Note that $\text{PID}_i^{DI,adapt} + \text{PID}_i^{POI,adapt} = \text{PID}_i^{K} = \sum_{j \neq i} \text{GDP}_{i,j}^{K}$. The reason to subsume the OI-part of $\text{PID}_i^{IMF,K,raw}$ under the other two parts is that bilateral data are available for the investment positions of DI and POI, but not for OI. This bilateral information will be used to allocate $\text{PID}_i^{DI,adapt}$ and $\text{PID}_i^{POI,adapt}$ to countries of destination.

The component $\text{PID}_i^{DI,adapt}$ is allocated on the basis of data on foreign direct investment positions. Let DI_{ji} denote the value of country *j*'s direct investment in *i* and $\sum_{j \neq i} \text{DI}_{ji}$ gives the total stock of foreign direct investment in country *i*. Then we assume that the income from returns are allocated accordingly. That is, if for instance 10% of all direct investments in country *i* are by country *j* ($\text{DI}_{ji}/\sum_{j \neq i} \text{DI}_{ji} = 0.1$), then it is assumed that 10% of country *i*'s transfers of direct investment income consists of income payments sent to investors in *j*. Hence,

$$\text{GDP}_{i,j}^{K,DI} = \frac{\text{DI}_{ji}}{\sum_{j \neq i} \text{DI}_{ji}} \text{PID}_i^{DI,adapt} \tag{5.16}$$

Data on PID_i^{DI} is available from the IMF. Data on DI_{ji} are available from bilateral FDI statistics (Further details are given in Annex IV).

Finally, component $\text{PID}_i^{POI,adapt}$ is allocated on the basis of data on foreign portfolio holdings. Let POI_{ji} denote the value country *j*'s portfolio holdings in country *i* and $\sum_{j \neq i} \text{POI}_{ji}$ gives the total foreign portfolio holdings in country *i*. Then we assume that the income from returns are allocated accordingly. That is,

$$\text{GDP}_{i,j}^{K,POI} = \frac{\text{POI}_{ji}}{\sum_{j \neq i} \text{POI}_{ji}} \text{PID}_i^{POI,adapt} \tag{5.17}$$

Data on PID_i^{POI} is available from the IMF. Data on POI_{ji} are available from a global database on bilateral portfolio holdings. (Further details are given in Annex V).

Combined off-diagonal labor and capital elements

The last step, is to add the labor and the two capital components (i.e., compensation of employees, direct investment income, and portfolio investment income) determined in equation (5.15) – (5.17):

$$\text{GDP}_{i,j} = \text{GDP}_{i,j}^{L} + \text{GDP}_{i,j}^{K,DI} + \text{GDP}_{i,j}^{K,POI} \tag{5.18}$$

In estimating the data for $\text{GDP}_{i,j}$ we have chosen to start from the debtor side. The same calculations could—in principle—have also been set-up from the creditor perspective (i.e., estimating $\text{GDP}_{j,i}$), which should in theory provide the same results. In practice, however, this is not the case because of bilateral asymmetries in the data. That is, trading partners report different figures for the same flow (which is also known as the problem of the mirror statistics). Our choice to adopt the debtor perspective is due to the superior quality of data that is available to proxy the bilateral relationships on direct and portfolio investments. The inward positions (i.e., where the owners of foreign asset holdings in the domestic economy reside) are typically reported more comprehensively and accurately by statistical agencies than the outward positions (i.e., where the assets holdings of domestic investors are held abroad). In addition, the preferred data on direct investment stocks are based on the ultimate beneficiary country, which are currently only available for the inward positions. (Further details are given in Annex IV). For this reason, the analysis focusses on the row-elements ($\text{GDP}_{i,j}$, which represents the exported transfers of income) and not on the less accurate column-elements ($\text{GDP}_{j,i}$, representing the imported transfers of income).

5.4 Data sources

The geographical scope of the matrix of transfers of income is determined by data availability and potential applications. Our primary motivation for creating the matrix is to develop an indicator for exports of income. This requires modifications to the trade in value added data derived from world input-output tables (world IOTs). For this paper the World Input-Output Database (WIOD) is chosen as a benchmark or reference point.[93] The most recent version of

[93] This database is freely available online at: http://www.wiod.org/release16. See also Timmer et al. (2015).

the WIOD, released in 2016, contains annual time-series of world IOTs for the period 2000 to 2014. The consistent and harmonized tables include detailed data for 43 countries, including all 28 EU members and several major advanced and emerging economies.[94] The IOTs account for all inter-country and inter-industry transactions in 56 industries, distinguishing between intermediate and final goods and services.

We incorporate all WIOD countries into the matrix except for one: Taiwan, which is excluded from almost all data sources that are drawn upon to construct it. Therefore, the matrix has a dimension of 43×43 (42 countries plus the Rest-of-World aggregate ROW, which now includes also Taiwan) and is constructed for the years 2013 and 2014. This represents a "proof of concept" that can be drawn upon to extend the time-frame in follow-up work. These two years were chosen due to the quality of the available data. The data sources used to construct the matrix, detailed below, contain almost no missing data in these two years for any of the 42 countries.

The source for GDP and GNI data, which give the respective row-wise sums and column-wise sums for every country in the matrix, is the World Development Indicators dataset from the World Bank.[95,96] The BoP data used to compute the main diagonals of the matrix ($\text{GDP}_{i,i}$) is from the IMF's Balance of Payments and International Investment Position (IIP) statistics.[97] The Conference Board (CB) provides the labor shares, i.e., the ratios $\alpha_i^{CB} = \text{GNI}_i^L/\text{GDP}_i$, in the Total Economy Database, which we use to estimate GDP_i^L, GNI_i^L, GDP_i^K and GNI_i^K.[98]

The most data intensive step involves the estimation of the diagonal elements, i.e., the exported transfers of income to partner countries ($\text{GDP}_{i,j}$). The calculations use disaggregated

Alternative reference world IOTs include the OECD/WTO TiVA and Eora databases. The 2018 edition of the OECD/WTO TiVA database has a larger country coverage than the WIOD (64 economies) with a 2005-2015 timeframe. The Eora covers even more countries but relies more on extrapolations and estimations than WIOD.

[94] Non-EU countries in the WIOD include Australia, Brazil, Canada, Switzerland, China, Indonesia, India, Japan, Korea, Mexico, Norway, Russia, Turkey, Taiwan, and the US.

[95] This database is freely available online at: http://data.worldbank.org.

[96] World GDP is reported to be slightly different than world GNI. We ensure that both values are the same in the matrix by basing global totals on world GDP. The only adjustment this implies for the matrix is to ROW's column-wise sum (= ROW's GNI), which we estimate by subtracting the sums of the reported GNIs of the 42 countries from world GDP.

[97] This database is freely available online at: http://data.imf.org/?sk=7A51304B-6426-40C0-83DD-CA473CA1FD52. For mainland China, only aggregated investment income data are available after 2004 and not the breakdown into direct investment, portfolio investment, and other investment. Therefore, we assume the shares of each category in total investment in the years 2013-2014 are the same as the corresponding shares in the most recent available year (2004).

[98] This database is freely available online at: https://www.conference-board.org/data/economydatabase/. To approximate factor shares for Rest of World (ROW), we sum up the weighted factor shares of all countries in the database but not among the 42 in the GDP-GNI matrix based on α_i^{CB} (the weighted shares are obtained by multiplying the factor shares α_i^{CB} by the GDP of each ROW country). The procedure used to average mainland China, Hong Kong, and Macao's factor shares is similar.

BoP data. The main components of the primary income account include compensation to employees, direct investment income, and portfolio investment income. (See Annex I for details and definitions.) The IMF provides data on primary income debits (PID_i^{IMF}) and credits (PIC_i^{IMF}) for all 42 countries in 2013 and 2014 and, to the extent applicable or available for a given country, data for each of the (sub-) components mentioned in the methodology section: $\text{PID}_i^{IMF,L,raw}$, $\text{PID}_i^{IMF,K,raw}$ $(= \text{PID}_i^{IMF,DI,raw} + \text{PID}_i^{IMF,POI,raw} + \text{PID}_i^{IMF,OI,raw})$ and $\text{PID}_i^{IMF,OPI,raw}$.

We use data from the IMF, World Bank, and national statistical agencies to make the following two approximations. The bilateral shares of PID_i^L $(= \text{PID}_i^{IMF,L})$ correspond to employee compensation. The bilateral shares of PID_i^K $(= \text{PID}_i^{IMF,K} - \text{PT}_i)$ correspond to direct investment ($\text{PID}_i^{DI,adapt}$) and portfolio investment ($\text{PID}_i^{POI,adapt}$). For these approximations, we employ intercountry databases. These are: the World Bank's Bilateral Remittances Database (WBRM), the IMF's Coordinated Direct Investment Survey (CDIS), and the IMF's Coordinated Portfolio Investment Survey (CPIS). For about half of the countries, we use a new and preferred type of FDI data. When available, this data gives FDI by ultimate investing country. This data is obtained from central banks, national statistical offices, and the OECD International Direct Investment Statistics database. We use it instead of the CDIS to make the calculations for bilateral direct investment shares. See Annexes III-V for details on all databases.

Unique data challenges relate to greater China. While the final matrix combines mainland China, Hong Kong, and Macao into one entity (to be consistent with the WIOD database), all data sources that we use provide only data for each entity individually. The main issue is ensuring that internal income transfers and internal investments/labor payments between the three entities are excluded before making any calculations. For example, if BoP data for the three are summed up with no adjustments, then our approach may erroneously attribute some internal flows (which are part of China's national income, i.e., part of $\text{GDP}_{CHN,CHN}$) as income transfers by greater China to the other 42 countries/ROW. Annex VI explains in detail how we combine data for mainland China, Hong Kong, and Macao into aggregated data for greater China.

A complete matrix also includes a row-vector and a column-vector for the ROW aggregate. It should be noticed that the calculations for the column-vector ROW (the elements contributing to ROW's GNI) are straightforward given that the matrix is constructed from the debtor's perspective. By definition, $\text{GDP}_{i,ROW}$ gives the exported transfers of income that are not already accounted for by transfers to the other 41 countries. Based on equation (5.15), we define $\text{CE}_{i,ROW} = \sum_{j\neq i}\text{CE}_{ij} - \sum_{j\neq i,ROW}\text{CE}_{ij}$, which then implies $\text{GDP}^{L}_{i,ROW} = \text{PID}^{IMF,L}_{i} - \sum_{j\neq i,ROW}\text{GDP}^{L}_{i,j}$. In the same way we define $\text{GDP}^{K,DI}_{i,ROW}$ and $\text{GDP}^{K,POI}_{i,ROW}$. It should be mentioned that the implication is that ROW is the "sink" of any errors in the bilateral estimations for other countries.

The row-vector ROW poses a different issue. Simply deriving the missing ROW elements $\text{GDP}_{ROW,i}$ as the difference between GNI_i and the column-wise sum (that is, $\text{GNI}_i - \sum_{j\neq ROW}\text{GDP}_{ji}$), leads to negative values of $\text{GDP}_{ROW,i}$ for some countries.[99] Therefore, a different strategy is used. First, we approximate the share of ROW's GDP that is part of ROW's national income, $\text{GDP}_{ROW,ROW}/\text{GDP}_{ROW}$, by taking the simple average of the corresponding shares that were obtained for the largest six emerging countries in the matrix: Brazil, India, Indonesia, Mexico, Russia, and Turkey.[100] These are the countries that best approximate ROW because they share similar characteristics in terms of development status (e.g., GDP per capita).

Instead of taking the average of emerging countries to also proxy the off-diagonal elements $\text{GDP}_{ROW,i}/\text{GDP}_{ROW}$, we use a global database on direct investments developed by Damgaard and Elkjaer (2017). This database provides estimates of the bilateral inward investment positions of 116 countries on an ultimate investing country basis in 2015.[101,102] We start with a 42×74 matrix where the rows represent the FDI stocks of each of the 42 WIOD countries in the 74 ROW countries contained in the database. Next, all columns are collapsed to create a single 42×1 column-vector representing the direct investments of each of the 42 WIOD countries in the ROW (proxied by the 74 ROW countries covered by the database). Normalizing

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[99] Negative values for income transfers are not possible. The cases where this occurred were residuals for countries with much pass-through income (e.g., Luxemburg, Cyprus, and Great Britain). This is likely attributed to an overestimation of the incomes transferred to them from non-ROW countries, resulting in an underestimation for the income transferred from ROW (i.e., the residual).

[100] That is, $\frac{\text{GDP}_{ROW,ROW}}{\text{GDP}_{ROW}} = (\frac{\text{GDP}_{BRA,BRA}}{\text{GDP}_{BRA}} + \frac{\text{GDP}_{IND,IND}}{\text{GDP}_{IND}} + \frac{\text{GDP}_{IDN,IDN}}{\text{GDP}_{IDN}} + \frac{\text{GDP}_{MEX,MEX}}{\text{GDP}_{MEX}} + \frac{\text{GDP}_{RUS,RUS}}{\text{GDP}_{RUS}} + \frac{\text{GDP}_{TUR,TUR}}{\text{GDP}_{TUR}})/6$. An alternative approach to derive $\text{GDP}_{ROW,ROW}$ is to subtract the aggregated income debits of all 100+ ROW countries (countries not in the matrix) from ROW's GDP. However, this requires the additional step of removing all income going from ROW countries to other ROW countries from the BoP data (as these would be considered pass-through or internal), which would be nearly impossible to estimate.

[101] See Damgaard and Elkjaer (2017) for details on the methodology used to construct the database. The data are publicly available here and we assume the data are the same for 2014: https://www.imf.org/en/Publications/WP/Issues/2017/11/17/The-Global-FDI-Network-Searching-for-Ultimate-Investors-45414

[102] Even if the approximations based on this data relate only to the direct investment component of the BoP, we consider them more detailed and accurate than taking the average of emerging countries to proxy ROW's off-diagonal elements.

this column yields the 42 shares (adding up to 1). Each share tells which part of all ROW income transfers that go to WIOD countries is received by a specific WIOD country. This gives the estimated, offsetting shares of income transferred by ROW to each of the 42 WIOD countries (excluding intra-ROW transfers). Each of the 42 shares is then multiplied by $1-(\text{GDP}_{ROW,ROW}/\text{GDP}_{ROW})$ to obtain $\text{GDP}_{ROW,i}/\text{GDP}_{ROW}$.[103] These represent shares of ROW's GDP that end up in the national income of each country in the matrix. Finally, each of the 43 shares, now including the diagonal share $(\text{GDP}_{ROW,ROW}/\text{GDP}_{ROW})$, is multiplied by GDP_{ROW} to determine the actual values of $\text{GDP}_{ROW,ROW}$, $\text{GDP}_{ROW,i}$ (for i = 1, …, 42) in the 43rd row.

Finally, although all row-wise sums now correctly add up to the GDP of each country/ROW in the matrix, the column-wise sums do not precisely add up to the GNI of each country/ROW. This is due to reporting discrepancies related to the issue of mirror statistics discussed in Section 5.3. Therefore, a matrix balancing technique is employed (Miller and Blair, 2009). It follows the generalized RAS (GRAS) algorithm from Lenzen et al. (2007) and uses a Matlab program written by Temurshoev et al. (2013). The GRAS variant has the advantage of also being able to make adjustments for rows that have elements with negative signs even if the aggregated constraints are positive, which in some cases is true for our matrix.[104] The balancing technique thus ensures that all rows and columns of the final matrix add up properly.

The balancing procedure is applied to two matrices separately. The GDP-GNI matrix is split into a matrix of transfers of labor income and a matrix of transfers of capital income (including also the diagonals that reflect 'transfers' of income within the same country). The reason the labor and capital parts are separated before applying RAS is that labor income is not subject to significant data problems (i.e., pass-through income). Most of the data problems are contained in the capital side. Therefore, any adjustments by RAS related to the matrix involving only labor components are expected to be smaller than the adjustments by RAS related to the matrix involving capital components.

Note that prior to applying RAS, the row-wise sums of the matrix of transfers of labor income add up to the labor part of GDP of each country, GDP_i^L, and the column-wise sums should (but do not) add up to the labor part of GNI of each country, GNI_i^L. The same applies to

[103] If we denote the 42 shares obtained from normalization by n_i, we have $n_i = GDP_{ROW,i}/\sum_i GDP_{ROW,i}$. Next, note that $1-(\text{GDP}_{ROW,ROW}/\text{GDP}_{ROW}) = (\text{GDP}_{ROW} - \text{GDP}_{ROW,ROW})/\text{GDP}_{ROW} = \sum_i GDP_{ROW,i}/\text{GDP}_{ROW}$. Hence, $n_i[1-(\text{GDP}_{ROW,ROW}/\text{GDP}_{ROW})] = GDP_{ROW,i}/\text{GDP}_{ROW}$.

[104] This is possible because of some negative data in the CDIS database used to estimate bilateral shares of direct investment incomes. Negative data can occur when there are negative retained earnings or for other reasons, see: http://datahelp.imf.org/knowledgebase/articles/484342-what-is-the-meaning-of-negative-data-in-the-coordi

GDP_i^K for the row sums and GNI_i^K for the column sums. RAS is then applied separately to each matrix and the results are added.

5.5 Results

The analysis is organized in two parts. The first part uses the matrix that relates countries' GDP to their GNI (i.e., the GDP-GNI matrix) to explore the characteristics of incomes that are transferred. First, we discuss the diagonal elements of the matrix (Section 5.5.1). Then we analyze the off-diagonal elements from the standpoint of understanding the to-whom geography of income transfers (Section 5.5.2). In the second part we derive the global trade in income through GNI exports in the GNIX matrix. The columns of the GNIX matrix show for each country their GNI footprint (i.e., the income imported and consumed by a country, disaggregated by counterpart country) and the rows show for each country the part of their income contained in the final demands of other countries. The analysis compares the share of a country's GNI that is exported (which are the exports of income) with the share of GDP that is exported by the same country (which are the exports of value-added) (Section 5.5.3). Finally, we discuss trade balances of income and how they differ from trade balances of value-added (Section 5.5.4.)

5.5.1 Diagonal elements of the matrix

The diagonal elements of the GDP-GNI matrix indicate the value added generated from domestic production that ends up as part of the national income of the same country ($\mathrm{GDP}_{i,i}$). This was computed using equation (5.12) in the methodology section. Table 5.2 displays the diagonal values for each country as a percent share of the country's GDP.

The percent share of countries' GDP that went to their own people was upwards of 90% for all but six countries. High diagonal shares could be expected given that GDP and GNI overlap to a large extent and are often of a similar magnitude. The share of GDP that went to the same country reached more than 98% in four larger economies (China, Japan, Turkey, and Korea). This implies a very large share of the value added of these countries represented income gains for their residents. By contrast, the residual shares were higher (i.e., diagonal values were relatively smaller) in business-friendly economies and tax havens. Luxembourg, Ireland, Cyprus, Malta, and the Netherlands, which are the five countries that had the lowest diagonal shares, are known to attract large numbers of multinational firms and/or foreign investors. Even amongst these four, Luxembourg was an outlier with an exceptionally low share of GDP, 33.3%, that it retained as income. Two-thirds of Luxembourg's GDP thus represented income gains to residents of another country. This is consistent with Luxembourg's integration in international capital markets and its dependence on cross-border workers. Luxembourg is also the largest investment fund center in Europe.[105] Hence, the estimates indicate that a large share of Luxembourg's GDP embodies foreign-owned capital and/or payments to foreign factors.

Table 5.2. The percent share of GDP that is part of the national income of each country, 2014

CHN	98.9	DEU	96.5	PRT	94.7	CZE	91.6
JPN	98.8	LTU	96.5	LTA	94.7	BEL	91.2
TUR	98.7	BGR	96.2	AUS	94.6	GBR	90.9
KOR	98.5	IDN	95.9	NOR	94.4	HUN	90.4
IND	97.8	RUS	95.9	HRV	94.2	CHE	87.2
GRC	97.8	DNK	95.8	AUT	94.2	NLD	80.7
ROM	97.6	ESP	95.7	SWE	94.2	MLT	65.6
BRA	97.5	FRA	95.5	FIN	94.2	CYP	65.0
USA	97.4	SVN	95.1	CAN	94.0	IRL	63.2
ITA	97.2	SVK	95.0	ROW	93.8	LUX	33.3
MEX	96.7	POL	94.9	EST	92.8		

Notes: Calculations are based on: $100(\frac{\mathrm{GDP}_{i,i}}{\mathrm{GDP}_i})$ and are after applying the RAS procedure. See Annex VII for the names of the countries that ISO country codes refer to.

It is noteworthy that the diagonal shares in the years 2013 (not shown) and 2014 were similar for the same country. This supports the robustness of the results and consistency of the data sources used. Percent change in the diagonal shares of a country between these two years (i.e.,$100[(\mathrm{GDP}_{i,i}^{2014}/\mathrm{GDP}_i^{2014})/(\mathrm{GDP}_{i,i}^{2013}/\mathrm{GDP}_i^{2013}) - 1]$) were less than 2% for every country in the GDP-GNI matrix. Large fluctuations between consecutive years might have raised some concerns about the data, but this is not the case. For this reason, only results for the year 2014 will be discussed in the remainder of the analysis (Sections 5.5.1-5.5.4). The changes that did occur to the diagonal shares were, in three-fifths of all countries, negative percentage point changes. Even if this finding is based on two consecutive years only, it is consistent with the idea that globalization and the increasingly complex activities of investors and multinational firms are gradually leading to a less robust relationship between a country's value-added production and the share of income that this generates domestically.

Next, we consider the pass-through income in each country to assess the extent of pass-through investment and its impact on the diagonal shares of the GDP-GNI matrix. Table 5.3,

[105] Source: Central Bank of Luxembourg: https://www.banquedeluxembourg.com/de/bank/corporate/luxembourg-key-advantages-for-investment-funds

column (1) shows the monetary value (in millions) of all income debits reported by the IMF (PID_i^{IMF}, the raw capital income debits plus labor income debits and other income debits). Column (2) shows the monetary value of the income debits after adjusting for pass-through income ($\mathrm{PID}_i^{IMF} - \mathrm{PT}_i = \mathrm{PID}_i$). The adjustments are based on the methodology explained in Section 5.3.3. Column (2) thus shows the row-wise sums of non-diagonal elements representing the transfers of income to other countries. For easier interpretability, each column shows all debits before applying the RAS balancing procedure (hence, $\mathrm{PID}_i^{IMF} - \mathrm{PT}_i \neq \sum_{j \neq i} \mathrm{GDP}_{i,j}$ in the GDP-GNI matrix).[106] Column (3) reports the ratio between the unadjusted and adjusted figures ($= \mathrm{PID}_i^{IMF} / (\mathrm{PID}_i^{IMF} - \mathrm{PT}_i)$). The countries are ranked based on this ratio from low to high.

Table 5.3. Income debits (PID_i^{IMF}) and adjustments for pass-through income ($\mathrm{PID}_i^{IMF} - \mathrm{PT}_i$), 2014

	PID_i^{IMF} (1)	$\mathrm{PID}_i^{IMF} - \mathrm{PT}_i$ (2)	(1)/(2) (3)		PID_i^{IMF} (1)	$\mathrm{PID}_i^{IMF} - \mathrm{PT}_i$ (2)	(1)/(2) (3)
IDN	31832	31719	1.0	PRT	15679	14251	1.1
HRV	2987	2976	1.0	CAN	100228	90519	1.1
BRA	57160	56811	1.0	ESP	74852	67526	1.1
TUR	13113	13012	1.0	JPN	72854	65410	1.1
IND	37581	37229	1.0	AUT	29992	26868	1.1
ROM	5899	5823	1.0	USA	606150	541750	1.1
MEX	41905	41336	1.0	HUN	20142	17817	1.1
BGR	2383	2335	1.0	DEU	177694	157027	1.1
LTU	1711	1672	1.0	NOR	31373	27383	1.1
LVA	1679	1634	1.0	FRA	146923	127328	1.2
KOR	22666	21896	1.0	FIN	20232	17468	1.2
POL	34095	32909	1.0	DNK	20528	17631	1.2
SVN	2016	1942	1.0	GBR	302328	256793	1.2
CHN	234515	225872	1.0	SWE	50746	42388	1.2
RUS	115135	110263	1.0	BEL	64223	52118	1.2
CZE	20043	19132	1.0	CYP	6541	4377	1.5
SVK	5909	5614	1.1	CHE	150653	99489	1.5
AUS	79434	74484	1.1	IRL	116897	74582	1.6
ITA	83092	77448	1.1	NLD	342512	183462	1.9
EST	2262	2098	1.1	MLT	14293	4345	3.3
GRC	9391	8591	1.1	LUX	263601	39242	6.7

Notes: own calculations derived from official data from the IMF (see Section 5.3.3). (1) and (2) are in millions. $\mathrm{PID}_i^{IMF} - \mathrm{PT}_i$ would be equal to $\sum_{j \neq i} \mathrm{GDP}_{i,j}$ in the GDP-GNI matrix after applying the RAS balancing procedure.

[106] Note that Table 5.3 is the only part of the analysis that shows data prior to the RAS method. All other results in Section 5.5 are after applying RAS to the GDP-GNI matrix.

The ranking of countries based on the estimations of their pass-through income appears plausible. Luxembourg and Malta, which one would expect to have considerable pass-through income due to their attractiveness to foreign investors, are at the bottom of column (3). This implies that these two countries had the biggest relative discrepancies between the unadjusted values in column (1) and the corresponding adjusted values in column (2). Luxembourg sent income abroad at a magnitude of approximately four times its GDP in the year 2014 (i.e., $\text{PID}_{LUX}^{IMF} = 4 * \text{GDP}_{LUX}$). This also implies that, following equation (5.1), the diagonal element for Luxembourg (giving how much of Luxembourg's GDP goes to itself) would be negative in the case of no adjustments for pass-through income (i.e., $\text{GDP}_{LUX,LUX} = \text{GDP}_{LUX} - \text{PID}_{LUX}^{IMF} \approx \text{GDP}_{LUX} - 4 * \text{GDP}_{LUX} < 0$). The example reinforces the need to correct for pass-through income. At the same time, pass-through income appears, in general, not to be a major or pervasive issue. Most countries had diagonal shares exceeding 90% of their GDP even before adjusting for their pass-through income (not shown in Table 5.3). In addition, all but 7 countries had adjusted values for their diagonals that differed by two percentage points or less from their unadjusted diagonal values.

5.5.2 Off-diagonal elements of the matrix

This section assesses the bilateral part of the GDP-GNI matrix. A subset of the matrix relating countries' GDP to their GNI is shown in Table 5.4 for the European Union (EU15 countries) and in Tables 5.5 and 5.6 for North America and East Asia, respectively. The tables provide the shares (in percent) of all exported income transferred by the row countries to each column country. The percent share of country i's transfers of income to country j is obtained with $100(\text{GDP}_{i,j} / \sum_{j \neq i} \text{GDP}_{i,j})$.[107] This is domestic value-added that represents income gains to residents of other countries j. The diagonal values $\text{GDP}_{i,i}$, which are not considered exported transfers of income, were taken out of all tables in this analysis. Only shares of the bilateral component of GDP are reported. The full matrix is broken down into regional blocs for easier interpretability. Our application of the data considers to what extent geographical proximity explains transfers of income between countries. It could be that, like the trade of goods and services, gravity is important and there is less income repatriated between countries that are further apart.[108]

[107] To obtain $\text{GDP}_{i,j}$, multiply share $\text{GDP}_{i,j} / \sum_{j \neq i} \text{GDP}_{i,j}$ from Tables 5.4-5.7 with denominator $\sum_{j \neq i} \text{GDP}_{i,j}$ (the pass-through adjusted transfers of income from country i). Data on $\sum_{j \neq i} \text{GDP}_{i,j}$, are available from the author.

[108] In the case of labor payments associated with cross-border workers, though accounting for only a small share of total primary income debits, it is almost by design only possible for income to end up in neighboring countries.

We begin by analyzing the situation for the EU15 countries, which form a natural geographic bloc. The first observation is that the average EU15 country sent about half of its transfers of income (49.1%) to another EU15 country. This is obtained by the sum of the income transferred by all members of the EU15 to all other countries in the EU15 as a share of the region's total transfers of income. Geography thus played an important role in determining where Europe's transfers of income went to. That is, half of this income contributed to the national income of other EU15 countries. Returns on direct investment accounted for most of the income that was transferred by countries in the entire matrix of 42 countries plus ROW.[109] Firms exercise caution when making direct investments, which are a deep and sometimes risky form of international commitment. Direct investments in neighboring EU countries may be perceived as relatively safe and uncomplicated in the common market relative to investments in other regions, which could explain the importance of geography in determining where the income of the EU15 ended up.

Table 5.4. European Union (EU15): transfers of income by row-country as share of total transfers of income, 2014 (shares of each country to EU15 + US + Other = 100)

	AUT	BEL	DEU	DNK	ESP	FIN	FRA	GBR	GRC	IRL	ITA	LUX	NLD	PRT	SWE	EU15	US	Other
AUT	-	2.3	28.2	0.4	0.9	0.7	8.7	2.9	0.2	0.8	7.0	0.6	7.2	0.3	0.5	60.7	9.6	29.8
BEL	0.7	-	7.3	0.6	0.1	0.8	28.2	0.7	0.3	0.5	1.3	3.8	32.7	-0.1	2.6	79.4	6.2	14.4
DEU	3.1	1.7	-	1.9	1.9	1.0	7.4	10.1	0.1	1.8	4.4	1.2	7.8	0.4	1.8	44.4	23.2	32.3
DNK	0.5	0.9	9.1	-	0.9	6.8	3.2	4.8	0.0	1.2	0.6	1.0	6.6	0.1	17.7	53.6	23.1	23.3
ESP	0.8	1.9	14.7	0.6	-	0.4	16.6	8.3	0.7	2.2	10.5	1.0	4.9	1.9	1.1	65.5	16.2	18.4
FIN	1.1	0.9	11.0	4.4	0.4	-	4.6	4.9	0.0	1.9	1.1	0.7	10.2	0.2	22.4	63.8	15.8	20.4
FRA	0.9	5.2	14.5	0.7	2.1	0.7	-	9.2	0.1	2.7	5.7	1.3	7.2	0.5	0.8	51.6	20.0	28.4
GBR	0.3	0.7	6.8	0.8	2.0	0.4	7.5	-	0.6	4.8	1.6	0.7	5.8	0.2	1.3	33.6	37.7	28.7
GRC	1.9	2.9	14.6	0.4	1.0	0.3	12.7	19.4	-	1.9	8.6	1.2	6.1	3.7	1.3	76.0	20.5	3.5
IRL	0.4	1.0	5.2	0.6	1.1	0.9	3.7	7.3	0.0	-	3.7	0.5	2.4	0.4	0.6	28.0	59.8	12.2
ITA	1.8	2.4	16.1	0.9	6.3	0.5	21.2	7.2	1.4	4.5	-	1.6	4.7	1.3	0.5	70.4	11.0	18.6
LUX	0.8	17.5	10.2	1.1	1.7	1.1	6.4	5.0	1.2	2.0	7.6	-	6.4	2.3	2.5	65.8	13.2	21.0
NLD	0.6	6.9	12.6	1.8	1.7	0.9	8.8	12.1	0.1	2.5	1.7	1.8	-	0.3	1.5	53.3	19.6	27.1
PRT	1.1	2.5	11.8	1.1	17.1	0.0	13.4	5.9	1.0	2.7	4.8	1.7	15.2	-	0.3	78.7	9.6	11.7
SWE	0.9	0.8	9.2	7.8	0.8	9.9	3.6	9.9	0.0	2.0	0.6	1.6	12.7	0.1	-	59.7	18.3	22.0
EU15	1.0	3.2	9.4	1.3	2.0	1.0	8.5	6.4	0.4	2.7	3.3	1.2	6.5	0.5	1.8	49.1	26.1	24.8

Notes: own calculations based on $\text{GDP}_{i,j}/(\sum_{j \neq i} \text{GDP}_{i,j})$. The average, weighted share of EU15 to EU15 is based on the equation $\sum_{h \neq j, h \in EU} \text{GDP}_{h,j} / \sum_{i \in EU} \sum_{k \neq i} \text{GDP}_{i,k}$, where EU indicates the EU15 region.

Two notable outliers among the EU15 countries were Ireland and Great Britain. Ireland sent only 28.0% of its transfers of income to another EU15 country and 59.8% to the US (more than twice the weighted average of 26.1% for EU15 countries to the US). This can be best

[109] Table 5.A2 (Annex II) shows that direct investment income debits accounted for a plurality (45.3%) of total income debits of the average country in the GDP-GNI matrix (as calculated using raw IMF data before any adjustments to pass-through income).

explained by tax incentives in Ireland that have attracted large numbers of US multinational firms. Great Britain similarly transferred more income to the US (37.7%) than to another EU country (33.6%). This is probably related to the strong historical and cultural ties between the two countries. The contributions of Ireland and Great Britain to other countries' GNIs were thus less influenced by geographical proximity as compared to other EU15 countries because of the key role played by the US.

Geographical proximity mattered less for the transfers of income from North America (defined as the US, Canada, and Mexico). Observe in Table 5.5 that only 21.3% of all income transferred by the three countries remained in the region (60.1% for Canada, 9.0% for the US, and 53.1% for Mexico). North America, and especially the US, seemed lucrative to EU investors – because almost 40% of US transfers of income contributed to the GNI of EU15 countries. Although more than half of Mexico's and Canada's transfers of income went to the US, indicating the importance of US direct investments and US portfolio holdings in the neighboring countries, these investments were dwarfed by those of investors in countries outside of the region (notably Europe) investing in the US. The European influence is thus part of the reason why North America's transfers of income, especially by the US, did not depend as much on geographical proximity.

The US may be an interesting case because two-thirds of all US transfers of income involved returns on portfolio investments. The ratio of transfers of portfolio income to total transfers of income (i.e., $\sum_{j \neq USA} \mathrm{GDP}_{USA,j}^{K,POI} \,/ \sum_{j \neq USA} \mathrm{GDP}_{USA,j}$) was higher for the US than for almost every other country in the GDP-GNI matrix.[110] This is relevant because portfolio holdings are probably less dependent on geography than are direct investments. They do not require the same type of up-front and deep commitments or knowledge of the local market as do direct investments. If most foreign investors holding portfolios in the US reside far away from the US, then US transfers of income representing the returns on these investments necessarily also end up further away (outside the region). This could help to explain why almost all US transfers of income (91.0%) contributed to the national income of countries outside of North America.

[110] Table 5.A2 (Annex II) shows that 63.5% of US transfers of income were considered portfolio investment incomes, which is much higher than the weighted average of 45.5% for all countries in the full matrix.

Table 5.5. North America (NA): transfers of income by row-country as share of total transfers of income, 2014

	CAN	USA	MEX	CHN	EU15	Other	NA	TOT
CAN	-	59.7	0.4	6.1	14.0	19.7	60.1	100
USA	8.2	-	0.7	2.3	39.2	49.5	9.0	100
MEX	2.9	50.2	-	0.5	33.8	12.7	53.1	100
NA	6.4	14.3	0.6	2.9	34.3	41.5	21.3	100

Notes: own calculations based on $\text{GDP}_{i,j}/(\sum_{j\neq i}\text{GDP}_{i,j})$. NA = North America (Canada + USA + Mexico)

Geographical proximity was least important for the transfers of income from Japan and South Korea as compared to countries in the other two regions. Japan and South Korea seem to be heavily dependent on investments from the US and EU because more than one-half (South Korea) and two-thirds (Japan) of all income transferred by those countries ended up in the national income of either the US or EU.

Table 5.6. East Asia: transfers of income by row-country as share of total transfers of income, 2014

	CHN	JPN	KOR	USA	EU15	Other	TOT
CHN	-	9.8	3.3	9.7	13.6	63.6	100
JPN	8.6	-	3.1	44.6	25.7	18.0	100
KOR	10.4	19.7	-	32.2	20.1	17.8	100

Notes: own calculations based on $\text{GDP}_{i,j}/(\sum_{j\neq i}\text{GDP}_{i,j})$.

A key takeaway so far is that the EU15 countries and the US were important recipients of incomes transferred from countries in the three regions. Next, we check whether this finding also holds for incomes sent by countries outside of the three regions. Table 5.7 shows the transfers of income by emerging and developing countries (China, Brazil, India, Indonesia, Mexico, Russia, and Turkey, and ROW). Observe that about 22.5% of all income transfers from those countries went to the EU15 and 38.6% to the US. Furthermore, the full GDP-GNI matrix of 42 countries plus ROW shows that more than a third (35.6%) of all transfers of income worldwide were by the countries contained in Table 5.7. Poorer and emerging countries thus appear to send a relatively large share of their GDP to rich, developed regions like Europe and North America (despite greater geographical distance). The findings show the importance of the US, followed by the EU, as the major players in foreign investment worldwide. This also indicates the global reach of US direct investments and US portfolio holdings abroad, which account for almost all repatriated income.

Table 5.7. Emerging and developing countries: transfers of income by row-country as share of total transfers of income, 2014

	EU15	USA	Other	TOT
BRA	40.0	32.8	27.2	100
RUS	44.3	9.3	46.3	100
IDN	16.8	27.6	55.6	100
IND	23.1	29.7	47.2	100
CHN	13.6	9.7	76.7	100
TUR	41.8	23.0	35.2	100
MEX	33.8	50.2	16.0	100
ROW	19.2	47.8	33.0	100
TOT	22.5	38.6	38.9	100

Notes: own calculations based on $\mathrm{GDP}_{i,j}/(\sum_{j\neq i}\mathrm{GDP}_{i,j})$.

To reinforce the above findings in a different way, suppose that a country's GDP is a crude proxy for its attractiveness to foreign direct and portfolio investments. This is sensible given that the international business literature considers GDP (a proxy of market size) an important determinant of FDI (Dunning, 1993). Then it might be expected that - on average - countries invest in other countries in proportion to the partner country's share in global GDP. This would result in offsetting shares of incomes that are transferred by the country receiving inward investments to the counterpart countries. However, almost all countries in the GDP-GNI matrix sent a higher share of their transfers of income to the EU15 than the share of the EU15 region in global GDP.[111] This also held for income sent from non-EU countries to the US. Australia, Brazil, Canada, Indonesia, India, Japan, Korea, and Mexico all exported a higher share of their transfers of income to the US than the share of the US in global GDP. Also this comparison underscores the outsized importance of the US and EU15 as receivers of income – even from countries that are geographically distant.

In the Asian context, it is striking that most of China's transfers of income ended up in countries other than the US, EU15, Korea, and Japan (= 63.6%), rather than in the EU15 (13.6%) or US (9.7%) (Table 5.6). This is due to the influence of tax havens that are reflected in the data on China. We used the Coordinated Direct Investment Survey (CDIS) to proxy the offsetting shares of China's transfers of direct investment income going to counterpart countries. (the CDIS is discussed in Annex IV). The CDIS shows that in 2014 more than two-thirds (67.5%) of all direct investments in China were by the British Virgin Islands, Not Specified / Confidential, Singapore, Netherlands, Cayman Islands, and Bermuda. The British

[111] The exceptions were Canada, China, Cyprus, Indonesia, Korea, Malta, and ROW.

Virgin Islands, the largest investor, by itself made 38.6% of all direct investments in China. All these countries are well-known tax havens.

Given that nearly all transfers of income by China were attributed to returns on direct investments (see Table 5.A2, Annex II), these tax havens then accounted for a great majority of the income that China sent to 'Other' as reflected in Table 5.6. This shows that tax havens can have a big impact on bilateral investment statistics if the data are based on the immediate investing country. Although we used direct investment shares based on the ultimate beneficiary country for more than half of all countries in the GDP-GNI matrix to minimize the impact of tax havens, such data was not available for China. Hence, it could still well be that the US and EU15 were the biggest investors in China if they operate there indirectly via intermediaries (tax havens). China was the most extreme example of the apparent distortions in the data related to tax havens. Most countries in the study had more reasonable (smaller) shares of their transfers of income going to the 'ROW' countries not separately included in the matrix.

5.5.3 Analysis: exports of GNI

In this section, we use the GDP-GNI matrix to help derive estimates of incomes that are generated in a country due to demand for final goods and services. The analysis covers all types of income contributing to a country's GNI – e.g., the income a country gains from profit-shifting by MNEs, the income sent home by cross-border workers, and the income a country's citizens earn from portfolio investments in another country. The sum of the income generated from all sources of final demand, foreign and domestic, equals the country's GNI. The main contribution of this analysis is to differentiate between income that is induced by domestic final demand and income that is induced by foreign final demand. We consider the income that is generated in a country but induced by final demand abroad to be this country's exports of income or exports of GNI (hence GNIX). As part of the analysis we compare a country's exports of income to its exports of value-added (or VAX). The latter is the domestic value-added induced in one country due to final demand in foreign countries. Exports of income contribute to a country's GNI and exports of value-added contribute to a country's GDP.

The goal of the comparison is to investigate the extent to which a country is more (or less) dependent on foreign consumption of final products in terms of the generation of its own income compared to the generation of domestic value-added. This provides a better portrayal of the income benefits of final demand from abroad to a country's residents than the exports of value-added indicator because part of the value added might be transferred to foreign countries and vice versa.

So, it is important to observe the differences between the different types of exports. These are gross exports, exports of value-added, and exports of income. An example is illustrative. French consumers buy agricultural goods from the Netherlands, the production of which uses German fertilizers. The German fertilizer factory also employs cross-border workers from Poland (i.e., people who work in Germany but reside in Poland). In this case, the delivery of Dutch agricultural products to French consumers are part of the Dutch gross exports to France. These exported Dutch agricultural products also embody inputs of German fertilizers. The labor and capital used in the German fertilizer factory is part of the German value added. Hence, Germany exports value added to France. The earnings of the Polish cross-border workers are part of the German value added but are transferred to Poland and become part of Poland's income (GNI). This means that Poland exports income to France. The possible gross export, value added, and income linkages are illustrated in Table 5.8a.

Note that while exports of value-added and exports of income are the same in the aggregate in Table 5.8a (summed up across the four countries), this is not necessarily the case in every supply chain. The illustration in Table 5.8b now assumes that: i) the Dutch consume all the agricultural goods themselves instead of French people, and ii) a Spanish firm owns the farmland used to grow the agricultural products in the Netherlands, and repatriates part of the profits it makes from selling the goods to Dutch consumers back to Spain. All other assumptions are carried over from the first illustration. Then it is possible, as shown in Table 5.8b, that the aggregated exports of income (from Poland, Germany, and Spain to the Netherlands) exceed the exports of value-added (from just Germany to the Netherlands).

Table 5.8a. Illustration: gross exports, exports of value-added, and exports of income (in $)

	Gross exports (GE_i)	Exports of value-added (VAX_i)	Exports of income ($GNIX_i$)
POL	0	0	2 (POL → FRA)
DEU	5 (DEU → NLD)	5 (DEU → FRA)	3 (DEU → FRA)
NLD	10 (NLD → FRA)	5 (NLD → FRA)	5 (NLD → FRA)
FRA	0	0	0
TOT	15	10	10

Table 5.8b. Illustration: gross exports, exports of value-added, and exports of income (in $)

	Gross exports (GE_i)	Exports of value-added (VAX_i)	Exports of income ($GNIX_i$)
POL	0	0	2 (POL → NLD)
DEU	5 (DEU → NLD)	5 (DEU → NLD)	3 (DEU → NLD)
NLD	0	*5 (internal, NLD → NLD)*	*3 (internal, NLD → NLD)*
ESP	0	0	2 (ESP → NLD)
TOT	5	5	7

Notes: POL = Poland; DEU = Germany; NLD = Netherlands; FRA = France; ESP = Spain.

The two main components in the calculations for exports of income are the 43×43 GDP-GNI matrix, denoted GDP, and a 43×43 matrix with exports of value-added, denoted VAX. The matrix GDP was given in Table 5.1 and was constructed according to Sections 5.3-5.4. Its elements $\mathrm{GDP}_{i,j}$ give the transfer of incomes, i.e., the value added of i that goes to j and becomes part of j's GNI. The GDP matrix covers only 43 countries (instead of 44) because our definition of ROW includes Taiwan.

The VAX matrix is derived in two steps from the 2014 world IOT in the WIOD database. There are 56 industries included in the WIOT for each of the 44 countries.[112] Let v denote the 2464×1 vector of value-added coefficients; A the 2464×2464 matrix with input coefficients; I the 2464×2464 identity matrix; and F is the 2464×44 matrix of final demands. Value added includes wages and salaries, employers' contributions, capital depreciation, indirect taxes, price-decreasing subsidies, and operating surplus or other income. Final demands include private investments, government consumption and investments, and changes in stocks. The full 2464×44 value-added exports matrix is given by

$$VAX^{full} = \hat{v}(I - A)^{-1}F \tag{5.19}$$

where a 'hat' is used to indicate the diagonal matrix based on v. The second term in equation (5.19) is also known as the Leontief inverse (or multiplier matrix). The typical element $\mathrm{VAX}_{i,j}^{full}$ gives the value added generated in country-industry i (= 1, …, 2464) necessary for all 2464 final demands by country j (= 1, …, 44). The first step is to aggregate the 2464 (= 44 × 56) results for country-industries into the totals for the 44 countries (by summing over the 56 industries for each country). This yields a 44 × 44 matrix. The second step is to aggregate the results for ROW$^{\text{-TWN}}$ and Taiwan, which yields the 43×43 matrix VAX. Its typical element $\mathrm{VAX}_{i,j}$ gives the value added generated in country i necessary for all final demands in country j, with i, j = 1, …, 43 and ROW (which now includes Taiwan) is country 43. The off-diagonal elements of VAX give exports of value-added.

Similar to VAX, the matrix $GNIX$ gives in its off-diagonal elements the exports of income. $GNIX$ is derived as follows. The final demands of country j induce value added (and thus a contribution to GDP) in country i to the amount of $\mathrm{VAX}_{i,j}$. The share of country i's GDP that becomes part of country k's income (GNI) equals $\mathrm{h}_{i,k} = \mathrm{GDP}_{i,k}/\sum_j \mathrm{GDP}_{i,j} = \mathrm{GDP}_{i,k}/\mathrm{GDP}_i$.

[112] These are the 42 individual countries in the GDP matrix; the 43rd country is Taiwan (included separately); and the 44th country is ROW$^{\text{-TWN}}$. For the purposes of deriving VAX^{full} in equation (5.19) only, the rest of world aggregate exceptionally is not combined with Taiwan.

This share gives the part of an average dollar of GDP in i that is transferred to the GNI of k. In that case, the income transfer of $\mathrm{VAX}_{i,j}$ as part of GDP in country i to the GNI in country k equals $\mathrm{h}_{i,k}\mathrm{VAX}_{i,j}$. This gives the GNI in k that is due to final demands in j and which runs through GDP in i. Clearly, country i is not the only transmission channel. All GNI in k that is due to final demands in j is given by

$$\mathrm{GNIX}_{k,j} = \sum_i \mathrm{h}_{i,k}\mathrm{VAX}_{i,j}$$

Using matrix algebra, we have

$$GNIX = H^{\mathrm{T}}VAX \qquad (5.20)$$

where H^{T} denotes the transposed matrix of H.

The rows of $GNIX$ refer to income-generating countries and the columns refer to income-consuming countries. The income generated in country k that is embodied in all final demands consumed abroad (or total exports of income) is $\sum_{j\neq k}\mathrm{GNIX}_{k,j}$. It can be shown that the sum of row k of $GNIX$ equals the GNI of country k.[113] The columns of $GNIX$ give GNI footprints and show all pieces of income (and where it comes from) that are consumed by final users. $\sum_{k\neq j}\mathrm{GNIX}_{k,j}$ gives the imported income. It can be shown that the column sums equal the sum of final demands in the corresponding country.[114]

Table 5.9 compares countries' gross exports, exports of value-added, and exports of income in 2014. To facilitate ease of interpretation and to show the relative impact exerted by foreign final demand, all values are divided by GDP_i or GNI_i. We report gross exports as a share of GDP in column (1), $\mathrm{GE}_i/\mathrm{GDP}_i$ (=$\sum_{j\neq i}\mathrm{GE}_{i,j}/\mathrm{GDP}_i$), the share of GDP_i that was exported in column (2), $\mathrm{VAX}_i/\mathrm{GDP}_i$ (=$\sum_{j\neq i}\mathrm{VAX}_{i,j}/\mathrm{GDP}_i$), and the share of GNI_i that was exported in column (3), $\mathrm{GNIX}_i/\mathrm{GNI}_i$ (=$\sum_{j\neq i}\mathrm{GNIX}_{i,j}/\mathrm{GNI}_i$), for each of the 42 countries plus ROW. All shares are multiplied by 100 to express the ratios in percent. Column (4) shows the percentage point difference between (2) and (3), $\left(\frac{\mathrm{GNIX}_i}{\mathrm{GNI}_i}-\frac{\mathrm{VAX}_i}{\mathrm{GDP}_i}\right)*100$, and column (5) shows the ratio

[113] Taking the row sums of VAX^{full} in (5.20) yields the values-added in each country-industry. Taking the appropriate sums for countries implies $\sum_j \mathrm{VAX}_{i,j} = \mathrm{GDP}_i$. Hence $\sum_j \mathrm{GNIX}_{k,j} = \sum_j\sum_i \mathrm{h}_{i,k}\mathrm{VAX}_{i,j} = \sum_i \mathrm{h}_{i,k}\mathrm{GDP}_i = \sum_i \mathrm{GDP}_{i,k} = \mathrm{GNI}_k$ as follows from Table 5.1.

[114] Let e' denote the row summation vector consisting of ones, i.e., $e' = (1, \ldots, 1)$. For the value-added coefficients it holds that $v' = e'(I-A)$. Therefore we have $e'VAX^{full} = e'F$, which means that the column sums of VAX^{full} equal the total amount of final demands in each country. Next, $\sum_k \mathrm{GNIX}_{k,j} = \sum_k\sum_i \mathrm{h}_{i,k}\mathrm{VAX}_{i,j} = \sum_i \mathrm{VAX}_{i,j}$, because $\sum_k \mathrm{h}_{i,k} = 1$. $\sum_i \mathrm{VAX}_{i,j}$ equals the sum of all final products consumed in country j.

$(\frac{\text{GNIX}_i}{\text{GNI}_i})/(\frac{\text{VAX}_i}{\text{GDP}_i})$. The countries are ranked according to the ratio in the last column from high to low. Gross export figures were obtained from the WIOD database. GDP and GNI figures in the denominators were obtained from the row-sums of the VAX and $GNIX$ matrices, respectively.

Gross exports are the conventional measure of trade, but they do not always correspond to the contribution of trade to GDP of the exporting country. This is due to the use of imported intermediates (embodying foreign value-added), which are also captured in gross exports data. In this case, gross exports contribute less to the exporter's GDP than the reported value of the exports. That can explain the higher dependence of countries on gross exports than on exports of value-added as a share of their GDP. Hence, while gross exports accounted for 72.5% of Dutch GDP in 2014, it is not the case that nearly three-fourths of Dutch GDP came from abroad. The impact exerted by foreign final users, which is measured by the exports of value-added, was only 43.3% as a share of Dutch GDP. However, final demand from abroad generated much more income (54.0% as share of GDP or 54.1% as share of Dutch GNI) than value added.

Countries at the top of Table 5.9 have the largest ratio $(\frac{\text{GNIX}_i}{\text{GNI}_i})/(\frac{\text{VAX}_i}{\text{GDP}_i})$. This means that these are the countries that depend the most on foreign final demand from the perspective of income (as share of GNI) relative to their perceived dependence on foreign final demand from the conventional perspective of value added (as share of GDP). The first country, Cyprus, exported more than half of its income, but less than a third of its value added, to final users abroad. Observe that the top half of Table 5.9 is dominated by rich, developed economies. This suggests that while many emerging countries may appear to benefit from global integration based on their exports of value-added figures, it is the wealthy countries that benefit the most in terms of income.

Luxembourg was the country that exported the highest share of its GNI, more than four-fifths. At the same time, Luxembourg exported two-thirds of its GDP. This was also the most from any country, which is why it is just sixth in Table 5.9. Four other countries (Ireland, Malta, and Netherlands, and Cyprus) likewise exported more than half of their GNI. The countries that exported the most income as a share of their GNI tended to be smaller European countries. These countries are tightly integrated in international capital markets. The countries least dependent on foreign final demand to generate their income were the largest economies (Brazil, USA, India). This is reasonable given that investors and producers in larger countries are more home-country oriented and most production is sold (consumed) in the domestic market. The only five countries that exported less income than value-added (in gross terms) were Luxembourg, Czech Republic, Russia, Indonesia, and Poland.

Table 5.9. Gross exports (% share of GDP), exports of value-added (% share of GDP), and exports of income (% share of GNI), 2014

	$\mathrm{GE}_i/\mathrm{GDP}_i$ (1)	$\mathrm{VAX}_i/\mathrm{GDP}_i$ (2)	$\mathrm{GNIX}_i/\mathrm{GNI}_i$ (3)	(3)-(2) (4)	(3)/(2) (5)
CYP	44.4	30.6	51.4	20.8	1.7
USA	11.1	8.9	13.0	4.1	1.5
MLT	141.9	47.2	63.9	16.6	1.4
JPN	18.4	13.5	17.7	4.1	1.3
GBR	28.2	21.4	27.2	5.8	1.3
LUX	203.3	65.4	82.4	17.0	1.3
NLD	72.5	43.3	54.1	10.8	1.2
FRA	29.9	20.0	24.6	4.6	1.2
CHE	51.8	37.1	45.0	7.9	1.2
IRL	115.4	55.9	67.7	11.7	1.2
FIN	42.8	26.0	31.1	5.1	1.2
NOR	41.9	32.7	38.5	5.9	1.2
SWE	46.4	31.3	36.8	5.5	1.2
ESP	30.9	20.0	23.2	3.2	1.2
DNK	56.8	33.6	38.9	5.4	1.2
GRC	27.0	17.5	19.9	2.5	1.1
BEL	80.4	40.2	45.8	5.6	1.1
AUS	21.2	17.6	20.0	2.4	1.1
CAN	33.6	24.7	28.1	3.4	1.1
AUT	54.1	32.8	36.8	4.0	1.1
PRT	38.0	23.6	26.4	2.8	1.1
DEU	48.3	32.3	35.9	3.5	1.1
ITA	30.6	21.2	23.4	2.2	1.1
LTA	53.0	34.8	38.0	3.3	1.1
ROW	35.5	23.8	26.0	2.2	1.1
HRV	48.3	32.6	35.5	2.9	1.1
HUN	99.8	43.3	46.4	3.1	1.1
EST	78.1	40.9	43.5	2.7	1.1
IND	18.5	13.5	14.3	0.8	1.1
SVN	72.0	41.9	44.4	2.5	1.1
MEX	30.0	19.3	20.4	1.1	1.1
BGR	64.2	36.5	38.4	1.9	1.1
SVK	90.1	42.3	44.4	2.1	1.1
BRA	13.0	10.0	10.5	0.5	1.1
CHN	23.6	18.7	19.6	0.9	1.0
KOR	54.2	32.4	33.6	1.3	1.0
POL	51.9	33.6	34.7	1.2	1.0
IDN	24.2	19.6	20.2	0.6	1.0
ROM	44.0	30.0	30.9	0.8	1.0
RUS	30.4	26.1	26.8	0.7	1.0
LTU	74.8	44.7	45.9	1.2	1.0
CZE	86.8	42.8	43.8	1.0	1.0
TUR	35.1	23.2	23.6	0.4	1.0
SUM-W	27.7	19.3	22.2	2.9	1.2

Notes: Rounded to the nearest tenth. Weighted averages are based on (1) $\sum_i \mathrm{GE}_i / \sum_i \mathrm{GDP}_i$; (2) $\sum_i \mathrm{VAX}_i / \sum_i \mathrm{GDP}_i$; and (3) $\sum_i \mathrm{GNIX}_i / \sum_i \mathrm{GNI}_i$. GE_i are *i*'s gross exports, VAX_i are *i*'s value-added exports, and GNIX_i are *i*'s exports of income.

Observe in Table 5.9 that percentage point differences in column (4) were positive in every country, $\left(\frac{\mathrm{GNIX}_i}{\mathrm{GNI}_i}\right) - \left(\frac{\mathrm{VAX}_i}{\mathrm{GDP}_i}\right) > 0$, and that the related ratio in column (5) always exceeded 1 (including the unrounded ratios of the countries at the bottom displaying a rounded '1.0'). In other words, the share of GNI a country exported was always larger than the share of GDP exported by the same country. Overall, global exports of income exceeded global exports of value-added by 15.0%. This tells us that the world is more globalized and/or interconnected in terms of countries' dependence on foreign demand from the perspective of income exports than from the perspective of value-added exports.

This finding could be explained by the rapid pace of financial globalization. Consider that cross-border direct investment activities can contribute to the exports of income of the investing country via profit shifting whenever income is generated through foreign consumption. Cross-border direct investments increased globally by 18.2% between 2011 and 2014 (source: CDIS database), which are the years following the 2007/2008 financial crisis recovery period. On the other hand, global exports of value-added increased by only 4.8% in the same period (source: WIOD database). This is consistent with an analysis by Timmer et al. (2016) that international production fragmentation only increased marginally since the financial crisis and that the slowdown in global trade may be part of a longer trend. Hence new cross-border investment activities greatly exceeded the pace of increased trade in value added in recent years.[115] This pattern held to a lesser extent also for the longer period from 2001-2014 as cross-border direct investment increased by 239% (source: UNCTAD (2019) bilateral FDI database) and value-added exports increased by 186% (source: WIOD database, 2016 release). These developments suggest that final demand sometimes induced exports of income without inducing any corresponding exports of value-added (e.g., along the lines of the illustration in Table 5.8b where Dutch final demand induced more exports of income than exports of value-added).[116] This is possible when the production processes used by subsidiaries of multinational firms are more capital intensive, involve home-country or cross-border workers, use few foreign inputs, and primarily serve final consumers in the host-country market.

[115] This trend also holds for portfolio investments and remittances. Cross-border portfolio investments increased globally by 23.9% (CPIS database) and remittances increased by 13.7% (WBRM database) in 2011-2014.

[116] Note that the reverse is also possible: exports of value-added that do not translate into exports of income for the same or another country. Suppose a US multinational firm outsources all production to a subsidiary in Ireland (e.g., for tax avoidance purposes or to lower production costs) but markets their products solely to US consumers. This generates Irish exports of value-added that are consumed by final users in the US. Then there may be substantially fewer exports of income than exports of value-added if all profits are shifted to the US (especially if production is capital-intensive). However, given that $\mathrm{GNIX}_{World} > \mathrm{VAX}_{World}$, this type of scenario is less frequent (on balance).

Although all countries depended more on foreigners to generate their income (GNI) than to generate their domestic value-added (GDP), this occurred to varying degrees. The largest percentage point difference in the two indicators, based on column (4), were in Cyprus (+20.8 p.p.), Luxembourg (+17.0 p.p.), Malta (+16.6 p.p.), Ireland (+11.7 p.p.), and the Netherlands (+10.8 p.p.). Note that the big percentage point difference in the case of Luxembourg does not contradict the previous finding that it exported less income than value-added (in gross terms). This is because Luxembourg's GDP was much higher than its GNI, which are the denominators of the shares underlying the calculations in column (4). Meanwhile, the differences for 13 other countries were less than two percentage points.

5.5.4 Analysis: trade balance of income

In this section we use information obtained from the trade in income matrix, $GNIX$, to examine trade balances of income. The goal is to cast more light on the impact of foreign final demand on income by considering a country's (bilateral) income surplus or deficit. We compare trade balances that are conventionally based on gross exports, and more recently analyzed from the perspective of value added, with trade balances of income. Note that the trade in income data used to calculate a country's income balance has the same broad scope as before. That is, exports of income involve not just the income generated by foreign final demand that relate directly or indirectly to the physical cross-border flows of goods and services. The exports may also arise due to profit shifting in relation to domestic supply chains where no intermediary inputs or final products cross the border.

We obtain the trade balance of income as follows:

$$\text{Trade balance of income}_i = \sum\nolimits_{j \neq i} \text{GNIX}_{i,j} - \sum\nolimits_{j \neq i} \text{GNIX}_{j,i} \tag{5.21}$$

Where $\text{GNIX}_{i,j}$ denotes country i's exports of income to country j and $\text{GNIX}_{j,i}$ denotes country i's imports of income from country j. $\sum_{j \neq i} \text{GNIX}_{i,j}$ are country i's exports of income to all countries j ($j \neq i$) and $\sum_{j \neq i} \text{GNIX}_{j,i}$ are country i's imports of income from all countries j ($j \neq i$). The trade balances of value-added and gross exports are constructed similarly (i.e., by replacing GNIX with VAX or GE in equation (5.21).

Table 5.10 shows the trade balances for each country in the year 2014. Column (1) reports the (gross) trade balance for all countries as a share of GDP. Column (2) reports the trade balance in value-added terms as a share of GDP. Column (3) is the novel part, showing the trade balance of income as a share of GDP. For example, Ireland had a large (gross) trade surplus. Gross exports minus gross imports amounted to 22.7% of Irish GDP. This surplus was 1.4 percentage points smaller from the perspective of value-added exports minus value-added imports (21.3%). Ireland had a much lower trade surplus in income (7.6% as share of GDP). On the one hand, this implies that Ireland exported more income than it consumed from abroad. That is, the income induced by non-Irish final demand that ended up in Ireland exceeded the income Irish consumers sent abroad to satisfy their own domestic final demand. However, the discrepancy between Ireland's value-added and income surpluses is relatively large. This could be explained by the prevalence of multinational activities in Ireland, which results in the repatriation of income and is likely related to the influential role of the US.[117]

Table 5.10. Trade balances (surplus/deficit) as percent share of GDP, 2014

	Gross trade balance (1)	Value-added balance (2)	Income balance (3)		Gross trade balance (1)	Value-added balance (2)	Income balance (3)
AUS	-0.1	-0.1	-2.7	IRL	22.7	21.3	7.6
AUT	4.2	3.9	4.1	ITA	3.6	3.2	3.3
BEL	5.8	4.2	5.0	JPN	-1.6	-1.6	2.1
BGR	-5.8	-6.9	-7.8	KOR	10.5	8.6	9.0
BRA	-2.3	-3.2	-5.2	LTU	5.2	3.7	2.3
CAN	1.1	1.2	-0.3	LUX	27.1	25.2	-9.0
CHE	12.8	12.4	12.2	LTA	-3.1	-2.9	-3.1
CHN	5.7	5.7	5.8	MEX	0.5	0.5	-1.5
CYP	-8.2	-7.8	-14.9	MLT	-1.7	-1.5	-5.6
CZE	10.4	8.0	1.3	NLD	15.6	14.6	14.5
DEU	11.2	10.8	12.9	NOR	13.9	12.8	16.2
DNK	8.9	8.2	12.4	POL	3.9	3.3	0.0
ESP	0.5	0.2	-0.2	PRT	-3.3	-4.7	-6.3
EST	0.7	-0.5	-3.3	ROM	0.2	-0.5	-1.8
FIN	1.3	0.6	1.8	RUS	7.1	6.1	2.9
FRA	-0.7	-1.1	0.4	SVK	7.8	5.1	3.9
GBR	-0.7	-0.9	-2.6	SVN	5.1	3.8	3.3
GRC	-8.7	-8.9	-8.2	SWE	6.2	5.9	8.3
HRV	0.7	-0.3	-1.8	TUR	2.8	1.9	1.1
HUN	9.4	6.4	2.0	USA	-2.8	-2.5	-0.2
IDN	0.9	1.1	-2.3	ROW	-10.6	-9.5	-12.7
IND	-0.1	-1.0	-2.2				

Notes: Rounded to the nearest tenth. (1) reports trade balances based on gross exports, $(\mathrm{GE}_i - \mathrm{GI}_i)/\mathrm{GDP}_i$, where GI_i are i's gross imports. (2) reports trade balance based on value added, $(\sum_{j\neq i} \mathrm{XAX}_{ij} - \sum_{j\neq i} \mathrm{VAX}_{ji})/\ \mathrm{GDP}_i$. (1) and (2) were obtained from the WIOD database. (3) reports trade balances of income, $(\sum_{j\neq i} \mathrm{GNIX}_{ij} - \sum_{j\neq i} \mathrm{GNIX}_{ji})/\ \mathrm{GDP}_i$.

In general, the more developed economies had a higher income surplus (or a lower income deficit) relative to their value-added surplus (or deficit). The opposite was true for many

[117] The role of the US in terms of Ireland's income exports was demonstrated by the GDP-GNI matrix, which showed that 59.8% of Ireland's exported income transfers ($=\sum_{j\neq IRL} \mathrm{GDP}_{IRL,j}/\mathrm{GDP}_{IRL}$) went to the US in 2014.

emerging and developing countries. The ROW aggregate for all countries not in the GNIX matrix, which arguably demonstrates this pattern the best, had not only the largest deficit in value-added terms (-9.5%) but, after Cyprus, also the largest deficit in terms of income (-12.7%) as share of GDP. This represents (for ROW) an income deficit that was US$ 354bn larger than its value-added deficit. These patterns make sense given that developed countries tend to invest more in developing countries than the other way around. Returns on investments, which account for much of the discrepancy between the GNIX and VAX indicators, result in higher net exports of income for those wealthier countries. Compared to the trade balances of value-added (which in most cases did not differ much from the corresponding gross trade balances for each country), the trade balances of income not just in Ireland but also Luxembourg, Cyprus, and the Czech Republic were much less positive and/or more negative.

As mentioned in the introduction, US President Trump often complains about the bilateral US trade deficit in goods with other countries and cites this as a justification for tariffs and other protectionist measures. However, the analysis thus far portrays a story that may counter such concerns about 'fairness' by showing how much the US truly lost (or benefitted) from an open trade and investment climate vis-à-vis counterpart countries. First, US investors are major players in foreign investment worldwide. This is related to the analysis of the GDP-GNI matrix in Section 5.5.2, which indicated that a large share of many countries' transfers of income ended up in the US, even from countries that are geographically distant from the US. The US had a positive primary income balance with a GNI that exceeded GDP. Second, the analysis in Section 5.5.3 indicated that US exports of income (US$ 2308bn) were nearly 50% higher than its exports of value-added (US$ 1545bn), and higher too than its gross exports (US$ 1927bn). Although most countries exported more income than value-added, none (except for Cyprus) exported so much more as a percent difference in the export volumes. Thus, the US benefitted more in terms of the income it earned from foreign consumption than in terms of the value added that was generated.

The data in Table 5.10 shows that the US trade deficit in income was much lower than its trade deficit in value-added. The US income deficit was only 0.2% as share of US GDP. This compares to a 2.5% deficit in value-added trade and a 2.8% deficit in gross exports trade as shares of US GDP. Thus, the US income generated after accounting for all activities that US workers, firms, and investors were involved in to satisfy foreign final demands, irrespective of whether those activities generated value added in the US, almost matched the income the US paid to foreigners to satisfy its own final demands. The US income deficit was US$34bn, which was US$ 394bn smaller than its deficit in value-added (= US$ 428bn). Any arguments for protectionism to hinder the cross-border movements of labor, capital, goods and services are thus weaker if not misleading given the large amounts of income the US is earning. At the same time, it is worth noting a caveat to the results that applies not just to the US. The (investment) income generated from final demand is not equally distributed over all citizens but might end up in the hands of only a few. This ties into the discussion on rising income equality within countries, which is observed worldwide, and which has also become a key political issue.

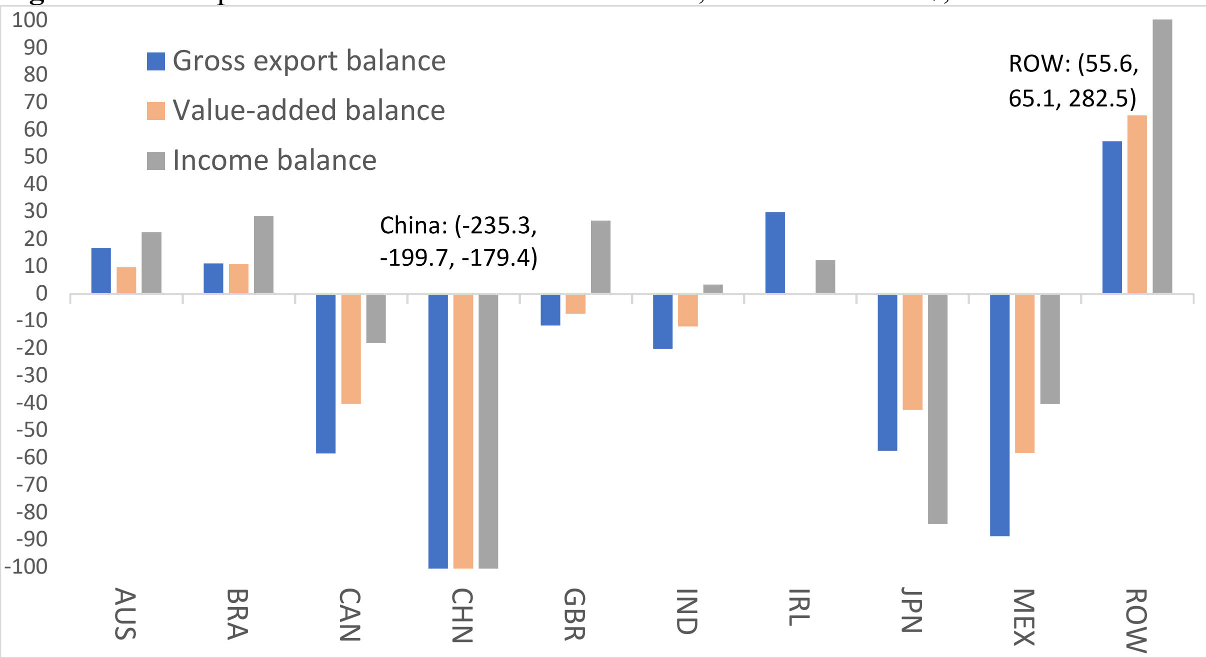
Figure 5.1 compares the bilateral US trade balances in gross terms, value-added terms, and income terms with the ten countries with whom the latter two balances differed the most. Bilateral US trade balances in income are defined as exports of income from the US to each 'trading' partner minus the trading partner's exports of income to the US. This is obtained by selecting only one element in the row-vector and one element in the column-vector of a given country in the GNIX matrix that pertain to the same counterpart country. A long-standing debate in the public and policy circles concerns who benefits the most from bilateral trade in the US-Mexican trade relationship, and about what can be done to make trade more 'balanced'. The US had a US$ 88bn bilateral gross trade deficit with Mexico. This deficit was already much smaller in terms of value-added (US$ 58bn), which can partly be attributed to the large amount of intermediate goods that are traded across the border. Mexico imports many intermediates from the US, which may contain US value added, and (re-) exports intermediates to the US, which may then be turned into final products by US workers (Amiti et al., 2017). However, this story is still incomplete. From the perspective of income, the US bilateral trade deficit with Mexico is reduced an additional 30% to just US$ 40bn. The reason is the dominance of US-led supply chains and US-owned production facilities (e.g., US subsidiaries) in Mexico, which not only assemble products that contains US value added, but also repatriate Mexican value added as income to the US. Hence, the bilateral US trade deficit in income is half of the bilateral US trade deficit in gross terms. Trade is thus more balanced than it may appear at first glance.

The data show that the bilateral US income surplus was larger (or the bilateral US income deficit was smaller) than the corresponding value-added surplus or deficit with 38 of 43 countries, including ROW. This included 18 economies with whom the US had a bilateral income surplus whilst having a bilateral value-added deficit.[118] Overall, from the conventional GDP perspective, the US had a bilateral trade deficit in value-added with 31 of 42 countries. In contrast, from the GNI perspective, the US had a bilateral trade deficit in income with only 14 countries. The fact that the US still had a small overall deficit from the perspective of income

[118] Those 18 countries were Bulgaria, Czech Republic, Spain, Estonia, Finland, Great Britain, Croatia, Hungary, India, Ireland, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, and Turkey.

is explained by bilateral deficits with large economic players such as China (US$ -179bn), Japan (US$ -84bn), Germany (US$ -46bn), Mexico (US$ -41bn), and Korea (US$ -26bn), even if they were for the most part less than the corresponding deficits in value-added. For example, the largest bilateral US deficit from both the value-added and income perspectives was with China, though the income deficit with China was US$ 20bn smaller. The one notable exception was the bilateral US deficit with Japan, which was about twice as large in terms of income than in terms of value-added. Hence, the income perspective casts bilateral US trade deficits in a new light and its position vis-à-vis counterpart countries appears much stronger in this way (except for with Japan).

Figure 5.1. Comparison of US bilateral trade balances, in billions of US$, 2014



For China the respective value-added (5.7%) and income (5.8%) surpluses as shares of its GDP were almost identical. This reflects that foreign final demand induced slightly higher levels of income than value added in China. Although the larger surplus in income may come as a surprise given the extent of foreign investment activities in China, there are some possible explanations. First, China was a net receiver of income transfers because its GNI was slightly higher than its GDP. This may be related to China being one of the world's biggest players in outward FDI (UNCTAD, 2018), which would result in a large influx of income from the returns on investment. Thus, profit shifting goes in both directions. Second, notoriously strict capital controls might incentivize foreign multinationals operating in China to reinvest rather than to repatriate more of their profits. Third, 98.9% of China's GDP ended up in China, which was the highest share of any country in the GDP-GNI matrix. This means China had the fewest transfers of income relative to the size of its economy, which limits the extent to which the subsequent calculations result in exports of income figures that differ from exports of value-added.

Those results are interesting in light of a case study by Duan et al. (2012). The authors found that 85.6% of the domestic value-added generated by China's exports went to China's GNI in 2007. This was attributed to the role of foreign invested enterprises involved in China's exports. Although their method involves a decomposition of gross exports and thus does not directly compare to our final demand approach, the finding suggests that a considerable part of the value added induced in China by trade does not end up in China. However, we show that China's capital income 'losses' to other countries in a broader sense may be offset by income that flows into China from abroad due to final demand in other countries. This depicts a much more favorable perspective for China in terms of how it benefits from globalization.

In summary, the countries that benefitted the most from the income perspective in terms of having a lower income deficit or a higher income surplus relative to the value-added deficit or surplus were, as measured by the percentage point difference in the respective shares in their GDP (and multiplied by 100): Denmark (+4.3 p.p.), Japan (+3.8 p.p.), Norway (+3.4 p.p.), Sweden (+2.4 p.p.), the US (+2.3 p.p.), Germany (+2.1 p.p.), and France (+1.5 p.p.). All of them are highly industrialized countries. The US, followed by Japan, were by far the biggest 'winners' in gross terms, which makes sense given the size of their economies. The data indicates that the 14 'winners' that had higher net exports of income than net exports of value-added, including those 7, were particularly influential because they collectively 'gained' as much (net) income as the other 28 other countries plus ROW collectively 'lost'. This pattern of a large number of developing and emerging countries earning income for a small group of (investors in) highly developed countries can also be interpreted as being consistent with the high levels of income inequality we see today.

5.6 Conclusion

The emergence of multinational firms is closely linked to (and indeed, is arguably driving) the growing fragmentation of production processes (Cadestin et al., 2018). While the activities of multinational firms and their subsidiaries within global value chains have been instrumental to the increasing levels of cross-border trade and investment around the world, they also raise new questions with respect to the implications for income. What part of value added does a country lose through the repatriation of income to other countries? How much income does a country gain from value-added production at home and abroad? And more generally, as it relates to trade and investment, what is the impact of foreign demand on a country's GNI?

The focus of recent efforts has been on developing trade in value added indicators. These indicators capture the contributions of foreign final demand to a country's GDP more accurately than gross export statistics. Databases currently used to analyze trade, such as the WIOD, are constructed on a GDP-based framework due to data constraints. However, the value-added indicators do not reveal the impact of foreign final demand in terms of income gains to a country's residents. For example, Mexico's automotive exports to final users in France generate Chinese value added and US income. This distinction between value added and income is relevant in the era of the multinational firm and global value chains, which enable the repatriation of earnings (UNCTAD, 2013). Domestic value-added induced abroad may end up in another country through profit-shifting (e.g., from China to the US), and the income induced by final users (e.g., in France) directly impacts countries' consumption possibilities (GNI) (e.g., of the US). The income measure is thus arguably the more relevant perspective in terms of how much a country relies on (and/or benefits from) foreign demand.

This paper has contributed to the current literature in two ways. First, we constructed a 43 × 43 GDP-GNI matrix with a breakdown of GDP for 42 countries plus ROW into bilateral transfers of income. This decomposition of value added showed how much of GDP goes to the producing country itself and how much goes to each of the other 42 countries in the matrix. Second, we built on these insights by using supplementary trade in value added data to create a GNIX matrix of trade in income. We then used the GNIX matrix to analyze the income implications of final demand in 42 countries plus ROW.

US President Trump views some aspects of globalization skeptically and points to trade balances to suggest that the US 'loses' much more money than it 'gains' in important bilateral relationships. However, a deeper analysis into the income repercussions of final demand, which incorporates not just trade linkages but also investment linkages, cross-border work, and the resulting capital flows, provides much needed context. We show that conventional indicators understate the extent to which the US benefitted from foreign consumption. The US exported US$ 763bn more income than value-added in the year 2014. The analysis showed that all 42 countries plus ROW depended relatively more on foreign final demand to generate their income (i.e., GNI) than value added (i.e., GDP). This indicates that the world is more interdependent in terms of income than value added, which likely reflects financial globalization. However, no country benefited from the new perspective as much as the US. The large US trade deficits in goods and (to a lesser extent) in value-added vanished almost completely in terms of income (-

0.2% as a share of US GDP). Bilateral US deficits with many countries, including China, were lower from the standpoint of income. At the same time, there is some debate about how the SNA and BoP treat incomes related to intangible capital, which our analysis (based on official data) does not address (Bruner et al., 2018). For example, the incomes of U.S. foreign affiliates related to the use of intellectual property are considered returns on US foreign direct investment abroad and reflected as such in the primary income account. However, if these incomes were reattributed to the US operating surplus and considered US services exports, US output (and GDP) would increase, and the US would receive fewer primary incomes from the rest of the world. This would likely imply a reduction in the US exports of income found in our analysis.

Most other industrialized countries, especially Japan, also earned (much) more income from foreigners than value added. They generally had lower income deficits or higher income surpluses as compared to value-added. Much of this extra net income came from emerging and developing countries, which sent more than half of their exported income transfers to the US and EU15. In contrast to the wealthy regions, poorer countries tended to have lower net exports of income relative to their net exports of value-added.

The paper addresses calls by the WTO and OECD to move beyond 'trade in value added', based on the local of production of income (GDP), towards a 'trade in income' approach that is focused on the location of owners of income (GNI) (Ahmad and Ribarsky, 2014). As our study showed, the income 'captured' by a domestic economy through final demand linkages is not the same as its value-added contribution. Apart from the implications for trade, the paper relates to the literature strand on Global Flow of Funds (N. Zhang, 2015; Errico et al., 2013; Shrestha et al., 2012). It is also in line with recent efforts by the IMF to encourage the collection and dissemination of more from-whom-to-whom cross-border data, with the aim of better tracking cross country investment positions by individual counterpart economy and shedding more light on globalization patterns.[119]

More generally, the data provided in the GDP-GNI and GNIX matrices cast new light on the bilateral interdependencies of countries in times of ever-growing financial interconnectedness. It is beneficial for policymakers to know who they are depending on for investments in their country (whether directly or indirectly via intermediary countries), which may help with the formulation of bilateral policy agreements. A better understanding of bilateral capital flows can help with financial stability monitoring (Cowan, 2013; Milesi-Ferretti et al.,

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[119] See Errico et al. (2013) for more information on the efforts of the IMF to break down the aggregate data in the 'rest-of-the-world' account of the national accounts into data by bilateral counterpart country, of which the CDIS and CPIS databases are two of the key initiatives with respect to the international investment position components.

2010). Especially emerging countries depend on capital inflows to finance increased consumption and investment. A better understanding of the interdependencies between countries also can assist researchers to better predict the spillover effects of external shocks on the domestic economy - such as those resulting from an economic crisis abroad.

The quality of the GDP-GNI matrix (which directly impacts the GNIX matrix of trade in income that is derived from it) depends crucially on the data that is available to proxy bilateral transfers of income (e.g., inward FDI positions, portfolio assets, etc.). It is expected that more countries will soon release FDI data by ultimate investing country in line with the recommendations in the 4th edition of the OECD Benchmark Definition of Foreign Direct Investment (BMD4). Given the challenges involving tax havens and SPEs, data based on the ultimate investor would improve the estimates for bilateral transfers of direct investment income. Estimates for the bilateral transfers of portfolio investment income would similarly benefit if data were made available that is based on the ultimate (rather than intermediate) counterpart. Many portfolio investments go through intermediate international financial centers, and this intermediary is often different from the final investment destination. While the databases used in the development of the GDP-GNI matrix represent an important first step, new/different data sources can be incorporated in future work to refine the estimations further and provide an even more precise geographic decomposition. Data limitations also concern the BoP data. Official estimations of pass-through incomes and/or more details about the residual categories ‘other investment income’ and ‘other income’ would improve the respective weighting of these categories and the allocations of income to partner countries.

Data constraints also impacted the scope of the analysis. Although it is theoretically possible to extend the analysis to before the 2013-2014 timeframe, the data are worse and/or incomplete for some countries, especially for the years that entirely predate the CDIS and CPIS databases. GDP-GNI matrix replications for earlier years (and/or efforts to incorporate more countries) would require entirely different databases or methods to proxy the bilateral income outflows. A longer timeframe would nonetheless help to identify trends over a longer period. This might show how much more important pass-through income was in 2013-2014 relative to earlier years, how the role of the US and European countries as beneficiaries of income transfers has evolved, and whether any countries have experienced rapid growth in their exports of income and/or changes to their trade balances of income over time. An even more ambitious extension of the GDP-GNI matrix could involve going beyond the country-level by splitting up the transfers of income to and from different industries within countries.

The GDP-GNI matrix was set up from the debtor perspective. Future research could use similar techniques to construct a matrix from the creditor perspective and estimate more precisely the countries that are responsible for generating a country's GNI (i.e., the imported transfers of income by counterpart country). That would better address the question: how much of GNI can be attributed to transfers of income from different countries? However, due to bilateral data asymmetries in official data, constructing the matrix in this way is much more difficult and is unlikely to result in the same precision as the GDP decomposition in our study.

Finally, we encourage future research to focus more on the mechanisms that underpin income repatriation. Although it is clear that at least some firms and investors repatriate part of the income they earn abroad, what share of all MNEs and investors do repatriate income? Does a small group of influential investors explain most income transfers? And what are the different investor types involved in the repatriation of income? Addressing such questions could help to more accurately distinguish immediate counterpart investors from the ultimate counterparts, as well as to show how susceptible the GDP-GNI relations are to changes to investment behavior and to external economic shocks.

Appendix Chapter 5

Annex I. The primary income account: key definitions

This annex discusses the IMF's Balance of Payments BoP and International Investment Position (IIP) statistics, from which all data on primary incomes was obtained.[120] This dataset provides a year-by-year breakdown of the current account for each country into the trade of goods and services, the primary income account, and the secondary income account (each subdivided into multiple components). That is, the dataset shows for each component all credits received by residents of a country from another country (the "world") and all debits payable by residents of a country to another country, but without a disaggregation by partner country. Table 5.A1 shows these different components and the relationships between them within the context of the current account. Only the primary income account part of the current account, providing the balance of primary incomes, is relevant to the creation of the GDP-GNI matrix. In line with the definitions in the System of National Accounts, this is the only part of the BOP that is relevant with respect to accounting for the difference between GDP and GNI.

Primary income transactions involve the compensation of employees and investment income. Compensation of employees is defined as income for the contribution of labor inputs in the production process (= credits (1) and debits (1) in Table 5.A1). These are the earnings (salaries and benefits) of individuals for work performed in another economy and paid for by residents of the foreign economy. For example, this includes income earned by cross-border workers. Employee compensation is not subject to significant pass-through issues because the country where the individuals reside is typically the main beneficiary. Hence, these workers typically contribute to the labor part of GDP in the country in which they work and to the GNI of their home country. Labor income in equation (5.5) (e.g., $\text{PID}_i^{IMF,L,raw}$) are defined as incomes involving debits (1).

Investment income is the *return* on foreign investments and holdings of financial assets abroad (i.e., not the investments themselves). They include returns on direct investment (credits (2) and debits (2)), portfolio investment (credits (3) and debits (3)), other investment (credits (4) and debits (4)), and reserve assets (credits (5)). Direct investments themselves contribute to the GDP of the country receiving the investment (assuming no pass-through capital). The returns on direct investment, which is the important part reflected in the IMF data, increase the

[120] The data are available for free at: http://data.imf.org/?sk=7A51304B-6426-40C0-83DD-CA473CA1FD52. For more detailed information about the different components, see the Balance of Payments and International Investment Position Manual published by the IMF (IMF, 2009).

GNI of the country where the ultimate beneficiary owner resides. Portfolio investment incomes reflect the return on debt securities, dividends on equity, and interest payments. Capital income in equation (5.6) (e.g., $\text{PID}_i^{IMF,K,raw}$) are defined as incomes involving debits (2+3+4).

For some countries there is also a 'other primary income' component (= debits (6), or $\text{PID}_i^{IMF,OPI,raw}$). Income in this component is proportionally allocated to $\text{PID}_i^{IMF,L,raw}$ and $\text{PID}_i^{IMF,K,raw}$ in the calculations as explained in the methodology section.

According to the accounting identities discussed in Section 5.3.1, $\text{GNI}_i = \text{GDP}_i + \text{PIC}_i - \text{PID}_i$ (the balance of primary incomes) and, in following, $\text{GDP}_i - \text{PID}_i = \text{GNI}_\text{i} - \text{PIC}_i$. The statistical discrepancies with respect to the left-hand-side and right-hand side of these two identities when using IMF data (i.e., PIC_i^{IMF} and PID_i^{IMF}) are very small. In fact, when using GDP and GNI data from the World Development Indicators in combination with the reported BOP data from the IMF, the statistical discrepancies in the second identity were less than one percent for 35 of 42 countries in the GDP-GNI matrix in 2014 (and less than four percent for the remainder).[121]

[121] Though in theory the discrepancy should be zero, the discrepancies could be due to the WDI's GDP and/or GNI data not being perfectly harmonized with GDP/GNI data the IMF uses to match to the BoP (possibly due to different methods of converting GDP into US dollars). The IMF does not publish GNI data.

Table 5.A1. Current account – overview and proxies for bilateral relationships

<table>
<tr><td rowspan="8">Current account</td><td colspan="4">Goods and services</td></tr>
<tr><td rowspan="6">Primary income account</td><td colspan="2">Compensation of employees

(proxy: World Bank remittances database. See note)*</td><td>Credits (1)
Debits (1)</td></tr>
<tr><td rowspan="4">Investment income

*(proxy: IMF CDIS and CPIS databases; FDI statistics by ultimate investor; OECD statistics. See note**)*</td><td>Direct investments</td><td>Credits (2)
Debits (2)</td></tr>
<tr><td>Portfolio investments</td><td>Credits (3)
Debits (3)</td></tr>
<tr><td>Other investments</td><td>Credits (4)
Debits (4)</td></tr>
<tr><td>Reserve assets</td><td>Credits (5)</td></tr>
<tr><td colspan="2">Other primary income

(proportionately allocated to the other two components.)</td><td>Credits (6)
Debits (6)</td></tr>
<tr><td colspan="4">Secondary income account</td></tr>
<tr><td colspan="2">TOTAL (Primary income account)</td><td colspan="3">PIC_i^{IMF} = Credits (1+2+3+4+5+6)
PID_i^{IMF} = Debits (1+2+3+4+6)

Net = $\text{PIC}_i^{IMF} - \text{PID}_i^{IMF}$
$\text{GNI}_i = \text{PIC}_i^{IMF} - \text{PID}_i^{IMF} + \text{GDP}_i$</td></tr>
</table>

*The proxy in the case of compensation of employees are the bilateral shares of all remittances sent by a country, which we use to estimate the allocation of primary labor income debits over the destination countries. See equation (5.15).

**The proxy in the case of investment income are the bilateral shares of different countries in total foreign investment in a country, not the investments themselves, which we use to estimate the allocation of primary investment income debits (i.e., the returns on these investments) over the destination countries. See equations (5.16) and (5.17).

***Note that the secondary income accounts are not relevant for this analysis. They would only be incorporated if constructing a GDNI (gross disposable national income) based matrix. Reserve assets are provided on a gross basis and include all fees and interest payments. The IMF reports reserve assets only as credits or, if not available for publication, includes them under other investments (Credits (4)).

Annex II. The primary income account: IMF data

Table 5.A2 summarizes the IMF's BoP data with respect to shares of primary incomes corresponding to labor income (i.e., compensation of employees), capital income (i.e., direct investment, portfolio investment, and other investment), and other primary income for all 42 countries in 2014.[122] Columns (1) - (5) show the shares before correcting for pass-through income and are based on the raw IMF data. Columns (7) – (9) show the shares after correcting for pass-through income and reflect the scaled-up shares of columns (1) – (3) for compensation of employees, direct investment income, and portfolio investment income. This means that the last columns also incorporate the residual components 'other investment income' (from column 4) and 'other primary income' (from column 5), as described in Section 5.3 (methodology). All numbers are in percent.

The weighted average of each category in Table 5.A2 (W-AVG) is obtained by summing up the income debits corresponding to this category for all 42 countries and dividing by the total income debits of the 42 countries, e.g., for column (1): $\mathrm{W-AVG} = 100(\sum_i \mathrm{PID}_i^{\mathrm{L}} / \sum_i \mathrm{PID}_i)$. The simple average of each category (S-AVG) is obtained by summing up the percent shares of all 42 countries in the corresponding column and dividing by 42.

This depiction of primary income shares indicates which components are particularly important and deserve the most attention when estimating the bilateral part. It also shows whether the lack of a proxy for the bilateral part of the residual categories in columns (4) and (5) may pose an issue. Observe that income debits attributed to the compensation of employees accounted for 4.1% of all income debits for the average country (column 1). The largest category was direct investment income debits, accounting for 45.3% of all income debits (column 2). Portfolio investment income debits accounted for 40.7% (column 3); other investment income debits for 9.0% (column 4); and other primary income debits for 0.9% (column 5) of all income debits in the average country. The residual categories in columns (4) and (5) constituted only small shares of all income debits. The lack of suitable proxies for these categories is thus seen as less of a concern.

[122] The actual debits corresponding to the shares in Table 5.A2 can be determined as follows: the column of interest with shares in Table 5.A2 is multiplied by the column of total debits in Table 5.3 (Section 5.5.1). Columns (1)-(5) in Table 5.A2 would be multiplied by column (1) in Table 5.3. Columns (7)-(9) would be multiplied by column (2) in Table 5.3.

Table 5.A2. Primary income account– component debits as percent share of all income debits (2014)

	$\frac{\text{PID}_i^{L}}{\text{PID}_i}$ (1)*	$\frac{\text{PID}_i^{DI}}{\text{PID}_i}$ (2)*	$\frac{\text{PID}_i^{POI}}{\text{PID}_i}$ (3)*	$\frac{\text{PID}_i^{OI}}{\text{PID}_i}$ (4)*	$\frac{\text{PID}_i^{OPI}}{\text{PID}_i}$ (5)*	Sum (1-5) (6)	$\frac{\text{PID}_i^{IMF,L}}{\text{PID}_i^{IMF} - \text{PT}_i}$ (7)	$\frac{\text{PID}_i^{DI,adapt}}{\text{PID}_i^{IMF} - \text{PT}_i}$ (8)	$\frac{\text{PID}_i^{POI,adapt}}{\text{PID}_i^{IMF} - \text{PT}_i}$ (9)	Sum (7-9) (10)
AUS	7.2	38.0	48.1	6.6	0.1	100	7.7	40.8	51.6	100
AUT	13.2	21.9	48.5	14.6	1.8	100	15.1	26.4	58.5	100
BEL	5.9	59.9	26.7	5.0	2.6	100	7.4	64.0	28.6	100
BGR	6.9	63.5	3.3	25.4	1.0	100	7.1	88.4	4.5	100
BRA	0.3	48.8	37.7	13.2	0.0	100	0.3	56.3	43.4	100
CAN	3.3	47.7	42.0	7.0	0.0	100	3.7	51.2	45.1	100
CHE	17.2	53.3	21.8	7.7	0.0	100	26.0	52.5	21.5	100
CHN	0.2	81.2	4.3	14.3	0.0	100	0.2	94.7	5.1	100
CYP	1.4	50.7	7.0	40.5	0.5	100	2.1	86.1	11.8	100
CZE	4.1	81.7	8.5	4.3	1.3	100	4.4	86.6	9.1	100
DEU	8.7	30.2	44.9	12.9	3.3	100	10.2	36.1	53.7	100
DNK	15.4	32.5	44.5	4.9	2.6	100	18.5	34.4	47.1	100
ESP	0.5	37.3	47.3	12.2	2.7	100	0.6	43.8	55.6	100
EST	3.2	86.4	4.8	3.9	1.8	100	3.6	91.4	5.0	100
FIN	3.8	33.3	54.0	6.0	2.9	100	4.5	36.5	59.0	100
FRA	1.0	19.9	67.3	10.0	1.8	100	1.2	22.6	76.3	100
GBR	0.8	29.2	51.4	16.9	1.6	100	1.0	35.8	63.2	100
GRC	6.9	5.4	30.3	52.3	5.1	100	8.0	14.0	78.0	100
HRV	1.5	38.2	32.8	27.5	0.0	100	1.5	53.0	45.5	100
HUN	3.6	73.3	16.3	5.9	0.9	100	4.1	78.4	17.5	100
IDN	4.4	61.1	25.5	9.0	0.0	100	4.4	67.4	28.1	100
IND	7.7	37.3	19.3	34.6	1.1	100	7.8	60.8	31.4	100
IRL	0.8	45.9	42.8	10.2	0.3	100	1.2	51.1	47.6	100
ITA	3.0	20.2	66.9	6.5	3.3	100	3.3	22.4	74.2	100
JPN	0.3	36.0	53.3	8.9	1.5	100	0.3	40.1	59.5	100
KOR	5.4	52.6	37.3	4.7	0.0	100	5.6	55.3	39.2	100
LTU	9.4	34.3	39.3	10.3	6.7	100	10.3	41.8	47.9	100
LUX	4.8	46.0	46.2	3.0	0.0	100	32.4	33.7	33.9	100
LVA	4.0	63.8	14.5	14.9	2.8	100	4.2	78.1	17.7	100
MEX	0.0	51.3	42.5	6.2	0.0	100	0.0	54.7	45.3	100
MLT	0.6	85.5	0.3	12.8	0.8	100	1.9	97.9	0.3	100
NLD	2.2	71.7	21.1	4.1	0.9	100	4.1	74.1	21.8	100
NOR	18.9	32.2	13.1	35.7	0.0	100	21.7	55.6	22.7	100
POL	5.8	65.4	19.5	7.6	1.7	100	6.1	72.3	21.6	100
PRT	2.3	28.7	41.2	25.8	2.0	100	2.5	40.0	57.5	100
ROU	1.4	42.0	21.2	33.0	2.4	100	1.4	65.5	33.1	100
RUS	12.3	59.6	11.8	16.2	0.1	100	12.9	72.7	14.4	100
SVK	3.2	69.1	20.0	4.8	2.8	100	3.5	74.8	21.7	100
SVN	7.5	-1.3	58.5	12.7	22.6	100	10.1	-2.1	92.0	100
SWE	2.2	49.1	44.0	3.0	1.7	100	2.6	51.4	46.0	100
TUR	6.2	17.9	32.9	42.9	0.0	100	6.3	33.0	60.7	100
USA	2.8	32.6	62.3	2.3	0.0	100	3.1	33.3	63.5	100
W-AVG	4.1	45.3	40.7	9.0	0.9	100	5.3	49.2	45.5	100
S-AVG	5.0	46.0	32.7	14.3	1.9	100	6.5	54.0	39.5	100

*The numerators in columns (1)-(5) reflect the raw IMF data (e.g., $\text{PID}_i^{L} = \text{PID}_i^{IMF,L,raw}$ and $\text{PID}_i^{DI} = \text{PID}_i^{IMF,DI}$). Columns show shares of income debits from row-countries reflecting: employee compensation (1); direct investments (2); portfolio investments (3); other investments (4); and other primary income (5). Scaled shares (7), (8), and (9) incorporate residual categories (4) and (5) and have been adjusted for pass-through income.

On the creditor's side - not shown in Table 5.A2 – the income shares for the average country were 4.0% for employee compensation; 50.9% for direct investment income; 32.7% for portfolio investment income; and 12.3% of the remainder.[123] Note that the shares on the debtor and creditor sides do not coincide precisely because only income credits and debits for countries in the matrix (not all countries in the world) are reflected in the data in Table 5.A2. Nevertheless, direct and portfolio investment incomes were by far the largest categories from both perspectives and accounted for more than 85% of the discrepancy between GDP and GNI.

Annex III. Allocating labor compensation incomes to partner countries

This annex discusses the World Bank Bilateral Remittance Matrix (WBRM).[124] We allocate transfers of income relating to employee compensation to the GNIs of counterpart countries based on bilateral shares of remittance payments in the WBRM (see equation (5.15) for details).

The WBRM was created to obtain a global picture of the size of remittances flowing from one country to another. Matrices in the WBRM have been constructed annually for the years 2010-2017. These provide the total amount of remittances of each country ($= \sum_{j \neq i} \mathrm{CE}_{ij}$ in equation (5.15)) and the bilateral remittances between country-pairs ($= \mathrm{CE}_{ij}$ in equation (5.15)). The World Bank uses two datasets to derive the data in the matrix (see Ratha and Shaw 2007, upon which the WB methodology is inspired). The first is UN Population Division estimates of migrant stock by country of origin and destination. The second dataset is remittance inflows data. A country's total remittance inflows in a given year were allocated to its emigrant stocks, adjusting for the migrant sending and receiving countries' per capita income. The remittance inflows data that can properly be interpreted as transfers of funds from migrants were constructed as the sum of three components in the IMF's Balance of Payments Statistics: (i) compensation of employees, (ii) workers' remittances, and (iii) migrants' transfers.

The definition of remittances used to construct the WBRM (= i + ii + iii) is thus broader than compensation of employees (= i only). However, compensation of employees (= i) is the only component of the three relevant in terms of analyzing the difference between GDP and GNI. Hence ideally this should be the only part of the data embedded in the WBRM to be considered when allocating labor incomes to partner countries (i.e., $\mathrm{GDP}^{L}_{i,j}$). Workers' remittances (ii), which refer to current transfers between residents of different countries by

[123] A full breakdown of the creditor side is available upon request.
[124] The data is available for free at:
http://www.worldbank.org/en/topic/migrationremittancesdiasporaissues/brief/migration-remittances-data
For more information, see the *Frequently Asked Questions* document accompanying the database.

migrants who are employed in new economies and considered residents there (nonresidents of the home economy), are technically part of the current transfers in the secondary income account. This goes towards computing gross disposable national income but not gross national income. And migrants' transfers (iii), which relate to capital account changes caused by a change in residence of a household, belong to capital transfers in the capital account.

A disaggregation of the matrix output data into (i), (ii) and (iii) is unfortunately not currently available, but the WBRM should still serve as an adequate representation for the 'compensation of employees' component that is relevant. This assumes the relative importance of these three flows (i), (ii), and (iii) are the same across different country-pairs. For instance, if country i sends 20% of its total remittances to country j (based on the WBRM), we assume that this approximates the share of i's total labor compensation payments going to j. This may not necessarily be the case if workers' remittances and migrants' transfers over-proportionally represent the remittances flows from i to j for this country-pair and the share of all employee compensation payments from i to j is less than 20%.

Data from the WBRM on remittances payments is available for all 42 countries contained in the matrix in 2013 and 2014.

Annex IV. Allocating direct investment incomes to partner countries

We allocate transfers of direct investment income to the investing countries based on bilateral shares that are obtained from data on direct investment positions (see equation (5.16) for details). This annex first discusses data issues related to conventional measures of direct investment positions and why they are problematic for the construction of the matrix relating GDP to GNI. Then we explain how our selection of novel and newly released data on direct investment positions based on the ultimate beneficiary investor mitigates or even resolves this issue for most countries. Lastly, we introduce the Coordinated Direct Investment Survey (CDIS) database, which we use as an alternative when the preferred type of data is unavailable.

Data issues

Bilateral breakdowns of inward direct investment (or FDI) are available for nearly all countries from OECD, UNCTAD, Eurostat, and IMF databases.[125] This data is conventionally based on the immediate (or direct) counterpart country, which sheds light on the immediate source of direct investment funding.[126] However, due to the complex behaviors and financing structures of MNEs in a globalized world, it is no longer the case that the immediate investors are also the ultimate investors. This development has been driven by "the need of MNEs to manage global production networks", and their "desire to reduce tax and regulatory burdens" (OECD, 2015). In many cases the immediate counterpart and ultimate investing country (where the beneficiaries of the returns on direct investment reside) is the same. However, the distinction can matter greatly in certain investment relations, especially when the immediate counterpart is a tax haven.

There are two well-known issues related to conventional bilateral FDI statistics (reported on an immediate or direct counterpart basis) (see Damgaard and Elkjaer, 2017 for a thorough discussion of these issues): 1) the role of special purpose entities (SPEs) and of tax havens more generally, and 2) "round-tripping", to be described below. Both SPEs and round-tripping are related to the pass-through income issues discussed in Section 5.3 (methodology). They may indeed go a long way towards explaining the very existence of pass-through capital.

Special purpose entities are firms (or "entities") that typically have few or no employees and little or no physical presence in the country in which they operate. Colloquially called "mailbox" companies, their existence is typically attributed to jurisdictions that provide low or concessional tax rates to foreign investors. MNEs may channel their investments through SPEs before reaching their intended destination. Luxembourg and the Netherlands are two examples of countries that host large numbers of SPEs, but there are many more. Suppose that FDI is reported by the intermediary country, e.g., Luxembourg, as inward investment from the US. Because the investment only "passes through" to, say Germany, then Luxembourg may appear to receive substantial foreign investments when in fact it only plays the role of a conduit to

[125] For example, bilateral FDI statistics from UNCTAD are available for free at: https://unctad.org/en/Pages/DIAE/FDI%20Statistics/FDI-Statistics-Bilateral.aspx

[126] The IMF defines and operationalizes direct investment as follows: "Direct investment arises when a unit resident in one economy, which is called direct investor, makes an investment that gives control or a significant degree of influence on the management of an enterprise that is resident in another economy which is called direct investment enterprise. There is a significant degree of influence when a direct investor owns equity that entitles it to 10 percent or more of the voting power in the direct investment enterprise". This definition is from the *Frequently Asked Questions* document accompanying the IMF's Coordinated Direct Investment Survey database, available at: http://data.imf.org/?sk=40313609-F037-48C1-84B1-E1F1CE54D6D5&sId=1390288795525

pass-through capital. This pass-through capital could distort the perceived role of FDI on Luxembourg's economy and more generally reduce the analytical interpretability of bilateral FDI data.

The potential for misinterpretation of FDI statistics extends to the country of the intended recipient (Germany), which registers the direct investment as originating from the direct counterpart (Luxembourg) and not the ultimate investor (US). Thereby the perceived role of the intermediary on the German economy is overstated while the perceived role of the ultimate investor is understated. Although the stock of genuine FDI is not inflated in the intended destination (unlike the case of an intermediary country with SPEs), some FDI stocks may be misattributed. Despite having long been identified as a problem by disseminators of FDI statistics, this is an issue that persists in nearly all databases providing bilateral FDI positions. These issues make it difficult for policymakers to discern who is genuinely investing in their country and, crucially for our analysis, where the returns on investment (the primary income) may end up.

The second issue is round-tripping. Round-tripping refers to foreign investments that represent funds that have been channeled abroad by resident investors, such as through SPEs, and returned to the domestic economy in the form of FDI (Aykut et al., 2017). In this circular form of investing, the intended recipient of FDI may be the same country from where the investment originates. Many factors can cause round-tripping, but the most common are tax, regulatory or other incentives provided by a foreign country that encourage an investor to re-locate their company abroad. If the investor still resides and invests from the home country, then this investment may show up as FDI in conventional statistics when in fact it should be regarded as a round-tripping investment (but is not identified as such). Investors may also pursue round-tripping as a reaction to capital market restrictions and inefficiencies at home to gain flexibility, or to conceal their identity.

Round-tripping means that the overall stock of genuine FDI would be overstated for all receiving countries. Round-trip investments should not be considered genuine FDI because receiving countries do not reap any of the additional benefits of FDI (e.g., in terms of finance, knowledge, technology transfers, and access to foreign distribution networks). Round-tripping also contributes to the general multiple counting of cross-border capital flows.

The problem of round-tripping for the creation of the GDP-GNI matrix is essentially the same as the issue of direct investment stocks in countries with SPEs: these investments do not necessarily have an impact on the real economy (GDP and GNI) of the intermediary. Fortunately, pass-through incomes are not a large issue in most countries of the matrix (see

Section 5.5.1, Table 5.3). But the allocations of (pass-through adjusted) transfers of income to partner countries should only consider where the returns of investments ultimately end up. That is, transfers of income should not be attributed as going to an intermediary country if they do not become part of this country's national income (GNI). This distinction is highly relevant for the calculations underlying equation (5.16).

FDI data by ultimate investing country and excluding special purpose entities

Considering the issues involving SPEs and round-tripping, it is best to use bilateral FDI data that excludes SPEs or, even better, identifies the ultimate investing country. Data on inward FDI that distinguishes between SPEs and non-SPEs and/or that is based on the ultimate investing country was almost non-existent before the year 2013. The OECD developed the fourth edition of its Benchmark Definition of Foreign Direct Investment (BMD4) in part to provide more meaningful FDI measures and illuminate more light on the prevalence of pass-through capital and round-tripping. The BMD4 encourages the collection of this type of data and recommends that countries compile statistics on inward FDI by the ultimate investing country. The OECD noted that only a handful of countries provided these statistics by March 2015: Austria, Estonia, Finland, France, Poland, and the United States (OECD, 2015). Since then, more countries released similar statistics and additional ultimate investing country-based data was obtained for Canada, Czech Republic, Germany, Hungary, Iceland, Italy, Lithuania, Switzerland, and Turkey.

Given that all OECD countries are being encouraged to produce these new statistics, we searched for data from central banks and national statistical offices, including annual investment reports, of all 42 countries in the GDP-GNI matrix to ascertain whether more data by ultimate investing country had been compiled but not (yet) been provided to the OECD. In this way, additional estimations were obtained for Australia, Brazil, Spain, Great Britain, India, Ireland, Japan, and Slovenia. In all, FDI data by ultimate investing country was available for more than half (22/42) of all countries in the matrix. This is the data that was used to determine bilateral stocks of direct investment, DI_{ji}, and total investment positions, $\sum_{j \neq i} \mathrm{DI}_{ji}$, for those 22 countries in equation (5.16).

All countries with FDI data by ultimate investing country are listed in Table 5.A3 along with the source of the data and the years it is available. Table 5.A4 reports the extent of round-tripping in the same 22 countries as a share of total inward investment in 2014 (if available). It should be noticed from Table 5.A4 that round-tripping shares were relatively small in most countries. Round-tripping was less than 10% in all but 2 of the 18 countries that reported data and less than 5% in 10 of these 18 countries. Yet this still suggests that, in many of the countries reporting round-tripping, one of the largest 'foreign' investors in a country is - indirectly - the same country receiving those investments.

The total investment positions are in principle unaffected when using data by ultimate investing country because the new perspective only (potentially) redistributes inward direct investments based on the direct counterpart to the ultimate investing country. However, FDI that could be attributed to round-tripping based on the ultimate investing country perspective was first taken out of the raw data (in all 18 countries included in Table 5.A4). More specifically, in countries with information on round-tripping, suppose $\sum_j \mathrm{DI}_{ji}$ denotes the reported or 'gross' stock of inward direct investments and DI_{ii} denotes the round-tripping components of these investments (which are the direct investments in *i* that are attributed to *i*). Then $\sum_{j \neq i} \mathrm{DI}_{ji} = \sum_j \mathrm{DI}_{ji} - \mathrm{DI}_{ii}$ (Hence this small modification to the raw data results in the true value of $\sum_{j \neq i} \mathrm{DI}_{ji}$ in these countries).

This correction is necessary because FDI related to round-tripping does not contribute much (if at all) to another country's GNI and should not be used to allocate transfers of income to partner countries (which necessarily increase the GNI of another country). Another consequence of removing round-tripping is that the relative importance of all other countries investing in country i increases slightly (that is, share $\mathrm{DI}_{ji}/\sum_{j \neq i} \mathrm{DI}_{ji}$ in the case of country j is larger than $\mathrm{DI}_{ji}/\sum_j \mathrm{DI}_{ji}$).

In addition, several countries reported FDI statistics that excluded SPEs. All countries in the matrix for which inward FDI positions excluding SPEs differed from inward FDI positions including SPEs are listed in Table 5.A5 (all data from the OECD). The table provides the inward direct investments in these countries that did not involve SPEs as a share of total FDI (hence, the residual share is likely to reflect pass-through investment). There is also information provided on whether a bilateral disaggregation of FDI data excluding SPEs was available and, if so, for which years. One can see that the influence of SPEs varied widely but was generally small in most countries. SPEs were most influential in the so-called tax havens. Notably, Luxembourg and the Netherlands, which we found to be the countries that had the most pass-through income as a share of the total income debits reported by the IMF (see Section 5.5.1, Table 5.3), recorded 93% (Luxembourg) and 82% (Netherlands) of FDI stocks in their respective countries as going to SPEs. It should be noticed that the countries providing FDI data excluding SPEs were generally the ones most affected by SPEs. OECD statistics indicate that the inward FDI positions of 15 more countries in the matrix did not differ depending on the inclusion of SPEs. Hence it can be assumed that SPEs play a minor to no role in most of the countries in the GDP-GNI matrix that are not included in Table 5.A5.[127]

Six countries in Table 5.A5 (Estonia, Great Britain, Hungary, Poland, Spain, and Switzerland) also provided the preferred data by ultimate investing country. For this reason, the data excluding SPEs was not needed to proxy the shares of their transfers of direct investment income going to partner countries. Two other countries in the table (Luxembourg and Sweden) did not provide a bilateral breakdown of inward FDI excluding SPEs. Hence this data could not be used. However, six of the countries in the table did provide a bilateral breakdown of inward FDI excluding SPEs but did not provide FDI data by ultimate investing country (Belgium, Denmark, South Korea, Netherlands, Norway, and Portugal). The bilateral inward FDI data excluding SPEs was thus used for allocating the transfers of direct investment income from these six countries to partner countries.

In summary, three types of data are used to proxy the shares of transfers of direct investment income going from one country to another: 1) the first preference is bilateral inward FDI data by the ultimate investing country (i.e., for the 22 countries in Table 5.A3); 2) if bilateral FDI data excluding SPEs existed for a country, but there was no additional data identifying the ultimate investor, then this is used as a second-best solution (for 6 additional countries); 3) in the absence of both FDI data identifying the ultimate beneficiary and FDI data differentiating between SPEs and non-SPEs, the IMF's Coordinated Direct Investment Survey (CDIS) was drawn upon (for the remaining 14 countries). The next section discusses the CDIS database. A complete overview of the sources used for all 42 countries is shown in Table 5.A6.

[127] According to data reported by the OECD, countries where SPEs play little to no role include Austria, Czech Republic, Germany, Finland, France, Greece, Italy, Japan, Lithuania, Latvia, Mexico, Slovakia, Slovenia, Turkey, and the US (OECD International Direct Investment Statistics database).

Table 5.A3. Countries that publish bilateral FDI statistics by ultimate investing country

Country	Source	Years available
Australia	Australian Bureau of Statistics, Economic Activity of Foreign Owned Businesses in Australia, 2014-15.	2014 only
Austria	OECD International Direct Investment Statistics database	2012-2016
Brazil	Central Bank of Brazil, Census of Foreign Capitals	2010-2016
Canada	OECD International Direct Investment Statistics database	2014-2016
Czech Republic	OECD International Direct Investment Statistics database	2013-2016
Estonia	OECD International Direct Investment Statistics database	2013-2016
Finland	OECD International Direct Investment Statistics database	2013-2016
France	OECD International Direct Investment Statistics database	2011-2016
Germany	OECD International Direct Investment Statistics database	2013-2016
Great Britain	Office for National Statistics, Dataset on inward foreign direct investment involving UK companies: inward	2014-2016
Hungary	OECD International Direct Investment Statistics database	2014-2016
India	Independent study by Rao and Dhar (2016)	2014 only
Ireland	Central Statistics Office of Ireland (CSO), Foreign Direct Investment in Ireland 2015	2015 only
Italy	OECD International Direct Investment Statistics database	2013-2016
Japan	Bank of Japan, Ministry of Finance	2015 only
Lithuania	OECD International Direct Investment Statistics database	2015-2016
Poland	OECD International Direct Investment Statistics database	2013-2016
Slovenia	Central Bank of Slovenia (2017)	2014-2016
Spain	Spain’s Ministry of Industry, Trade, and Tourism, DataInvex-MINCOTUR database	2010-2016
Switzerland	OECD International Direct Investment Statistics database	2014-2016
Turkey	OECD International Direct Investment Statistics database	2016 only
USA	OECD International Direct Investment Statistics database	2011-2016

Table 5.A4. Round-tripping as percent share of total FDI positions in selected countries, 2014

Country	Share	Country	Share
Ireland	13.15*	Poland	4.17
Lithuania	10.36*	Great Britain	3.62
Finland	9.29	Brazil	3.43
Germany	8.00	USA	2.98
Estonia	6.84	Austria	1.71
Italy	6.67	Slovenia	1.62*
Czech Republic	6.15	Hungary	0.60
France	5.03	Canada	0.82
Spain	4.46	Turkey	0.06*

Notes: Data are based on the sources in Table 5.A3. *The data for Ireland, Lithuania, and Slovenia is from 2015 and data for Turkey is from 2016. **The ultimate investing country data provided by Switzerland is very aggregated and does not provide estimates of round-tripping. Data sources used for Australia, India, and Japan also do not report round-tripping.

Table 5.A5. Ratio of FDI positions excluding SPEs to total FDI positions, 2014

Country	Ratio	Bilateral FDI data excluding SPEs?
Belgium	0.89	Yes, 2013-2016
Denmark	0.77	Yes, 2013-2016
Estonia	0.97	Yes, 2015-2016
Great Britain	0.72	Yes, 2013-2016
Hungary	0.45	Yes, 2011-2016
Luxembourg	0.07	No
Netherlands	0.18	Yes, 2013-2016
Norway	0.99	Yes, 2013-2016
Poland	0.99	Yes, 2013-2016
Portugal	0.86	Yes, 2011-2016
South Korea	0.99	Yes, 2013-2016
Spain	0.98	Yes, 2013-2016
Sweden	0.92	No
Switzerland	0.87	No

Notes: A ratio of 0 means that all reported inward FDI is SPE-related; a ratio of 1 means that none of the reported inward FDI is SPE-related. The source for all countries is the OECD International Direct Investment Statistics database.

FDI data by direct counterpart country (CDIS)

The Coordinated Direct Investment Survey (CDIS) provides inward and outward investment positions by bilateral counterpart country.[128] The data is constructed on the basis of the immediate investor (i.e., direct investment into the reporting economy) and immediate investment (i.e., direct investment abroad by the reporting economy).[129] The IMF considers the database an important tool in capturing world totals and the geographic distribution for direct investment positions in a coordinated matter. This builds on the successes of initiatives such as the UNCTAD, OECD and Eurostat bilateral FDI databases. The IMF conducts the CDIS annually (starting in 2009) across a wide range of countries, uses consistent definitions, and encourages best practices in compiling and disseminating quality, harmonized data on direct investment positions. One advantage of using CDIS data is that the concepts and principles in the sixth edition of the IMF's Balance of Payments and International Investment Position Manual (BPM6) and the fourth edition of the OECD Benchmark Definition of Foreign Direct Investment (BMD4) are used as the basis of compiling data reported in the CDIS. It is therefore better harmonized to the BoP data that we use to create the matrix that relates countries' GDP

[128] The data is available for free at: http://data.imf.org/cdis

[129] For more information on the construction of this database, see the IMF's comprehensive "Coordinated Direct Investment Survey Guide" (IMF, 2015) and accompanying *Frequently Asked Questions* document. These are accessible at: http://data.imf.org/?sk=40313609-F037-48C1-84B1-E1F1CE54D6D5&sId=1390288795525

to their GNI. Investment positions in the CDIS are also broken down into equity and debt instruments. For our purposes the type of instrument is not consequential and only the aggregated data is used.

CDIS data is used to proxy the shares of transfers of direct investment income going to partner countries for the 14 countries identified in Table 5.A6 (which provide neither bilateral FDI positions by ultimate investing country nor bilateral FDI positions that exclude SPEs). Data is available for all 14 countries in 2013 and 2014.

Table 5.A6. Summary: data sources used to proxy bilateral shares of transfers of direct investment income (2014)

Country	Data source	Country	Data source
Australia	UIC**	Italy	UIC
Austria	UIC	Japan	UIC*
Belgium	non-SPE	Latvia	CDIS
Brazil	UIC	Lithuania	UIC*
Bulgaria	CDIS	Luxembourg	CDIS
Canada	UIC	Malta	CDIS
China	CDIS	Mexico	CDIS
Croatia	CDIS	Netherlands	non-SPE
Cyprus	CDIS	Norway	non-SPE
Czech Republic	UIC	Poland	UIC
Denmark	non-SPE	Portugal	non-SPE
Estonia	UIC	Romania	CDIS
Finland	UIC	Russia	CDIS
France	UIC	Slovakia	CDIS
Germany	UIC	Slovenia	UIC*
Great Britain	UIC	South Korea	non-SPE
Greece	CDIS	Spain	UIC
Hungary	UIC	Sweden	CDIS
India	UIC	Switzerland	UIC
Indonesia	CDIS	Turkey	UIC*
Ireland	UIC*	USA	UIC

Notes: UIC refers to direct investments by ultimate investing country (using the underlying sources in Table 5.A4). Non-SPE refers to FDI data that excludes FDI related to SPE activities (using OECD Statistics). CDIS refers to the IMF's Coordinated Direct Investment Survey.
*In Ireland, Japan, Lithuania and Slovenia, UIC data is only available for 2015; in Turkey only for 2016. The bilateral FDI shares are assumed to be the same for these five countries in 2014. **In Australia, UIC data is based on the Australian Taxation Office Businesses Income Tax dataset (ATO BIT). This provides information on the country of ownership on the Ultimate Holding Company (where the ultimate investor of foreign-owned assets is located).

Annex V. Allocating portfolio investment incomes to partner countries

This annex discusses the Coordinated Portfolio Investment Survey (CPIS).[130] We allocate transfers of portfolio income to the investing countries by using information from the CPIS on foreign portfolio holdings (see equation (5.17) for details).

The CPIS is a sister database of the CDIS and is also published by the IMF. It is currently the only global survey available on portfolio investment holdings. The CPIS provides data collected from reporting economies on the holdings of asset stock positions by bilateral counterpart country, as well as derived (mirror) liabilities for all economies.[131] The data is available from 2001 onwards. The type of equity or security is, as is the case with the CDIS, not consequential for the creation of the GDP-GNI matrix. Only the aggregated data is used. The data reported in the CPIS is augmented with data from two companion surveys: Securities Held as Foreign Exchange Reserves (SEFER), and Securities Held by International Organizations (SSIO). SEFER and SSIO provides geographic and instrument detail on securities that are held as reserve assets and held by international organizations, respectively. Data from the CPIS and SSIO surveys provide comprehensive information on holdings of portfolio investment securities. The IMF used data from those two surveys together with data from the SEFER survey to capture better geographic detail and derive estimates of portfolio investment liabilities for every economy. It should be noted that the SEFER data is reported by individual economies but delivered only confidentially to the IMF; these data are released only in aggregate form.

The IMF derives liabilities for all economies - not just those participating in the CDIS survey. Hence the country coverage is particularly wide in scope and bilateral data by economy of liability (which uniquely incorporates data from the SEFER and SSIO) are available for all 42 countries contained in the matrix in 2013 and 2014. Therefore, foreign portfolio holdings by counterpart country (POI_{ji}) and total foreign portfolio holdings ($\sum_{j\neq i} \mathrm{POI}_{ji}$) in equation (5.17) are based on the derived (mirror) liabilities statistics contained in the CPIS.

[130] The data is available for free at: http://data.imf.org/cpis

[131] For more information on the construction of this database, see the IMF's comprehensive "Coordinated Portfolio Investment Survey Guide" (IMF, 2017) and accompanying *Frequently Asked Questions* document. These are accessible here: http://data.imf.org/?sk=B981B4E3-4E58-467E-9B90-9DE0C3367363&ss=1481574691948

Annex VI. Greater China data issues

The GDP-GNI matrix includes Greater China as one country. Greater China represents mainland China (CN-ML), Hong Kong (CN-HK), and Macao (CN-MO). However, GDP and GNI data and data from the IMF, WBRM, CDIS, and CPIS databases used to create the matrix are only provided in disaggregated form for CN-ML, CN-HG, and CN-MO.

GDP and GNI data are summed up for the three entities. Although there may be internal factor payments between CN-ML, CN-HK, and CN-MO, they cancel out when aggregated. Hence Greater China's GDP and GNI are exact functions of the published data and not estimated.

A simple aggregation is more problematic in the case of primary incomes reported by the IMF. Although net income is unaffected through aggregation ("internal" credits and debits offset each other), this approach could lead to an underestimation of the share of Greater China's GDP that is part of the national income of either CN-ML, CN-HK, or CN-MO and an overestimation of Greater China's transfers of income. To see how, suppose for illustrative purposes that there is no pass-through capital income between greater China, which has a GDP of $100 in this example, and the world. If CN-ML has $5, CN-HK $4, and CN-MO $1 in income debits, then following equation (5.1) the diagonal element is $\text{GDP}_{CHN,CHN} = \text{GDP}_{CHN} - \text{PID}_{CHN} = \$100 - \$5 - \$4 - \$1 = \$90$. However, suppose that reflected in the same income debits are $3 from CN-ML that end up in CN-HK and $2 from CN-HK that end up in CN-ML. As internal incomes are still part of greater China's GNI, they should not be included as part of its transfers of income (PID_{CHN}). Therefore, the correct calculation of the diagonal is $\text{GDP}_{CHN,CHN} = \$100 - \$2 - \$2 - \$1 = \$95$.

The approach for Greater China requires an adjustment. We estimate the share of income internal to greater China based on information from the WBRM, CDIS, and CPIS databases. Suppose that all debits in the example above are direct investment incomes and the CDIS shows that total FDI in greater China is $10, the bilateral investments of CN-HK in CN-ML are $3, and the bilateral investments of CN-ML in CN-HK are $2. Then the share of internal direct investments is 0.5 [($3+$2)/10]. To estimate internal income, we multiply 0.5 with the combined debits reported by the IMF, which in the example is $0.5 * (\$5 + \$4 + \$1) = \$5$. Finally, we subtract $5 from the reported debits of the three entities, $\$10 - \$5 = \$5$, to estimate direct investment income debits that are *not* internal. Using $5 as the new estimate for PID_{CHN}, we proceed with the standard approach to obtain the diagonal. This is $\text{GDP}_{CHN,CHN} = \$100 - \$5 = \$95$ (which is the same result as above).

The approach of using the WBRM, CDIS, and CPIS databases to determine true shares of off-diagonal elements $\mathrm{CE}_{CHN,j}/\sum_{j\neq CHN}\mathrm{CE}_{CHN,j}$ (equation 5.15), $\mathrm{DI}_{j,CHN}/\sum_{j\neq CHN}\mathrm{DI}_{j,CHN}$ (equation 5.16), and $\mathrm{POI}_{j,CHN}/\sum_{j\neq CHN}\mathrm{POI}_{j,CHN}$ (equation 5.17) (i.e., to ensure that $j\neq CHN$) is also adjusted slightly. Greater China is again treated as a region consisting of CN-ML, CN-HK, and CN-MO. For example, from equation (5.16) we have $\mathrm{GDP}_{i,j}^{K,DI} = (\mathrm{DI}_{ji}/\sum_{j\neq i}\mathrm{DI}_{ji})\mathrm{PID}_{i}^{DI,adapt}$ where j is one of the countries in the matrix and *i* is Greater China. Then the numerator refers to j's direct investments in greater China. This is the sum of all direct investments by j in CN-ML, CN-HK, and CN-MO. The total stock of direct investments in Greater China, $\sum_{j\neq CHN}\mathrm{DI}_{j,CHN}$, is equal to the sum of direct investments by all countries in CN-ML, CN-HK, and CN-MO *minus* the internal investments between CN-ML, CN-HK, and CN-MO ($\sum_{j\neq CHN}\mathrm{DI}_{j,CHN} = \sum_{j}\mathrm{DI}_{j,CHN} - \mathrm{DI}_{CHN,CHN}$). Therefore, when internal investments are nonzero, the share $\mathrm{DI}_{j,CHN}/\sum_{j\neq CHN}\mathrm{DI}_{j,CHN}$ is larger after removing these investments from the data than before the adjustments (which is similar to the outcome of removing round-tripping investments for other countries, see Annex IV.) Hence, adjustments are made to ensure that the right-hand side of $\mathrm{GDP}_{CHN,j}^{K,DI} = (\mathrm{DI}_{j,CHN}/\sum_{j\neq CHN}\mathrm{DI}_{j,CHN})\mathrm{PID}_{CHN}^{DI,adapt}$ (equation (5.16)) is correct and gives the true $\mathrm{GDP}_{CHN,j}^{K,DI}$.

Annex VII. Names and abbreviations of all countries included in the matrix

AUS = Australia
AUT = Austria
BEL = Belgium
BGR = Bulgaria
BRA = Brazil
CAN = Canada
CHE = Switzerland
CHN = China
CYP = Cyprus
CZE = Czech Republic
DEU = Germany
DNK = Denmark
ESP = Spain
EST = Estonia
FIN = Finland
FRA = France
GBR = Great Britain
GRC = Greece
HRV = Croatia
HUN = Hungary
IDN = Indonesia
IND = India
IRL = Ireland
ITA = Italy
JPN = Japan
KOR = South Korea
LTU = Lithuania
LUX = Luxembourg
LVA = Latvia
MEX = Mexico
MLT = Malta
NLD = The Netherlands
NOR = Norway
POL = Poland
PRT = Portugal
ROU = Romania
RUS = Russia
SVK = Slovak Republic
SVN = Slovenia
SWE = Sweden
TUR = Turkey
USA = United States
ROW = Rest of World

Chapter 6

Summary and conclusions

This thesis considered different ways of looking at trade. The globalization of the world economy raises new questions with respect to how services activities, the foreign workers embodied in a country's imports of goods and services, and the role of foreign factors of production influence the economic benefits a country obtains from open trade and investment policies. Suitable (and in some cases new) approaches are necessary to address these questions. Therefore, Chapter 2 provided a methodological overview of techniques used to assess trade in the context of globally fragmented production. I discussed several indicators that aim to shed light on a country's position in international production networks. These included indicators that were developed to overcome the analytical limitations of gross export statistics. In Chapters 3-5, I addressed different GVC-relevant questions (mostly at the country-level) by using existing and newly developed approaches. In general, I identified three factors that affect the extent to which a country benefits from trade: the competitiveness of its services sector, access/availability of foreign labor to produce the goods and services that its residents consume, and its income and investment linkages with other countries. This concluding chapter summarizes the main findings of my research, considers some caveats, suggests policy implications, and proposes ideas for future research.

In Chapter 3, I employed value-added export and gross export indicators to explore the role of services in globalization. First, I investigated whether services activities are becoming more important in trade relative to manufacturing activities in the EU-15, North America, and East Asia. Second, I analyzed whether trade in services has a more intraregional or interregional character. Based on the World Input-Output Database, I found that, in general, the share of services in exports of value-added grew over time between 2000 and 2014, whilst the share of manufacturing remained constant (or grew relatively less). Furthermore, the results showed that throughout the entire period, services had a larger share in interregional exports of value-added than in intraregional exports of value-added, whilst the opposite was true for manufacturing. Hence, trade in services was more global than trade in manufacturing. I also concluded that, because of the interregional characteristic of services and the underrepresentation of services in gross exports, trade is more global when measured in value added terms than in terms of gross exports.

These insights suggest that policymakers should consider focusing their efforts towards promoting services industries. This requires a strong regulatory framework and a level playing field. The international competitiveness of firms that produce goods for export depends in large part on their ability to source the most efficient services inputs (both domestic and imported). Policymakers need to be aware of this and should not solely focus on promoting exported manufactured goods without considering the upstream activities that go into their production. Suppliers of services inputs in the context of exported goods are often small and medium-sized enterprises (SMEs) (Maurer et al., 2016). SMEs tend to specialize in niche functions within the value-chain and sell their services to exporting MNEs. Therefore, identifying, supporting and encouraging these SMEs may be one way for governments to increase the amount of embodied (indirect) services in trade. At the country-level, some countries may in fact have a comparative advantage and/or create most of their value added in services even if (according to gross export statistics) they seem to rely heavily on manufacturing exports. In this context, the merchandise trade balance, which does not include services but is often cited by policymakers as an indicator of international competitiveness, is less instructive with respect to the benefits of trade.

Finally, services should receive more attention in trade policy beyond their roles in the World Trade Organization's General Agreement on Trade in Services (GATS) and ongoing plurilateral negotiations of the Trade in Services Agreement (TiSA). The overall importance of trade in services and the global nature of services reinforces the need for bilateral and multilateral efforts to reduce the high levels of behind-the-border barriers to trade in services. As underscored by the OECD Services Trade Restrictiveness Index (STRI) database, measures could include improving market access (i.e., dealing with national treatment and foreign entry barriers), reducing discriminatory measures against foreign services providers, and promoting pro-competitive regulations and global best practices. Progress in these areas would not only boost the direct cross-border trade of services, but also improve competitiveness of the manufacturing supply chains and products relying on the domestic outsourcing of services.

There are several avenues for future work to build upon this research. First, what are the sources or drivers of a country's rising dependence on trade in services over time (relative to manufacturers)? To address this from an economic point of view, it is necessary to look at the role of transaction costs affecting trade. This could include incorporating the roles of transport and communication costs, tariffs, non-tariff barriers, trade agreements, and cultural distance into a broader analysis. For example, countries which belong to regional agreements may have higher levels of convergence and thus export more services. Follow-up work could analyze the extent to which price level changes in services (rather than volume changes) played a role in their increasing embodiment in trade over time. It is possible that the prices of services remained relatively high compared to manufacturers if there were sectoral (or interindustry) differences in productivity growth. Second, my analysis used trade in value added indicators that do not distinguish between embodied (e.g., non-tradable) and direct services exports. By applying a vertical specialization approach (instead of a demand-side absorption approach), it would be possible to decompose gross exports into the direct and indirect value-added contributions of services, thus separating out these components. However, with this approach we do not learn who is consuming the services, and thus would know less about how far they travel.

One issue that could complicate the estimations of trade in services, not addressed in this thesis, involves the emergence of so-called "factoryless goods producers", or FGPs (Bernard and Fort, 2013; Kamal, 2018). FGPs are plants and firms that are traditionally considered to be outside of the manufacturing sector in official statistics. Yet FGPs such as Apple Inc. or Philips are heavily involved in manufacturing-related activities, including in the design and engineering of products and in coordinating production activities. There may be repercussions for the relative importance of manufacturing and services activities in trade if FGP establishments were reclassified as part of the manufacturing sector (and thus also the value added generated by them as reflected in WIOD data). However, there is no consensus on how to define FGPs, and moreover, it is far from simple to identify them. Bernard and Fort (2013), using US Census Bureau microdata, find that reattributing the output of FGPs in the wholesale sector to manufacturing would have increased US manufacturing output by between 5.2% (lower bound) and 16.8% (upper bound) in 2007, depending on the method used to measure FGPs. Therefore, even if it were feasible to account for the role of FGPs, it appears unlikely that the reallocation of value added would be enough to overturn the conclusions of the analysis in Chapter 3.

Chapters 4 and 5 provided new perspectives on the benefits of international trade by turning to the implications of trade for jobs, the consumption bundle, and income. These last two chapters were motivated by growing concerns in both developed and developing areas of the world about how international trade is now structured, including the dominating role of MNEs.

In Chapter 4, I used the labor footprint concept to assess how much countries rely on foreign labor to sustain their current consumption patterns and standards in the period 1995-2008. I analyzed the composition of the US labor footprint. I also compared labor footprints with labor endowments to evaluate the capacity of the US and 39 other countries to be self-sufficient in terms of labor in a hypothetical situation of autarky and perfect labor mobility. There were three key findings. First, I showed that US consumption increasingly depended on foreign workers. The analysis showed that the possible adverse impact of China with respect to job losses (at the national level) may be exaggerated. The share of jobs from China embodied in US consumption of final products was just 1.5% in 2008 after accounting for differences in labor productivities between US and Chinese workers. At the same time, US labor has benefitted from new jobs generated by the world economy, especially high-skilled jobs in the services sector. This also held in relation to US jobs induced by final demand in China.

Second, the counterfactual autarky exercises revealed that most countries in the study were able to produce all output for consumption themselves (by using only their own production technology and labor). However, once the assumptions that labor is perfectly mobile across skill levels and that all unemployed workers accept a job when offered one were relaxed, most countries could no longer be self-sufficient. That is, these countries would not be able to sustain their current consumption pattern. Third and finally, I concluded that there were positive labor gains of trade for most countries. That is, in no year could US consumption in the actual trade structure be sustained in a counterfactual situation of autarky by just using currently employed US workers.

The analysis in Chapter 4 builds on Chapter 3 by reinforcing the important role of services also for job creation. Although the results indicated a large increase of manufacturing jobs that were ‘imported’ by the US from abroad in the same period (i.e., foreign workers embodied in the US consumption bundle), which may have replaced US manufacturing jobs, this focus is misleading because these losses were offset by new US jobs generated in the services sector. The counterfactual analysis showed that the US benefited from trade not just by specializing in services and services-related jobs, but also from access to the global labor market with cheap and/or efficient foreign workers and suppliers. The main policy implication is that barriers to trade (e.g., a tariff war between the US and China) and an emphasis on ‘lost’ manufacturing jobs is misguided because a reversion to autarky, even if it were to lead to full employment, would require sacrifices in consumption. As Baldwin (2016) observes, the labor market is becoming global; therefore, labor footprint analyses will become more important.

A few caveats are appropriate. First, the counterfactual analysis was at the national level, which implies that what happens within a country (i.e., distribution across industries) is not covered. Overall labor gains in trade would do little to console the manufacturing worker who is out of a job. Second, the analysis only considered the factor labor. This was by design because the focus was on the labor footprint itself. This means that there are only partial links to the trade in factor services literature and the gains of trade literature. One direction for future research could involve employing a dynamic general equilibrium framework that introduces physical capital and/or land. The substitution between labor and capital could be as important as the substitution between domestic and foreign workers or the substitution between skilled and unskilled labor. Although data on capital are included in the WIOD database, which would make it possible to replicate the study for other production factors, the assumptions involved in the data construction are more severe. CGE models are an interesting alternative approach to address the impact of policy decisions, but they typically start off with specific questions and heavy data requirements, with outcomes that are sensitive to the models and economic parameters that are chosen. Input-output measures are more straightforward and provide the best numbers.

Follow-up research may wish to consider the role of automation. A substitution of domestic or foreign labor for machines would change the labor footprint without any change in trade. Automation may lower the US labor force participation rate and change input coefficients. This would mechanically increase the share of foreign labor compared to domestic labor. On the other hand, automation may decrease the role of trade if machines become more substitutable to foreign labor. The goal of a follow-up analysis could be to tease out which of trade and automation is the most important factor in explaining changes to the labor footprint and/or self-sufficiency prospects. However, this again would require a different, more dynamic, type of study. The goal of Chapter 4 was not to simulate autarky, but rather to highlight the implications for labor and consumption, as well as the potential use of labor footprints in empirical research.

There is also considerable potential to incorporate the insights of the growing literature on 'functional specialization' into labor footprint analyses. Countries' exports increasingly reflect a specialization in functions or sets of tasks carried out by occupational classes, which do not necessarily align with industries (Grossman and Rossi-Hansberg, 2008; Timmer et al., 2019). Industry-level analyses are thus imperfect indicators of comparative advantage or specialization patterns in trade. This caveat applies to the analysis of the US labor footprint in Chapter 4. Timmer et al. (2019) use a new dataset of occupations to subdivide labor income at the industry-level into income earned by workers performing four distinct functions: R&D, management, marketing, and fabrication. The authors, who have made this data publicly available, find some evidence that links different functions (e.g., R&D) with different types of countries (e.g., high-income). This type of data can be used to extend our study and the application of footprint analyses more generally to include insights into the type of work performed by domestic workers versus the workers that are imported (of different countries and industries).

Functional specialization suggests that US workers may perform different activities than foreign workers within the same industry, and that these functions also differ in their propensity to be relocated. Thus, one might argue that our industry-level wage comparison of US and foreign workers to determine US-efficiency equivalents in the counterfactual autarky exercises is not fine-tuned enough. However, Chapter 4 distinguished between workers with three different skill-levels (based on educational attainment). Timmer et al. (2019) find that education is to some extent related to functions. R&D activities in the US are mostly performed by college educated workers, while fabrication activities are overwhelmingly performed non-college educated workers. Therefore, we already have a rough proxy with respect to these two functions with the breakdown of skills. The results of our counterfactuals also did not meaningfully change when workers were not distinguished by skill-level and only industries were used. This suggests that differentiating workers by function instead of skill-type would not have a big impact on baseline outcomes with respect to the ability of the US to be self-sufficient in autarky.

In Chapter 5, I introduced a gross national income (GNI)-based trade framework as the next step compared to value added. This was motivated by the large capital investments linked to MNEs' foreign affiliates. The returns (profits) on foreign-owned investments and intangible assets may be repatriated to investors in another country despite contributing to host-country GDP. By making novel use of the Balance of Payments, national accounts, and data on cross-border investment positions, I deconstructed the GDP of 42 countries plus 'the rest of the world' to create a 43×43 matrix of exported transfers of income for the year 2014. The relation between GDP and GNI revealed that most transfers of income went to the US and the EU-15. Next, the GDP-GNI matrix was used together with trade in value added data derived from world input-output tables to generate a novel 43×43 matrix of trade in income. This matrix allowed me to estimate the national income of one country that is embodied in the final demands of other countries. While all countries exported a higher share of their income (GNI) than value-added (GDP) to final users abroad, the results showed that highly developed countries benefitted the most in relative terms from the income perspective. That is, their economic dependence on foreign consumption of final products appeared higher. Finally, perhaps the most interesting discovery was that the large US trade deficit in gross terms and in terms of value-added disappeared almost entirely when measured in terms of income. The trade deficits of several other highly developed countries were also less negative in terms of income.

Based on the results, I encourage trade policy analysts to think beyond value added and consider the national income implications of the activities that their country is engaged in or is promoting. Although upgrading into higher, more attractive value-added activities within

GVCs (e.g., R&D) is generally perceived as desirable and a way of capturing more domestic value-added via trade, these activities may generate profits that end up in other countries. The country-level benefits of attracting MNE investment and integrating into the global economy may thus be smaller in terms of what they mean for GNI than the corresponding contributions in terms of GDP. Therefore, the true benefits of a country's participation in GVCs also depend on how much income it retains from the earnings of foreign-owned production factors (labor and capital) at home plus the income that it earns from domestically-owned factors abroad.

The perspective of income also places some of the previous findings in the GVC literature in context, including my own findings in Chapter 3 on services. While Chapters 2 and 3 showed that correctly measuring domestic value-added contained in foreign consumption is one way to measure the impact of trade on the economy, Chapter 5's focus on the income channel is perhaps just as relevant (especially given the role of MNE foreign affiliates in generating the majority of world trade). GNI is an equally important indicator of the economy because this income represents national wealth for a country's people. At the same time, in interpreting the results, one should remember that not everybody benefits equally. Owners of capital (perhaps a small subset of the population) may earn a large share of the GVC-income. This characteristic of GVCs could be linked to the well-documented rise of income inequality within countries.

Given that this is a novel approach, there is much potential for additional analysis and improvements in the data. First, I constructed matrices for 2013 and 2014 only. This period should be extended once additional data becomes available and/or by using by using alternative databases. A more ambitious extension could involve splitting up the transfers of income on the industry- rather than country-level. Second, it would be interesting to set the matrix up from the creditor's perspective. This approach could yield a different decomposition than what is derived using the debtor approach of Chapter 5 because of bilateral asymmetries in the data reported by counterpart economies. For example, I used inward FDI stocks to proxy the bilateral shares of returns on direct investment incomes going to (and thus generating GNI in) other countries. However, the outward FDI of the counterparts (with the returns generating their GNI) may be reported differently in mirror statistics. The creditor perspective would provide more reliable estimates of the breakdown of a country's GNI into domestic and foreign value-added components. Third, I would have preferred that the investment data used to proxy offsetting transfers of income would only capture the ultimate investors and not the immediate counterpart investors. Data by ultimate counterpart country was not always available, but the IMF and OECD are encouraging the collection of this type of data. These efforts could lead to future improvements of the matrix.

The analyses of trade in jobs in Chapter 4 and trade in income in Chapter 5 may themselves inspire future extensions to the GVC indicators guide in Chapter 2. Although Chapter 2 provided an overview of many GVC-based measures of trade, it is not exhaustive and did not include a jobs or income component. International organizations such as the OECD have shown an interest in measuring these two components.[132] Therefore, the inclusion of indicators related to the labor footprint or based on GNI could be a reasonable next step in extending the guide.

In general, my research suggested some channels through which developed countries like the US gain from the liberalization of trade and investment. Chapters 3 and 4 demonstrated that most of the value added and newly generated jobs generated via trade were in services and due to service-related inputs into the production process. Chapter 4 showed that the aggregate impact of China on US jobs in the context of the US-China relationship was small. Despite the role China likely played in the decline of US manufacturing, these losses were offset by new US jobs in services. Furthermore, I found in Chapter 5 that the US received much income from countries like China due to US-owned intangible assets (which include services) and investment activities abroad. This investment nexus reduces the interpretability of the US-China trade deficit given that part of the US ‘deficit’ reflects US income or income that belongs neither to the US nor to China. These insights make tariff wars with China even more counterproductive from the US perspective. Finally, all chapters showed how gross exports – and following Chapter 5, even the exports of value-added with respect to the national income generated - are incomplete indicators of a country’s economic benefits from trade. Relying solely on gross trade statistics or any one GVC indicator create misperceptions as to what sectors to prioritize. I urge policymakers to consider a more diverse set of indicators in assessing the benefits of trade and in crafting strategies of how to best position their country in the new global economy.

The analytical limitations of conventional (i.e., gross) trade balances have also been underscored in this thesis. Adam Smith observed (in 1776) that, in countering the perceived threat of mercantilism, “nothing, however, can be more absurd than this whole doctrine of the balance of trade”. This assertion is not only still true today, but arguably even more so. The election of President Trump led to a resurgence of interest in and debate about the US trade balance. Although policymakers and the media still pay close attention to gross export figures and bilateral trade balances as indicators of the impact of trade on the economy, most

[132] The OECD discusses these future ambitions in the official background note accompanying the TiVA database, stating that “measuring these [trade in jobs and trade in income] flows will form an important part of the research programme in coming years”: http://www.oecd.org/sti/ind/TIVA_FAQ_Final.pdf
The OECD already provides data on trade in employment here:
http://www.oecd.org/sti/ind/TIVA_FAQ_Final.pdf

economists would agree that the trade balance is relatively unimportant. Indeed, as my research indicated, the current phase of globalization has made traditional trade balance indicators even less meaningful. The current fixation on bilateral asymmetries in trade is misguided because trade balances bear little relation to the competitiveness or health of the economy, and do not adequately reflect the true nature of economic interdependencies between countries.

Lastly, my research depended heavily on the WIOD database and input-output techniques. Chapter 2 (subsection 2.3.5) outlined general data constraints, the proportionality assumption, and other limitations inherent in IO-analysis, which also apply to my analyses. Looking forward, the OECD is committed to continue extending its own Trade in Value Added (TiVA) database by adding new countries, years, and indicators (e.g., involving trade in emissions and employment). As of 2018, TiVA covered 64 economies, 36 industries, and a period from 2005 to 2015. The next steps of my research could involve doing sensitivity checks by replicating the analyses using other multiregional input-output tables like TiVA or Eora. Beyond more detailed country- and industry-coverage, there are also efforts underway to separate input-output tables for export-processing vs. non-processing firms and domestic vs. foreign-owned firms. This requires data broken down by firm type. Opening the 'black-box' of firm heterogeneity would be fruitful for my analyses because foreign-owned firms (e.g., MNE affiliates) are likely to repatriate income. Foreign-owned (or export-oriented) firms also have different production structure than the average domestic firm. They use different technologies and produce exports with a higher than average imported input intensity relative to the output of domestic (or non-exporting) firms. I strongly endorse the above-mentioned initiatives as well as other ongoing or potential initiatives of the input-output community (see also Los (2017) and Johnson (2018) for reflections related to improving IO-data and methods). Additional analytical tools would allow for a deeper analysis into the topics I explored in this thesis.

In conclusion, the structure of trade has changed. The growing importance of intermediates in trade and the liberalization of capital and labor markets are driving a wedge (at the country level) between gross exports, the domestic value-added generated by exports, and the national income sustained by foreign final demand. New measures of trade based on value added, employment, and income are now much more relevant in terms of assessing the benefits of trade. Therefore, before drawing conclusions with respect to the importance of different sectors in trade, the repercussions of trade for employment, trade balances, trade and investment policies, and many other issues that are currently being debated and headlining the news, one has to measure what crosses borders in the correct way.

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Dutch summary – Nederlandse samenvatting

In dit proefschrift worden verschillende manieren behandeld om naar handel te kijken. De globalisering van de wereldeconomie roept nieuwe vragen op over hoe diensten, de buitenlandse arbeid vervat in de import van goederen en diensten van een land, en de rol van buitenlandse productiefactoren van invloed zijn op de economische voordelen van een open handels- en investeringsbeleid voor een land. Om deze vragen te kunnen beantwoorden, zijn passende (en in sommige gevallen nieuwe) benaderingen nodig. Hoofdstuk 2 biedt hiertoe een methodologisch overzicht van technieken die worden gebruikt om handel te evalueren binnen de context van wereldwijd gefragmenteerde productie. Ik bespreek verschillende indicatoren die licht werpen op de positie van een land binnen internationale productienetwerken, waaronder indicatoren die zijn ontwikkeld om de analytische beperkingen van bruto exportcijfers te ondervangen. In hoofdstuk 3 tot en met 5 behandel ik verschillende vragen die de mondiale waardeketens (vooral op landniveau) betreffen, waarbij ik gebruikmaak van bestaande en nieuw ontwikkelde benaderingen. Globaal heb ik drie factoren geïdentificeerd die van invloed zijn op de mate waarin een land profiteert van handel: de concurrentiekracht van de dienstensector, de toegang tot/beschikbaarheid van buitenlandse arbeidskrachten voor de productie van goederen en diensten die de inwoners van dat land gebruiken, en de verstrengeling van inkomsten en investeringen met die van andere landen.

In hoofdstuk 3 heb ik indicatoren voor export van toegevoegde waarde en bruto export gebruikt om de rol van diensten in globalisering te onderzoeken. Ik heb eerst binnen de EU-15, Noord-Amerika en Oost-Azië onderzocht of diensten voor de handel belangrijker zijn geworden in verhouding tot productiegoederen. Vervolgens heb ik gekeken of de handel in diensten meer intraregionaal of interregionaal is. Op basis van de World Input-Output Database heb ik ontdekt dat het aandeel van diensten in export van toegevoegde waarde in de periode van 2000 tot en met 2014 is gegroeid, terwijl het aandeel van productiegoederen in deze periode constant is gebleven (of relatief minder is gegroeid). Bovendien is uit de resultaten gebleken dat diensten gedurende deze hele periode een groter aandeel vormden van de interregionale export van toegevoegde waarde dan van de intraregionale export van toegevoegde waarde, terwijl voor productiegoederen het tegenovergestelde gold. Hieruit blijkt dat de handel in diensten mondialer was dan de handel in productiegoederen. Een andere conclusie is bovendien dat handel, vanwege het interregionale karakter van diensten en de ondervertegenwoordigung van diensten en bruto export, mondialer is als deze wordt gemeten in termen van export van toegevoegde waarde in plaats van bruto export.

In hoofdstuk 4 heb ik het concept van de arbeidsvoetafdruk gebruikt om te bepalen in hoeverre landen, in de periode van 1995 tot en met 2008, afhankelijk waren van buitenlandse arbeidskrachten om hun consumptiepatroon en -standaarden in stand te houden. Ik heb de compositie van de Amerikaanse arbeidsvoetafdruk geanalyseerd. Daarnaast heb ik de arbeidsvoetafdruk vergeleken met de arbeidscapaciteit om in een hypothetische situatie van een autarkie en perfecte arbeidsmobiliteit de capaciteit van de Verenigde Staten en 39 andere landen te bepalen om zichzelf in alle arbeid te voorzien. Hieruit zijn drie bevindingen voortgekomen. Ten eerste heb ik aangetoond dat de Amerikaanse consumptie steeds meer afhankelijk is geworden van buitenlandse arbeidskrachten. De analyse laat zien dat de mogelijke negatieve invloed van China voor wat betreft banenverlies (op nationaal niveau) waarschijnlijk wordt overdreven. Het aandeel van banen in China in de Amerikaanse consumptie van eindproducten bedroeg slechts 1,5% in 2008, waarbij rekening is gehouden met verschillen in arbeidsproductiviteit tussen Amerikaanse en Chinese arbeiders. Tegelijkertijd heeft de Amerikaanse arbeidsmarkt geprofiteerd van nieuwe banen die zijn gecreëerd door de wereldeconomie, met name hoogopgeleide banen in de dienstensector. Dit geldt ook voor Amerikaanse banen die zijn gecreëerd door eindvraag in China.

Ten tweede blijkt uit de contrafeitelijke autarkiesimulaties dat de meeste landen in het onderzoek alle output voor consumptie zelf konden produceren (door alleen van hun eigen productietechnologie en arbeid gebruik te maken). Zodra de veronderstellingen werden losgelaten dat arbeid volledig mobiel is tussen verschillende opleidingsniveaus en dat alle werkloze arbeiders elke baan accepteren, waren de meeste landen echter niet meer zelfvoorzienend. Met andere woorden, deze landen zouden hun huidige consumptiepatroon niet meer kunnen handhaven. Ten slotte heb ik geconcludeerd dat handel voor de meeste landen tot positieve arbeidsvoordelen leidt. Zo kon de Amerikaanse consumptie binnen de daadwerkelijke handelsstructuur in het geval van een contrafeitelijke autarkie in geen enkel jaar door enkel huidige Amerikaanse arbeiders worden gehandhaafd.

In hoofdstuk 5 introduceer ik een op het bruto nationaal inkomen (bni) gebaseerd handelskader als de volgende stap vergeleken met toegevoegde waarde. Dit is ingegeven door de grote kapitaalinvesteringen die zijn gelinkt aan de buitenlandse partners van multinationals (MNE's). De winst op investeringen en immateriële activa in buitenlandse handen kunnen worden gerepatrieerd naar investeerders in andere landen, ondanks dat ze bijdragen aan het bruto binnenlands product (bbp) van het land van herkomst. Door op een nieuwe manier gebruik te maken van de betalingsbalans, nationale rekeningen en gegevens over grensoverschrijdende investeringsposities, heb ik het bbp van 42 landen plus 'de rest van de wereld' gedeconstrueerd en een 43 × 43-matrix gecreëerd van geëxporteerde overdracht van inkomsten gedurende de periode 2013-2014. De relatie tussen het bbp en het bni laat zien dat de meeste overdrachten van inkomsten naar de VS en de EU-15 gingen. Vervolgens is de bbp-bni-matrix gebruikt in combinatie met gegevens over export van toegevoegde waarde uit World Input-Output-tabellen om een nieuwe 43 × 43-matrix te genereren van handel in inkomsten. Met deze matrix kon ik het nationaal inkomen inschatten van één land, vervat in de eindvraag van andere landen. Terwijl alle landen een hoger aandeel van hun inkomen (bni) dan toegevoegde waarde (bbp) exporteerden naar eindgebruikers in het buitenland, laten de resultaten zien dat hoogontwikkelde landen relatief meer profiteerden vanuit het perspectief van inkomsten. Met andere woorden, hun economische afhankelijkheid van buitenlandse consumptie van eindproducten leek hoger te zijn. Misschien wel de interessantste ontdekking, ten slotte, is dat het hoge handelstekort van de VS in bruto export en in export van toegevoegde waarde vrijwel geheel verdween als het werd berekend op basis van inkomsten. De handelstekorten van verschillende andere hoogontwikkelde landen waren ook lager in termen van inkomsten.

De conclusie is dat de structuur van handel is veranderd. Het groeiende belang van tussenpersonen in de handel en de liberalisering van de kapitaal- en arbeidsmarkt drijven (op landniveau) een wig tussen de bruto export, de nationale toegevoegde waarde die door export wordt gegenereerd, en het nationale inkomen dat in stand wordt gehouden door buitenlandse eindvraag. Nieuwe handelsmaatregelen op basis van toegevoegde waarde, werkgelegenheid en inkomsten zijn nu veel relevanter als het gaat om het evalueren van de voordelen van handel. Voordat er conclusies worden getrokken over het belang van de verschillende sectoren voor de handel, de gevolgen van handel voor de werkgelegenheid, handelsbalansen, handels- en investeringsbeleid en vele andere aspecten waar momenteel over wordt gediscussieerd en gesproken in de media, moet dus eerst op de juiste manier worden gemeten wat er de grenzen overgaat.