Global Value Chains in the European Union: an input-output approach

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Global Value Chains in the European Union: An input-output approach

María de los Ángeles Gómez Benítez

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Department of Public Leadership and Social Enterprise
Faculty of Business and Law
The Open University, UK
Global Value Chains in the European Union: An input-output approach

Abstract

This thesis explores the role of Global Value Chains (GVCs) in the structure of production and final export dynamics in the EU for the period 2000-2014. It also distinguishes between the EU core and periphery regions according to the domestic wage level and subsystem groups. Drawing on classical economics and input-output techniques, this thesis develops an original accounting framework that provides three new measures that deepen our understanding of the impact of GVCs on EU export performance and cost structures. First, it offers a new decomposition of final exports into two nominal variables (exchange rates and price indices) and two real variables (physical labour productivity and quantity of labour induced foreign demand). Second, inspired by Braun’s unequal exchange model, it proposes a (previously unexplored) contrafactual exercise to estimate the labour cost-saving in GVCs through the vertically integrated distribution of labour and vertically integrated nominal wages, disaggregated by geographic origin. Finally, it suggests an original measure of unit labour costs based on the vertical integration approach, which is based on physical units of production instead of income distribution variables based on value added.

Empirically, the thesis fills the existing literature gaps by addressing three objectives. First, it identifies monetary factors (the exchange rate and price index) as the main drivers of economic activity in the EU region, while real variables (productivity and required labour) lead the growth of final exports in the EU periphery. Second, this work finds that the international wage cutting strategy positively affects the EU core GVCs, but not the EU periphery. Nevertheless, in both cases, this wage cutting strategy slows down improvements in labour productivity, particularly in the core region. Finally, in the short run, the wage cutting strategy can help to sustain final export competitiveness, but in the long run this requires an improvement in technical conditions.
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Chapter 1: Introduction

1.1 Motivation for research

Since the 1980s, there has been an information and telecommunications revolution that has combined with a deregulation of international trade and finance. With a decrease in transport costs, it has become easier and cheaper to coordinate production across the world. An important consequence has been the growth of Global Value Chains (GVCs), which fragment the production process into stages conducted in different countries (Baldwin 2006; Amador and Cabral 2016). Smartphones, for example, are designed in the United States, sophisticated inputs such as semiconductors and processors are produced in South Korea, Japan or Germany. They are then assembled in China after being marketed in the United States and Europe, where after-sale services are also provided (Kraemer, Linden, and Dedrick 2011; Gereffi 2014).

As part of globalisation, there has been an increase in international competition. On the one hand, reduced labour costs have been often underlined as one of the main determinants in the structural change of production due to the sensitivity of final exports to costs. Firstly, the deregulation of international trade has permitted peripheral producers to introduce their lower-cost final products into markets around the world, which means core producers are forced to adopt a price-cutting strategy to be more competitive (Shaikh 2016a). And secondly, the fragmentation of production in GVCs has also helped core producers to benefit from the international division of labour. This has allowed them to adopt more aggressive price-cutting strategies (Ricci 2019). On the other hand, lower-cost and price-cutting strategies are also influenced by labour productivity, which indicates the levels of technology embodied in the production process (Timmer et al. 2014; Baldwin and Evenett 2015). Nevertheless, measuring international cost-competitiveness is a challenging task. Traditional export indicators of cost-competitiveness, such as the unitary labour costs, cannot detect the implications of international transactions in intermediate inputs, either in countries or with respect to the performance of final export industries. In this thesis, I propose redefining the measure of unitary labour costs into a new indicator that considers the impact of production fragmentation in cost-competitiveness; hence, providing a possible benchmark for future empirical works related to GVCs and international trade.

The EU is very much a part of this phenomenon. The integration of its members into GVCs has grown globally and at the regional level over the past decades. In this latter aspect, the European Single Market (ESM), the European Monetary Union (EMU) and the entry of the Eastern European economies into the EU has reinforced the integration process (Bruszt and
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Langbein 2017). They have played a key role in the EU becoming the largest trade block in the world (Foster, Stehrer, and Timmer 2013).

The EU value-chain networks have become an essential element in the domestic output of the member economies (Amador, Cappariello, and Stehrer 2015). However, the European integration process has also hidden productive structural differences among member states. The financial crisis in 2008/2009 undermined the idea of the European Union as a whole (Becker et al. 2010) and introduced the conception of the European Union as a hierarchical institution composed of controlling economies and subordinated peripheral counterparts.

There has been some discussion in the literature on the benefits and drawbacks of belonging to the EU, particularly in the case of peripheral countries. Some convergence has taken place in GDP terms, with faint improvements in peripheral socio-economic conditions (Bisciari, Essers, and Vincent 2020; Rodríguez-Pose and Tselios 2015). But it has also been argued that the participation in GVCs has strengthened the differences in EU core and peripheral patterns of specialisation. Core economies have kept those activities intensive in knowledge production, and peripheral economies have deepened their participation in those activities intensive in labour (Grodzicki and Geodecki 2016). Addressing these social-economic disparities between core and peripheral economies, and the existing gaps in the literature about GVCs and development in the EU, are a key motivation for this thesis.

This global fragmentation in production has motivated the design of new international trade databases that consider the new characteristics of the international inflows. The development of Multi-Regional Input-Output (MRIO) models using international input-output tables, such as the World Input-Output Database (WIOD), allows us to map the intra and inter-relationship between industries and economies (World Bank 2017b). There is an extensive literature that focuses on the value-added distribution across the world as the main measurement of production fragmentation (Hummels, Ishii, and Yi 2001; Johnson and Noguera 2012; Koopman, Wang, and Wei 2014; Kersan-Škabić 2019; Stöllinger 2021). Nevertheless, it is often forgotten that in national accounts the value added is measured as a residue between total production and the total required intermediate inputs. Therefore, it is basically an income level measurement associated with political and institutional factors. This characteristic, it may be argued, disturbs its potential to detect technical structural changes across the economies. Improvements in labour productivity and the technological content does not always mean a proportional income increase (Braun 1973; Emmanuel 1972). In order to explore the factors that lead to structural change and competitiveness across GVCs, and to avoid accounting disturbances, this dissertation will focus on changes in
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employment and physical labour productivity instead of value added. A contribution to the literature is possible by considering the somewhat unexplored relationship between labour distribution, productivity, cost structures and international competitiveness.

Based on the contributions of Sraffa (1960), Leontief (1986a) and Pasinetti (1973), the theory of vertical integration, or subsystems approach, provides an analytical framework to study production interdependencies and income distribution in the global economy in GVCs (De Juan and Febrero 2000; Garbellini, Marelli, and Wirkierman 2014; Scazzieri 1990). In addition, Multi-Regional Input-Output Models (MRIO) (Timmer, Los, and De Vries 2015; Amador and Cabral 2016) are a potential tool to identify the international transformation of trade introduced by GVCs in each global subsystem. This thesis aims, inspired by the classical economic tradition, are to develop a theoretical framework compatible with national accounts that sheds light on the role of GVCs in the international dynamics of the EU final export subsystems.

1.2 Objectives and research questions

This thesis studies the implications of production fragmentation in the EU final exports subsystems. The focus is on the changes provoked by GVCs in the EU final export dynamics and on the production structure of the EU final export subsystems. It distinguishes between core and peripheral regions and between product types.

This thesis has three specific objectives, linked to each other with explicit research questions:

➢ Objective 1: Identify the drivers of final export growth for EU subsystems in core and peripheral regions and by product type between 2000 and 2014.

Concerning this objective, this thesis will answer the following research questions:

▪ What are the determinants of final exports dynamics in the GVCs of core and peripheral countries? Which are the main differences between product types?
▪ Are the final export dynamics stable across the period?
▪ Do the final export dynamics impact on the market share of each region? Has this impact been uniform between product types?
Objective 2: quantify the structural changes linked to the reorganisation of labour across space in EU GVCs, adopting a core-periphery perspective (over the period 2000-2014).

In relation to this objective, the following research questions will be addressed:

- What is the structure of employment distribution in the EU core and peripheral subsystems? Has this structure changed across the period?
- Has the distribution of labour affected the average labour costs across the GVCs? Has this effect been different in core and peripheral subsystems?
- Has the cost reduction strategy impacted on labour productivity in core and peripheral GVCs?
- Have changes in labour distribution followed similar patterns in all the product types? Have these changes affected the cost structure differently according to product type?

Objective 3: Analyse the role of relative vertically integrated unit labour costs (rviulc), and their components, as determinants of final export performance in EU subsystems.

With respect to this objective, the following research questions will be answered:

- What is the role of relative vertically integrated unitary labour costs (rviulc) when accounting for the relative dynamism of final export subsystems in the EU?
- If rviulc are able to explain export performance in real terms, is this dynamic path determined via changes in nominal wages or (physical) labour productivity? Are those patterns similar in the short and long-run?
- Do rviulc impact EU core and peripheral economies in the same way?
- Is the role of rviulc and their components similar or different between product types?
1.3 Contributions

The vertical integration (subsystem) approach allows us to comprehend the links between economic activities, production interdependencies and income distribution in the economic system (Scassieri 1990; Garbellini and Wirkierman 2014a). In order to answer the above research questions, I develop a novel analytical framework that combines the vertical integration approach with empirical input-output techniques. The data analysis is primarily based on World Input-Output Tables (WIOTs) and Socio-Economics Accounts (SEAs) supplied by the WIOD database. However, the lack of available data in the SEAs for the rest of the world (RoW) complicates constructing an endogenous global economic system of dated labour and measuring the wage distribution at the global level. To resolve this problem, I suggest an original way to estimate RoW linkages compatible with WIOD through the data collected from the ILOSTAT (for the 15 analysed considered).

Overall, this research also sheds light on the EU core-peripheral discussions, providing evidence of the similarities and divergences in core and peripheral final export patterns. Moreover, it also contributes to the literature on EU structural change debates studying how the emergence of GVCs has affected the final export dynamics and competitiveness among industries.

With respect to objective 1, this research provides an empirical decomposition of the final export subsystems into nominal/monetary variables (exchange rates and price changes) and real/physical variables (productivity and scale of employment). The empirical results reveal the different drivers of the final export growth of the EU core and peripheral regions. Nominal variables are associated with the growth in core subsystems, particularly the nominal exchange rate. Moreover, volume increases have been addressed with increases in the labour induced by the real growth of final exports instead of improvements in labour productivity across the GVCs. By contrast, peripheral subsystems seem to be involved in a manufacturing industrialisation process led by foreign demand, showing the predominance of both real variables, induced labour and labour productivity, over nominal variables as determinants of final export growth.

Starting from the findings related to objective 1, objective 2 is addressed through an inward-looking analysis of the EU final export subsystems. It focuses on the changes in employment quantity and distribution and changes in the cost structure. Analytically, this dissertation presents the vertically integrated wage rate by geographical origin as a potential tool to explain the wage disequilibria across the GVCs. It also provides an original contrafactual exercise inspired by unequal exchange theory to measure the impact of labour offshoring in...
the GVCs’ labour cost structure. The analysis is complemented with a structural decomposition of the vertically integrated nominal wage per product disaggregated by geographical origin. It allows the changes in labour and cost structure to be related to changes in labour productivity. To my knowledge, it is the first study to analyse inequalities in inward-GVCs from an unequal exchange perspective by combining various vertical integration decompositions that are not based on value added measures.

In general, the EU core-country subsystems of final exports have followed a wage-cutting strategy by increasing the weight of labour imported from peripheral regions over the period. Although this strategy has positively fed back on the cost structure, it has also negatively affected the GVCs’ labour productivity because core domestic labour productivity has increased more than imported labour productivity. As a result, this core international competitiveness will be analysed in objective 3.

The EU peripheral subsystems experienced an upgrading process accompanied by a wage catching-up during the first part of the period (2000-2008), but it slowed down after the financial crisis. Similarly, the EU peripheral-country subsystems have been involved in an intensive labour offshoring process during the period, mainly through other peripheries with low wages and inferior technical conditions. In contrast with the core region, labour offshoring has had a limited impact on the cost structure of peripheral GVCs to a large extent, because of the increases in domestic labour productivity. Therefore, labour offshoring seems more related to an export-oriented strategy (driven by foreign-led growth) than an inward-oriented strategy (driven by domestic effective demand). This reproduces the cost competitiveness dynamic within its own peripheral GVCs and slows down the catching-up process to exceed the middle-income threshold.

Finally, under objective 3, I test if a wage-cutting strategy is the best strategy to increase cost competitiveness in the short and long run. Firstly, starting from the final demand decomposition of objective 1, I develop a new measure of relative vertically integrated labour costs (rviulc) split up into their determinants: the relative vertically integrated unitary nominal wages (rviunw) and the relative vertically integrated unitary labour productivity (rviulp). Secondly, I run several first difference econometric models to explore the relationship between rviulc, rviunw, rviulp and the changes in the real market share. I find that physical productivity is the main driver of real export performance, particularly in the long run. Therefore, a competitiveness strategy that focuses on a wage-cutting strategy instead of technical progress will tend to fail in the long run. It explains the bad export performance of the core economies during the period and the problems that the EU
periphery may face if it adopts a wage-cutting strategy instead of concentrating on improvements in labour productivity.

1.4 Thesis structure
Chapter 2 is a literature review covering the main literature about international trade, GVCs and economic development that motivates this research. Firstly, it presents a brief review of international trade and development theory (Section 2.2). Secondly, it discusses the empirical literature about the emergence of GVCs and their impacts on social-economic development, particularly for peripheral economies (Section 2.3). And thirdly, it focuses on the effects of the GVCS on EU membership. More specifically, it reviews the existing literature about the influence of the GVCs in the EU core-periphery relationship and the social-economic upgrading of EU economies (Section 2.4).

Chapter 3 explains the thesis’s methodological aspects. Section 3.2 describes the differences between the value added in trade and the trade in value added approaches. Section 3.3 explains the main theoretical and methodological implications of the vertically integrated approach as a foundational framework. Section 3.4 introduces an innovative systematic decomposition of the vertically integrated final export demand, into monetary and real variables, corresponding to research objective 1. Section 3.5 focuses on research objective 2. It presents an original analytical method to divide the total labour and wages paid in a final export subsystem by geographical origin, which permits distinguishing between delocalisation in core and peripheral regions and estimating the changes in the final export subsystems cost structure. Finally, section 3.5 suggests a novel measurement technique to estimate the vertically integrated labour costs and their determinants: vertically integrated unitary nominal wages and physical vertically integrated unitary labour costs.

Chapter 4 explores the findings for research objective 1: the main determinants of final export dynamics in the GVCs of the EU core and peripheral-country subsystems. Section 4.2 summarises the analytical decomposition of final exports detailed in section 3.4. Section 4.3 refers to the preliminary study of the data, to be followed across chapters 4, 5 and 6. Finally, section 4.4 presents the main empirical findings of the final export-dynamic analysis.

Chapter 5 introduces the theory of unequal exchange and presents the results of research objective 2: structural changes linked with the labour organisation in EU GVCs. Section 5.2 describes the main implications of Braun’s Model of Unequal Exchange and its links with the vertical integration approach. Section 5.3 shows the international division of labour trends
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and how they affect the cost structure of EU GVCs. Finally, Section 5.4 focuses on the international labour division and the cost structure of GVCs across the EU by subsystem groups.

Chapter 6 addresses research objective 3. It tests the relationship between cost competitiveness and real final export performance in the EU. Section 6.2 reviews the theoretical and analytical background, presented in detail in Section 3.5 and 3.6. Section 6.3 introduces the first difference econometric models used to determine the relationship between the real market share and the vertically integrated unitary labour costs. Lastly, Section 6.4 discusses the econometric results in response to objective 3.

Finally, chapter 7 presents the thesis’s main conclusions and contributions. Section 7.2 discusses the main findings in relation to the research objectives. Section 7.3 presents some of the limitations of the research. And section 7.4 explores possible future areas of research that follow from the main contributions of this work.
Chapter 2: Literature review

2.1 Introduction

The worldwide fragmentation of production has acquired international relevance over the last few decades. It is characterised by the disintegration of production in tasks spread around the global economy. The different phases of the production process are articulated through flows of exchange of intermediate goods: that is, by a growing inter and intra-industrial trade which has affected countries’ development processes and the relationship between core and peripheries economies (Milberg and Winkler 2013; Baldwin, Venables, and Bridgman 2012).

This chapter aims to provide a general picture of the impact of Global Value Chains (GVCs) on the socio-economic development of countries. The theory of vertical integration and the analytical richness supplied by multiregional input-output models (MRIO) in the empirical analysis of production fragmentation, under the international division of labour and trade, will be discussed in Chapter 3: Methodology and data preparation.

This chapter is organised into the following three sections plus the conclusions. Section 2.2 provides a brief review of different theoretical perspectives concerning international trade and the core-periphery international division of labour. We start by introducing the Heckscher-Ohlin-Samuelson model and new trade theory, and we finish with an important heterodox approach: dependency theory, world-systems theory, unequal exchange and absolute advantages.

In Section 2.3, we assess the empirical literature about the effect of global value chains on development. We assess both positive and negative effects of GVCs on economic development, as considered in the literature. This review focuses on the changes introduced by GVCs in international trade, the international division of labour, together with economic and social upgrading opportunities. It also revises the importance of the complexity and governance in GVCs as drivers of social-economic development.

In Section 2.4, we focus on the impact of the GVCs in the core-periphery relationship inside the EU. The EU has experienced several enlargements from its recent accession of countries with heterogeneous social-economic conditions. This EU integration has modified the position of the division of labour, connectedness, and social-economic development of the involved economies. The section provides an overview of different perspectives about the opportunities of social-economic upgrading provided by the integration in the EU GVCs and the costs and benefits of participating for both core and peripheral economies. Finally, in
Section 2.5, we resume a consideration of the main outlines of the scholarship specialised in international trade, GVCs and social-economic development.

2.2 International trade and the centre-periphery relationship: a brief theoretical review

Traditional trade theory is rooted in David Ricardo’s theory of comparative advantage, which bases international specialisation patterns on differences in relative opportunity costs. Economies should specialise in producing those commodities in which their relative costs are lower than other countries (Maneschi 2008). It is argued that because peripheral economies have a comparative advantage in labour costs, they should specialise in exporting low-tech, low skill and labour-intensive commodities. Core countries, on the other hand, should specialise in capital, and therefore, provide high-tech, high-skill and capital-intensive commodities to the international market (Shaikh 1979). While David Ricardo’s comparative advantage focuses on relative cost differentials, the Heckscher-Ohlin-Samuelson model emphasises the given national endowments of capital and labour. They assume that demand and production conditions are identical in core and peripheral economies. Therefore, relative capital-abundant economies will develop a comparative advantage in producing capital-intensive goods, while labour-abundant economies will be able to produce labour-intensive goods more efficiently. Following this reasoning, core economies will specialise in capital-intensive exports and peripheral economies in primary or unsophisticated labour-abundant exports. In short, from a comparative advantage perspective, the international division of labour into core and peripheral economies is the most efficient way of organising production in the world economy (Johnson 1970; Shaikh 1979).

The field of new trade theory also emphasizes in national or regional endowments of capital and labour from a slightly different perspective. The new trade theory claims that economic clusters with positive externalities, synergies, and network effects reduce information and transaction costs and drive greater innovation than in the case of firms operating in isolation (Krugman 1981). These clusters create highly competitive economic dynamics and generate external economies of scale. As a result, there are strong entry barriers to the industries dominated by those conglomerates. Therefore, those regions or industries that fail to catch up or reproduce their own external economies of scale are left behind. Krugman points out that the external economies of scale in core economies and constant returns to scale in peripheral economies lead to unequal development. Peripheral countries face very high barriers to entry into the international market, as the core countries have a much more
advanced technology and innovation capacity. Therefore, only those peripheral economies that foster external economies of scale will develop their productive power (Krugman 1981).

From these previous approaches, it may, however, be argued that the periphery does not benefit from this international division of labour. A much more critical view of centre-periphery relations is taken by dependency theory. Singer (1948) and Prebisch (1950) argue that integration into global markets has negatively affected peripheral countries. The international division of labour has forced them to specialise in producing and exporting non-reproducible goods, such as raw materials or naturally reproducible goods, such as agriculture. For these authors, specialisation in these types of commodities has had adverse effects on the development process. Firstly, the income elasticity associated with natural resources and agriculture is lower than in manufacturing products. Second, peripheral exporters face demand oligopolies. International markets for natural reproducible goods are highly competitive, and productivity gains are automatically passed on to price falls that mainly benefit the buyer countries, the core countries. Thirdly, the export of primary commodities generates few backward linkages with other sectors of the economy, limiting the production structure's diversity (Hirschman 1958).

In contrast, manufacturing production in the core countries implies a permanent development of new goods associated with higher incomes in the international market. In addition to the volatility of international prices for commodities produced mainly from natural resources, these commodities are victims of speculation in futures markets. This affects the exchange rates of the producing countries, which often appreciates negatively, impacting on the competitiveness of the nascent industrial structure. For dependency authors, under free trade rules peripheral economies have restricted their possibilities of industrialisation and, therefore, of development since their dependence on the production of natural resources has constantly deteriorated the terms of trade. Finally, in economies based on natural resources, national elites and foreign companies tend to concentrate the income to the detriment of production development (Cardoso and Faletto 1979). For the previous authors, the critical development element for peripheral economies is to break with the pattern of primary-export specialisation through a policy of import substitution to initiate a development process based on growth and technical progress (Hirschman 1958).

A more pessimistic view about the causes of unequal specialisation and the possibilities to overcome the underdevelopment is claimed by the authors of dependency and development that come from a Marxist perspective. The main idea behind these authors’ theories is that unequal development is not caused by the particular characteristics of a region but is rather
inherent to capitalist dynamics (Baran 1957). Hopkins and Wallerstein (1977) consider the international division of labour between peripheral, semi-peripheral and core countries as an intrinsic feature of the capitalist system. Their world-system theory stresses that there have historically been productive interdependencies between core and peripheral economies settling the international labour division. These authors argue that most manufacturing goods can be divided into core activities (high value-added and monopolistic tendencies) and peripheral activities (low value-added and cost-competitive). The capitalist dynamic itself drives nation-states at different levels of development to specialise in certain parts of the production chain and integrate into joint production units. The specific tasks performed by the centre-periphery may change over time, but they will never receive the same level of reward. Core regions will always specialise in comparatively more mechanised activities, with high profits, high wages, and more skilled labour than peripheral regions. In an economy based on the world system, inequality is intrinsic to the system. It is capitalism itself that reproduces the already existing divisions. Semi-peripheral economies are stationed in an intermediate position in the international division of labour, i.e. they have favourable terms of trade concerning the periphery due to their higher level of industrialisation, but unfavourable terms of trade with respect to advanced countries (Arrighi and Drangel 1986).

Starting from a similar perspective to world-system theory. Emmanuel's theory (1972) of unequal exchange generates a theoretical framework that explains the usual functioning of international trade and not so much the interdependencies generated by imperialism. Following Hopkins and Wallerstein (1977), Emmanuel claims that the international competition itself sets up international average prices. While labour is relatively immobile, the free mobility of capital tends to equalise profit rates across the world. Thus, the need for core countries to compete in the international market, under given prices and profit rates, leads them to try to reduce their labour costs and push for unequal terms of trade. The free flow of capital, inputs and technology from core to peripheral countries means that both core and peripheral countries can operate under similar technical conditions in export-oriented industries. However, wages in peripheral countries are relatively lower. As a result, there is a massive transfer of labour value from the periphery to the core countries. For Emmanuel, the key element is the exogeneity of wages which are driven by institutional factors mainly. That is, they are given exogenously to the system. Due to core wages not going automatically down when changes in international prices take place, core capitalists tend to put pressure on peripheral wages. Emmanuel points out that even when the technical conditions are inferior in peripheral economies, the greater wage differentials generate a massive transfer of labour value from peripheral to core economies.
Braun (1973)’s unequal exchange model and Shaikh’s theory of absolute advantage (1980) are both inspired by Emmanuel’s work. Braun develops a model of unequal exchange based on Sraffa’s price equation instead of Marx’s output prices and thus avoids the Marxist problem of transforming values into prices. In Braun’s model, all commodities are produced using labour and other commodities provided by core and peripheral countries. Since both types of economies operate under free competition, both are subject to the international rate of profit and prices. Nevertheless, core wages are given because they are determined by institutional factors, while peripheral wages are inversely dependent on core wages.

As is more explained in Section 5.2 of Chapter 5, Braun’s model of unequal exchange has two important implications. Firstly, it shows an inverse relationship between core and peripheral wages. A drop in peripheral wages is reflected in a drop in the relative price of the peripheral goods used as intermediate inputs by core goods. But also, for a given profit rate and prices, an increase in core wages will lead to a drop in peripheral wages. And secondly, the relationship between the rate of profit and core and peripheral wages is also negative. So, a higher profit rate will be translated into lower peripheral wages related to core wages. As in Emmanuel’s account, but based on Sraffian foundations, Braun also finds in this international trade dynamic the cause of unequal exchange between core and peripheral economies. It is Braun’s argument about the inverse dynamic between core and peripheral wages that has inspired objective 2 of this thesis.

The Shaikh (1980; 2016c)’s theory of absolute advantage rests on producing a commodity with the lowest absolute, not relative, costs. Suppose core economies have absolute advantages over peripheral economies. In that case, the trade imbalances between both regions will drive a deterioration in the exchange rate, a rise in the interest rate and a slowdown in investment in those countries with higher absolute costs. By contrast, the exchange rate will appreciate in the most efficient countries, and bank reserves will rise and increase. Some of these reserves will be absorbed by the production process itself, some as capitalist consumption and the rest will be converted into loanable money, which will bring down interest rates and expand production levels. That is, the world economy will be divided into peripheral and core economies with a chronic deficit and surplus in the commercial balance, respectively. Peripheral countries will reach unsustainable levels of indebtedness that will cut out imports until they balance their export capacity based on absolute peripheral

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1 As will be detailed in Section 4.3 of Chapter 4, Braun’s argument about the inverse relationship between core and peripheral wages will be key to distinguishing between the core and periphery in EU economies.
advantages. In other words, they will specialise in exporting local natural and agricultural resources and simple, low-tech manufacturing that is intensive in labour. As for Emmanuel, Shaikh also finds that unequal development is attached to free competition itself. Shaikh is pessimistic about the prospects for modernisation of the peripheral countries through importing foreign production methods and technologies, i.e., through foreign direct investment.

Nevertheless, the first consequence for peripheral countries will be a dualization of the export sector into those modern industries dominated by foreign capital and those traditional ones based on absolute local advantages. Furthermore, foreign direct investment may disincentivise the development of domestic productive forces unable to compete with foreign capital and increase the exchange rate of peripheral countries. This latter will worsen the exchange terms of traditional goods, counteracting the initial effect of foreign investment on the commercial balance.

Finally, the institutionalist theorists point out that core countries consolidate their position by imposing institutional frameworks or global rules on peripheral countries. The free trade policies advocated by neoclassical theory lead to the hegemony of those countries with an industry based on technical progress. In contrast, peripheral countries are trapped in the production of low-tech manufacturing sectors or raw materials. Active industrial policies that protect infant industries appear essential to overcome international development imbalances (Gereffi 1989). A historical review of economic development shows that the expansion of productive powers is not possible without a solid commitment of peripheral companies and governments to escape from the comparative advantage rule and specialisation based on factor endowments, i.e. a specialisation grounded in cheap labour (Chang 2002). For these authors, the static benefits of international trade are minimal compared to the advantages of growth based on learning and economies of scale (Chang 2002; Rodrik 2001).

2.3 The centre-periphery relationship and Global Value Chains

As international trade theorists point out, the economic integration of different regions is not a new phenomenon but inherent to capitalist dynamics (Emmanuel 1972; Braun 1973; Shaikh 2016b). Until the mid-1980s, globalisation developed at the level of firms or sectors. The main aim was to obtain raw materials from peripheral regions or set up production processes in these regions to expand their markets. Although it was more cost-saving to undertake some labour-intensive stages of production in the periphery, production stages
tended to be spatially clustered in a single facility as this facilitated coordination (Baldwin 2006).

Nevertheless, the deregulation of international trade and finance, the development of telecommunications, the fall of transportation costs and the adjustment of the wage gap to changes in productivity in core countries, made the production fragmentation in different geographical areas more attractive (Amador and Cabral 2016; Baldwin 2006; 2014). As a result, the internationalisation of production has shaped a new international division of labour (Fröbel, Heinrichs, and Kreye 1980; Grinberg 2016; Hudson 2016) based on international networks of suppliers and subcontractors coordinated by lead firms (Henderson et al. 2011; Milberg and Winkler 2013).

The impact of Global Value Chains (GVCs) in core and peripheral regions has been much discussed in the literature. Neoclassical authors argue that it is the exposure to international competition that makes countries increase their productivity and specialise in those goods and services that have relative cost advantages. Thus, these authors interpret GVCs as a development opportunity for peripheral countries (An and Iyigun 2004; Dollar and Kraay 2004; Harrison 2019).

Integration in GVCs allows these economies to generate comparative advantages in a certain part of the production chain without the need to have the production capacity to produce commodities as a whole (Lopez-Acevedo, G. 2016). The first stages of being offshored are those that are labour-intensive. Therefore, besides contributing to economic growth, GVC participation improves working conditions as workers from the agricultural or informal sectors move to better paid and higher value-added jobs (Javorcik 2015; Stone and Shepherd 2013). In turn, the settlement of these exporting firms also stimulates domestic production, as they generate a whole network of local suppliers, which also has positive spillover effects on employment (Shingal 2015). Although labour-intensive activities are the first offshored, activities requiring more skilled labour are also offshored, diversifying labour market needs in peripheral countries.

Finally, these authors point out that GVCs generate technology transfers or spillovers used by local firms to improve their production processes or upgrade GVCs (Ndubuisi and Owusu 2021; Pietrobelli and Rabellotti 2011). Thus, the relationship between the lead firm and suppliers is not restricted to exchanging goods and services but also affects know-how and technology transfer (Lema, Rabellotti, and Gehl Sampath 2018; Saliola and Zanfei 2009). Moreover, the entry of GVCs in peripheral countries also implies a diversification of the
inputs available to local firms, which can access cheaper or higher quality inputs that help them improve their productivity (Criscuolo and Timmis 2017; Goldberg et al. 2010).

However, the literature also points out that the relationship between global value chains and economic development and growth is not automatic (Ignatenko et al. 2019). The type of international specialisation developed by different countries affects growth (Amable 2000). Countries have different historical contexts and institutions which can encourage or neutralise the effect of GVCs on economic growth. The low-income periphery tends to improve its economic condition by participating in global production chains, which is a stimulus in stationary economies where domestic demand is scarce.

As is discussed in Section 2.4. for the EU periphery, for middle-income economies, integration in GVCs does not guarantee economic upgrading. There is a tendency in economies that have escaped from poverty to middle-income levels to fail in their attempt to reach the advanced economies' income levels. This phenomenon is known as the middle-income trap (Agénor 2017). The problem of these economies is that they are not capable of competing with the wages of low-income competitors. They neither have the innovations nor labour skills to compete with advanced economies. The main issue for these economies is to redirect their development strategy through new goals. In low-income economies, an outward strategy based on participating in GVCs diversifies the production structure of very primary economies, which boosts economic growth. Furthermore, it helps move the labour force from agriculture to better-paid manufacturing jobs. However, when the wage levels stop being competitive in labour-intensive activities, these economies need to reorient their strategy from outward to inward-focused on developing the domestic demand that can absorb a nascent industry of more complex products (Kharas and Kohli 2011). Turning from middle to high-income status requires the coordination of multiple public-private players such as consultative councils, robust legal systems, technological and educational clusters that encourage innovation, developed financial systems that channel investment, strong industrial relations between foreign and local capital, a regulated labour market and a balance of power between employers and trade unions (Bresser-Pereira, Araújo, and Costa Peres 2020; Doner and Schneider 2016).

In peripheral countries, the local social elite tends to own large conglomerates around natural resources, semi-processed or low-tech products and regulated sectors such as banking or energy. They also exert a strong political power against introducing changes in favour of social upgrading. On the other hand, high and medium-tech manufacturing activities are dominated by international companies that behave differently when they are
set up in peripheral or core countries. In peripheral countries, they are highly export-oriented and organised in hierarchical global value chains. The objective is to save costs, so they tend to import technology from home countries and protect them from local competitors. Moreover, these companies have their R&D programs in their home countries and are not interested in financing long-term costly domestic innovation and developing linkages with domestic economies (Doner and Schneider 2016).

The relationships between the different players in the chain vary depending on the bargaining power and the level of coordination required. In countries with low development of productive forces, lead firms will tend to exercise a more comprehensive control of the production chain. Suppliers depend on the guidelines designed by the parent companies, and their decision-making capacity is extremely limited. Leading firms control the key tasks of the value chains and distribution channels, taking the lion's share of the revenue generated. Peripheral suppliers obtain small margins that prevent them from investing in upgrading their capabilities (Ravenhill 2014).

The complexity of the chain also influences the type of governance that governs it. In chains with more complex production processes, cooperation and knowledge exchange between the different parties is necessary. Specialisation in the production of simple and standardised products, with low technological content and without significant barriers to entry, such as the food or textile industry, makes it difficult to improve the production process through the introduction of new technologies and, therefore, to increase the compensation of workers (Lall 2000). In contrast, in other industries with high technological content, a greater possibility of differentiation and higher entry barriers make it easier to introduce technical changes that reduce prices while maintaining rents. Depending on the level of countries’ development, leading firms will opt for one type of relationship or another. Different types of governance found within the same chain (Gereffi, Humphrey, and Sturgeon 2005; Gereffi and Lee 2016; Humphrey and Schmitz 2002).

The type of tasks performed in the GVCs also varies their impact on economic development. Those tasks located at the high or the low end of the production process are associated with high added value (Stöllinger 2021; Baldwin and Evenett 2015). Peripheral countries specialise in simpler, low-skilled, tangible production activities such as manufacturing or assembly. The aim of offshoring these activities is to reduce costs, especially wage costs, but also costs related to ecological and health regulations, etc. Leading companies try to take advantage of the laxer regulations in peripheral countries and the social inequality and more precarious labour relations. Therefore, there is a risk that they are trapped in certain stages of
production with slight possibilities of upgrading (Feenstra 2010). Core countries, in contrast, continue to maintain their comparative advantages in activities that have high value-added tasks and highly skilled labour such as the prefabrication stages – such as research and development or design and branding, as well as in after-sales services and marketing (Shin, Kraemer, and Dedrick 2012; Stöllinger 2019b). This distribution of tasks can be interpreted using the GVC ‘smile curve’ (Shih 1996). The core countries assume the prefabrication and post-manufacturing tasks of value-added manufacturing. Peripheral economies are more specialised in cost-competitive activities, which are simpler and have a low value-added content (Baldwin, Ito, and Sato 2014; Mudambi 2008). The development of financial markets (Durham 2004) and the implementation of effective industrial policies also affect the legacy of GVCs (Gereffi 1989).

The effects on the labour market are also unclear. According to the World Bank (2017a), the new international division of labour has led to an increase in industrial employment in peripheral countries and wages in export-oriented industries are above national averages. However, this is not true in all cases (Bernhardt and Pollak 2016). The performance of those more labour-intensive activities may imply truly precarious conditions for the workers involved (Anner 2015; Selwyn 2019). As Milberg and Winkler (2013) point out, there is a risk that peripheral countries specialised in a wide range of activities from manufacturing production to services may see their incomes decrease due to the type of integration in GVCs. Increasing wages and improving workers’ living conditions should be considered a key objective of national economies. Higher wages directly impact domestic demand, and thus on the expectation of growth, which is a stimulus for the development of the domestic industry. In addition, higher wages attract more skilled workers, which is important to stem the brain drain from peripheral economies (Milberg and Houston 2005).

However, these objectives are not shared with export-oriented multinational companies whose relocation to peripheral countries (it may be argued) tends to be motivated by low labour costs. Peripheral economies are very competitive on low labour costs. Therefore, multinationals introduce technologies that allow them to carry out labour-intensive processes with higher profitability, increasing productivity and encouraging a shift from agriculture or natural resource extraction to manufacturing. However, when economic upgrading translates into wage improvements, these countries lose their absolute advantages and the associated technological flows, leading to stagnation or recession, increasing the levels of poverty and social inequality (Agénor 2017).
There is also no consensus on the relationship between participation in global value chains, number of jobs and skilled labour development. The number of jobs created by global value chains is stagnating (Farole 2016; Pahl and Timmer 2020; Rodrik 2018). Moreover, the introduction of new technologies such as automation or robotics increases the demand for skilled labour and reduces the demand for unskilled labour, which poses a risk for peripheral economies. If labour-intensive tasks can be mechanised, firms will re-shore, further affecting peripheral labour markets (Rodrik 2018).

Finally, the net effects on productive structures and living conditions in Global Value Chains in core countries have been little studied. There is, however, a certain consensus that these countries concentrate on those activities that generate greater added value and, therefore, obtain greater benefits than peripheral economies. The literature also includes certain problems associated with the participation of core countries in GVCs.

Most of the core economies have experienced a shift away from manufacturing towards services. The decline in the share of manufacturing in core economies may cause a slowdown in their growth. Innovation and R&D investment are the key drivers of growth in developed economies, closely linked to manufacturing output. Moreover, productivity growth is higher in manufacturing sectors than in other sectors as technological change is more constant. Although the productivity of services has grown substantially, many of these services are not tradable, but the growth in manufacturing improves the balance of payments of exporting countries and reduces the risk of external defaults. There has also been a progressive fall in the share of manufacturing value-added in core countries (Stöllinger 2016).

The fragmentation of production translates into lower prices. Lower prices benefit consumers but also means lower wages. Lower wages may be translated into lower living standards. There is a link between offshoring with a fall in real wages of workers in core countries and an increase in wage inequality between skilled and unskilled workers and between workers employed in innovation sectors and traditional sectors (Davis and Naghavi 2011; Liu and Trefler 2019; Parteka and Wolszczak-Derlacz 2016).

In summary, economic development through participation in GVCs requires a broad institutional framework that encompasses all these fields. The construction of technical and productive capacities that allow scaling are slow and encounter both national and international barriers that, through economic liberalisation, prevent the development of long-term industrial plans capable of developing technologies and indigenous productive clusters (Bresser-Pereira, Araújo, and Costa Peres 2020).
2.4 GVCs and the core-periphery relationship in the EU

The European Union is the largest political and economic integration of sovereign countries in the world, with strong productive links between countries (Amador, Cappariello, and Stehrer 2015; Baldwin and Lopez-Gonzalez 2015). Despite the fact that its members’ economic and social convergence was one of the fundamental pillars in its formation, there are very significant differences between its members’ levels of economic development\(^2\). The diverse levels of income and production specialisation in GVCs between the EU economies have promoted emerging literature based on a core-periphery framework (Rubinić and Tajnikar 2020; Kersan-Škabić 2020; Gräbner et al. 2019). The rise of global production chains has increased the production links between the core and peripheral countries, making it particularly interesting to study whether these links have initiated a catching-up process.

The benefits of EU integration in terms of economic development have been discussed in the literature (Marques 2008; Strielkowski and Höschle 2016). On the one hand, the literature highlights a trend towards convergence in terms of GDP (Bisciari, Essers, and Vincent 2020; Bucur and Stangaciu 2015), some improvement in welfare conditions (Rodríguez-Pose and Tselios 2015) and the emergence of convergence clubs (Simionescu 2015) in some peripheral European regions. They highlight that EU peripheral medium technological level, labour costs’ competitiveness (Parteka and Wolszczak-Derlacz 2015) and geographical proximity (Martinez-Zarzoso, Voicu, and Vidovic 2015) to core countries have driven a process of reindustrialization (Nagy, Lengyel, and Udvari 2020) based on manufacturing specialisation (Cieślik, Biegańska, and Środa-Murawska 2016) and boosting their export performance (Ark et al. 2013; Foster-McGregor and Stehrer 2013; Hagemeyer and Mučk 2019).

On the other hand, the literature has also warned of the EU periphery’s risk of falling into the middle-income trap (Soreg 2018; Stöllinger 2019a). The EU peripheral economies follow a pattern of specialisation characteristic of semi-peripheral countries as pointed out by the world system theory and the theory of unequal exchange (Grinberg 2016). The absolute advantages of the EU periphery are based on its low labour costs, flexibility to adopt foreign technology and proximity to core countries. In other words, ‘the region remains dependent

\(^2\) Although, in absolute terms, the EU economies have income levels over most world countries, in relative terms, the disparities between the EU members are very significant, and their roles in international production differ considerably (Gräbner et al. 2019).
on foreign technology, foreign capital, and, perhaps most vitally, business strategies adopted by leading Western companies’ (Grodzicki and Geodecki 2016, 399).

The European periphery has been integrated into high-tech manufacturing chains; however, knowledge-intensive tasks are still concentrated in the core countries, which has continued to reproduce the initial asymmetries in the sectoral and employment structure (Bontadini et al. 2021). In general, peripheral countries are assigned simpler tasks with little technological content or assembly, while core countries have specialised in high-value-added upstream or downstream stages, which are very technology- and knowledge-intensive (Ambroziak 2018; Cieślik, Biegańska, and Środa-Murawska 2021; Stone and Shepherd 2013; Stöllinger 2021; Volintiru et al. 2021). As a result, although peripheral countries contribute more industrial workers than core countries to the total production of final European manufactures, the production of final goods is still mostly concentrated in core countries (Nagy, Lengyel, and Udvari 2020).

The EU membership has not brought with it an institutional homogenisation either. In the European periphery, employment rights in labour markets are less guaranteed. Work associated with GVCs in peripheral countries is associated with higher rates of temporary employment (Nikulin and Szymczak 2020). In peripheral countries, the weight of flexible fixed-term contractors in the total workforce and the number of temporary agencies are very high, whereas the share of unionised workers is low. It allows firms to adjust their workforces easily, but it also makes peripheral workers more vulnerable to changes in the business cycle (Gerôcs and Pinkasz 2019). The financing of the production structure is highly focused on FDI because domestic financial systems are not highly developed (Kersan-Škabić 2019). The less-regulated labour market and other factors such as looser environmental regulations make the European periphery very cost-competitive. These competitive advantages from below make these countries attractive for foreign capital and technology (Grodzicki and Geodecki 2016).

However, the entry into the EU implies a cession of sovereignty and the acceptance of free trade among all its members, which can be a barrier to developing innovation clusters that compete with the core countries (Bruszt and Langbein 2017). Furthermore, the growth of peripheral economies is strongly linked to foreign capital inflows (Gal and Schmidt 2017; Nölke and Vliegenthart. 2009) which makes them more vulnerable to exogenous shocks (Grela et al. 2017) such as financial crises and severe recessions than core countries and highly dependent on external finance (Soreg 2018). At the same time, domestic suppliers are under continuous pressure to reduce costs while having limited access to technological...
innovations and financial resources, which makes them dependent on the parent firm (Gerőcs and Pinkasz 2019).

Dependent development is based on a foreign-led development strategy (Bruszt and Greskovits 2009; Hagemejer and Mučk 2019; Nölke and Vliegenthart 2009) which may be fruitful in the short run but limited in the long run. Although the export capacity of the European periphery has grown remarkably, its high foreign value-added content reduces the income obtained from it, increasing the risk of these economies remaining stuck at middle-income levels (Leitner and Stehrer 2014; Stehrer and Stöllinger 2015; Stöllinger 2016).

The governance of European Global Value Chains is captive and hierarchical; the main reason for the relocation of production from core countries to the periphery is to save on those processes that are more standardised, which also implies an unequal distribution of benefits across GVCs (Gerőcs and Pinkasz 2019). Moreover, most investments are for the import of capital goods and services rather than R&D and innovation activities with spillovers to the local business fabric (Medve-Bálint and Šćepanović 2020).

Therefore, integration has not led to a technological catch-up between the two regions or a transfer of high value-added activities from core to peripheral regions (Kordalska and Olczyk 2021; Stöllinger 2021). The domestic value-added incorporated by the European periphery in its final exports has been argued to be (Olczyk and Kordalska 2017; Stöllinger 2016), proving these economies’ dependence on capital, technology, and business models coming from the core countries (Grodzicki and Geodecki 2016). This thesis intends to contribute the literature addressing the final export drivers in the periphery (objective 1), the wage and labour distribution dynamics in the EU peripheral GVCs (objective 2) and their impact on the EU international competitiveness (objective 3).

The expansion of GVCs also has negative effects on core countries. The rise of production chains has led to a process of deindustrialisation. The emergence of a highly sophisticated and cost-competitive industry not linked to imported technology in countries such as India or China has reduced the weight of core European economies in international markets (Brandt and Thun 2010; Cieślik 2020). Stöllinger (2016) points out that, excluding Germany and Austria, the participation in Global Value Chains has had mainly a negative effect in the EU core economies, accelerating deindustrialisation. The European manufacturing activity concentrates in GVCs around the German-Central European supply chain. Two core economies, Germany (the pivotal leader) and Austria which supply high-tech inputs; and four peripheral economies more specialised in onward processing and assembling of imported
inputs (Czech Republic, Hungary, Poland, and Slovakia) have become one of the largest global export hubs (Stehrer and Stöllinger 2015).

Finally, the offshoring of those middle-wage positions linked to rotary tasks typical of the industrial manufacturing process has caused the share of middle-wage occupations in core countries to fall significantly (Breemersch, Damijan, and Konings 2017). This has led to a polarisation of the labour market in core countries (Goos, Manning, and Salomons 2009; Celi et al. 2018). In addition, the fall in the weight of manufacturing in total production has led to a concentration of employment in service industries (Breemersch, Jože, and Konings 2019) and divided these into high paying employment related to high value-added tradable goods such as design or marketing and low paying employment concentrated in non-tradable services (Breemersch, Jože, and Konings 2019). As a result, this thesis aims to estimate the effect of labour offshoring in the final exports’ cost structure (objective 2), but also how it affects the final export’s growth dynamics in the EU core GVCs and its competitiveness, particularly in the long term (objective 3).

2.5 Summary
This chapter has reviewed the main discussion about the impact of the GVCs in social-economic development and the relationship between core and periphery economies. There is no consensus about the advantages and disadvantages of participating in international trade. On the one hand, some authors consider the specialisation of each country in those commodities for which they have a comparative advantage to be the most efficient and beneficial way to organise global production. On the other hand, there has been a focus on the unbalanced international division of labour between core and peripheral economies. While core economies produce intensive capital and/or knowledge commodities, and activities with high value-added that allows them to pay higher wages, peripheral economies are specialised in insensitive labour tasks and raw materials susceptible to changes in international prices. According to this approach, the international division of labour reproduces socio-economic imbalances between core and peripheral economies.

The type of governance and the complexity of the GVCs also affect the possibilities of upgrading. For example, for those GVCs with a hierarchical and captive governance in which leading firms make all the decisions and those GVCs, and in which the production can be easily standardised, the opportunities of upgrading will be reduced in comparison to those GVCs with governance based on cooperation and coordination.
Global Value Chains have modified the geographical distribution of global production. Nevertheless, the relationship between the new international division of labour and social-economic development is not automatic. Despite the fact that the low-income periphery tends to improve its economic performance when they participate in GVCs, a path of development from middle-income periphery to core requires very coordinated reforms that involve multiple public-private players with divergent concerns.

Peripheral economies tend to specialise in those activities related to physical production such as manufacturing and assembly, which are more straightforward and require the less qualified labour force and, therefore, are compensated with lower wages. By contrast, core economies concentrate on upstream and downstream tasks very intensive in capital and knowledge, which generates high levels of income and requires highly skilled labour.

The EU is the largest political and economic integration in the world. The literature has discussed the advantages and disadvantages of countries being integrated, particularly in the case of peripheral countries. A wider part of the literature defends that the integration in the EU, and participation in the GVCs drives the GDP convergence between the EU’s members and improves general socio-economic conditions. In comparison, authors with a development background are less optimistic. They argue that the EU GVCs have reinforced EU core and peripheral patterns of specialisation. EU peripheral economies are specialised in intensive-labour stages associated with low wages, while core countries have kept the knowledge-intensive upstream or downstream stages related to high wages inside their borders.

Furthermore, the reindustrialisation of EU peripheral countries is very dependent on the FDI and foreign technology, which has two critical negative implications. Firstly, these economies are more vulnerable to exogenous shocks such as financial crises. Secondly, the primary motivation of these foreign investments is to reduce costs, which restricts the technological transfer to domestic firms because domestic firms’ profits are diminished, limiting their innovation capabilities. Therefore, these authors claim that a foreign-led development can be fruitful, but it can lead to a middle-income trap in the long run (Soreg 2018; Stöllinger 2019a). On the other hand, despite core economies taking advantage of production fragmentation, compared to peripheral economies, the delocalisation of medium-skilled tasks to cheaper labour markets has provoked deindustrialisation of core economies and polarisation of labour markets.

In summary, the literature points out that the production fragmentation and the new division of labour are provoking dramatic changes in the organisation of production in Europe.
Therefore, this thesis is designed to contribute to this field by addressing the changes in the EU final export performance and the structure of GVCs.
Chapter 3: Methodology

3.1 Introduction

This chapter provides an accounting framework that permits addressing my three research objectives through a Multi-Regional Input-Output (MRIO) scheme rooted in classical economics (Kurz and Salvadori 2000). The original analytical tools displayed in this chapter aim to answer the research questions presented in Section 1.2 of Chapter 1. The development of these analytical tools is part of the contribution to the literature of this thesis, tools that can potentially be applied in future empirical work.

I start, in Section 3.2, with a brief theoretical explanation of the vertical integration approach and the advantages of the subsystems concept for the study of Global Value Chains. Section 3.3 reviews the main characteristics and differences between the two most common approaches in GVC analysis, value added in trade and trade in value added. In addition, it reviews the analytical relationship between the latter approach, trade in value added, and the vertical integration approach to input-output analysis.

Section 3.4. develops the first part of the analytical framework to identify the drivers of final export growth in European Global Value Chains (objective 1). It decomposes final export growth into changes in the exchange rate, prices, productivity, and scale of employment. Section 3.5 builds a measure of the nominal vertically integrated wage rate, which allows changes in the cost structure over time to be calculated (objective 2). Section 3.6 proposes a novel indicator to measure vertically integrated unit labour costs. These can, in turn, be decomposed into vertically integrated nominal wages and productivity to identify the role of cost competitiveness in the performance of final exports (objective 3).

3.2 The theoretical background of the vertical integration approach

As pioneered in the work of Luigi Pasinetti (1973), the vertical integration approach provides a foundational framework that can be applied for both national accounting and economic theory. Its main explicative power consists of taking into account the interdependence between production processes, highlighting two important characteristics: on the one side, the different production processes supplying essential inputs to one another; and it emphasises the transformation of primary or intermediate resources into final products, i.e., the role of the value chains in production processes.

Theoretically, Pasinetti bases his vertically integrated approach on Sraffa's idea of an economic system. In Production of Commodities by Means of Commodities, inspired by
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classical political economy, Sraffa (1960) defines an economic system as a set of production processes specialising in different commodities, namely, a set of subsystems formalised in a system of linear equations. The system can be divided into as many subsystems as there are commodities. Furthermore, the net product of each subsystem is equal to the means of production and labour needed to produce it plus the labour required across the period. In other words, Sraffa shows that the circular flow of production can be described as a set of semi-independent subsystems. There is a causal relationship between labour and production within each particular subsystem (Scanzieri 1990).

The notion of a subsystem also provides an economic model based on the quantities of labour that directly or indirectly enter the production of each commodity. Sraffa argues that all the means of production are commodities, and all the commodities are produced using means of production and labour which may be ‘replaced with a series of quantities of labour, each with its appropriate date’ (Sraffa 1960, 34). Therefore, the net product of each subsystem can be defined in terms of the old and current quantity of required labour. Regarding income distribution, ‘the net product of a subsystem is equal in value to the wage of the labour employed plus the profits on the means of production’ (Sraffa 1960, 89).

Leontief adopts an empirical approach bases on directly observable variables organised in tables of input-output flows between industries. Each commodity is produced in a particular industry, which supplies the whole set of industries in the economic system (including itself) according to their production needs. The output of all the industries, produced with industrial requirements of the whole economic system, is demanded by final consumers (domestic and international households, governments and businesses). As in the case of Sraffa’s model, Leontief’s input-output analysis is rooted in the idea of production as a circular flow in which the different industries are interrelated, with a focus on general interdependences and basic structural relationships given in an economic system (Kurz and Salvadori 2000; Baumol and ten Raa 2009). The value added in the economic system is equal to the sum of total payments made by final consumers, i.e., the final demand. At the same time, the output value is also equivalent to the sum of the value of the commodities required by the production and the net income, that is, the value of the payment to those who have participated in the production process. In contrast to Sraffa, Leontief is not concerned with how the net income is distributed between labour and capital (Pasinetti 1978; Leontief 1986a). Leontief’s main contribution is that his input-output approach permits identifying the whole, direct and indirect, set of technological requirements in the economic system from a disaggregated quantitative scheme through use of the Leontief inverse (Miller and Blair 2009).
Pasinetti’s notion of vertical integration links Sraffa’s direct and indirect quantities of labour with the direct and indirect technical requirements coming out of Leontief’s inverse matrix (Pasinetti 1973). Pasinetti provides a measurable economic model based on physical units built on coefficients that simultaneously represent actual outcomes, as will be demonstrated in the following sections.

This vertical integration approach is especially suited to the study of Global Value Chains (GVCs) since it is able to account for flows of intermediate inputs between inputs. Considering the global economy as a closed economic system, an international subsystem involves all the intra and interrelationships given in the global economy to produce a unit of output in a particular commodity: a way of modelling each Global Value Chain. Consequently, throughout this work, the notion of the international subsystem will be interpreted as a proxy of the role of GVCs in the EU economic area.

3.3 GVCs and MRIO models: value added in trade or trade in value added?

The development of Multi-Regional Input-Output (MRIO) tables (Tukker and Dietzenbacher 2013) has allowed the implementation of previous accounting frameworks and the development of new ones for the study of production fragmentation and its impact on international trade. The literature in this field can be classified into two major methodological approaches: value added in trade (VAiT) and trade in value added (TiVA). At a country level, both methods result in the levels of net trade that equal its trade balance in gross terms. However, their results differ when they are applied to bilateral country-industry relations (Stehrer 2012).

Value added in trade is based on the value added incorporated in a country’s gross trade flows (gross exports and imports). This analytical approach is associated with authors located in international trade studies (Stehrer 2012). After the rise of GVCs, they introduced input-output and value added content techniques in their studies, in order to measure the weight acquired by intermediate inputs in international trade. Their analysis starts from a producer perspective. The objective is to calculate the embodied value added in a country’s gross exports and imports and the subsequent quantity of net value added contained in gross trade flows (Stehrer 2012). The underlying question for this stream would be: How much foreign or domestic value added is embodied in a country’s gross trade flows?

Trade in value added measures the value added of one country incorporated directly and indirectly in the final demand of another country, not gross output. This method shares its
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theoretical framework with traditional input-output models based on intra- and inter-sectoral analysis and the circular flow of income (Leontief 1986a). The development of Multi-Regional Input-Output tables has made it possible to apply these techniques to international economic systems and, therefore, to analyse the international production fragmentation that has emerged in recent decades. It is rooted in the national accounts, i.e., expenditure on final goods is equal to the amount of value added generated during the production process. Therefore, domestic value added in exports represents the amount of home value added embodied in the final demand of each foreign country, i.e. GDP, sold in all destinations outside the country (Johnson 2014; 2018). Therefore, the underlying questions would be: How much domestic value added does a country r produce to satisfy the final demand of a country s? Or how much foreign value added does a country r need to import to satisfy the demand in country s or a third country?

At the aggregate level, value added in trade and trade in value added provide equivalent results in net terms. That is, the net trade in value added obtained by both methodologies is equal to the total trade balance of a country. This is because both methodologies satisfy the adding-up and negative symmetry conditions. The addition condition guarantees that adding up the bilateral flows yields the total flows in value added terms. The negative symmetry condition ensures that exports from country r to country s are equal to imports of country s from country r and vice versa. This also implies that the net trade of country r in value added terms of country r with respect to country s (e.g. value added surplus) has as a counterpart the negative net balance of country s with respect to country r by the same amount (Stehrer 2012).

Nevertheless, at country and country-industry levels, the results of both methodologies differ when they involve a global economic system with multiple countries. For example, the gross trade flow between countries r and s may be $4. However, the value added of country t contained in these flows as intermediate inputs is $1. Therefore, the value added balance between country r and country s is $3 once the foreign value added of third countries is deducted. Thus, the gross and final demand results diverge substantially from each other (Nagengast and Stehrer 2016).

In general terms, the export and import of value added are lower in trade in value added than in value added in trade estimations (Johnson 2014). This is due to the double-counting problem embedded in this second method. By multiplying the coefficient matrix by gross exports and imports, part of the intermediate inputs are double counted (Stehrer 2012; Nagengast and Stehrer 2016). This problem disappears at the aggregate level because double
counting is cancelled out but can lead to significant distortions in the analysis at the geo-
industry level (Stehrer 2012).

Under a value added in trade perspective, we can highlight the following studies. Hummels et al. (2001) were pioneers in separating the domestic content from the imported content in gross exports. Koopman et al. (2014) developed the most popular accounting framework based on value added in trade, also known as KWW, after the initials of its creators. These authors suggest an accounting framework capable of fully decomposing gross exports into their domestic and external content at the country level. Each of these parts are subdivided to capture more information about the degree of fragmentation. For example, domestic value added embodied in imports can be consumed by the importing country directly, returned to the exporter country again, or exported to a third country. They also try to estimate the double counting terms arising from double counting of certain intermediate inputs.

More recently, Borin & Mancini (2017; 2019) refine the KWW framework. They decompose the bilateral gross export flows into domestic and foreign value added at the country-industry level and suggest new ways of calculating foreign value added and double counting terms. Wang et al. (2018) introduce an alternative framework to KWW. They disaggregate the value added contained in gross exports at the country-industry level by tracing the international production structure at the disaggregated level across backward and forward industrial linkages. More focused on the identification of double-counting in those input-output models based on gross exports is the work of Miroudot & Ye (2021; 2017).

Following the trade in value added perspective, Daudin et al. (2011) identify the value added in trade in final goods for each country participating in their production. Starting from a very similar conceptual framework, Johnson and Noguera (2012) measure how much domestic income or value added is incorporated in the final exports and how much this domestic value added represents over gross exports. Dietzenbacher & Lahr (2013) combine trade in value added and the hypothetical extraction methods, in line with the classical Leontief demand-driven model, to measure changes in intermediate input production. Timmer et al. (2013), Timmer et al. (2014), and Los et al. (2015) propose a set of indicators of international competitiveness and offshoring based on GVC income decomposition. They disaggregate the final output of industry $i$ in country $r$ into the value added contributed by each country-industry involved in the production process. On the one hand, GVC income accounts for the domestic value added embodied in imported inputs. On the other hand, it measures the
multilateral nature of GVCs by capturing the value added incorporated through indirect routes (third country industries).

Los et al. (2016) also combine trade in value added and hypothetical extraction methods to estimate the domestic value added of a country or GDP is absorbed abroad and destined to the production (intermediate input) or direct consumption (final good). Los & Timmer (2018) follow a similar approach to Dietzenbacher & Lahr (2013) and Los et al. (2016). They decompose the value added used abroad in the final stage of production. This value added may be included in inputs imported from a third country. Thus, the producing country and the final recipient country may not have traded directly with each other. Bo (2019) combines trade in value added approach with network analysis to create an analytical framework capable of comprehensively and consistently tracing traditional trade, simple GVC trade and complex GVC trade; and, thus, determine whether GVCs tend more towards a process of globalization or regionalization.

Finally, a body of literature could be considered a bridge between both methods, trying to conjoin them into a common framework. Foster-McGregor and Stehrer (2013) develop an accounting framework that allows disaggregating the value added content of trade in intermediate inputs into domestic and foreign components. Nagengast & Stehrer (2016) generate an alternative analytical framework to KWW in which they distinguish between foreign value added generated by a trading partner's demand and (domestic and foreign) value added generated by third-country demand at a bilateral level (country level). Arto et al. (2019) attempt to integrate the trade in value added methodology within value added in trade. Their accounting framework decomposes an entire country's gross exports, measured at the border, into a single expression, covering the double counting of domestic and foreign VA at the country-industry level. It allows distinguishing between the country-industry in which the value added is generated, the exporter and importer countries-industries, the country-industry that produces the final goods and the country whose final demand drives exports.

Using the structure of the national accounts, and in line with the works of Johnson (2014), Nagengast & Stehrer (2016), and Los & Timmer (2018), I consider the trade in value added analytical framework reflects better the benefits or disadvantages of participating in international trade at both country and country-industry level. This choice is based on two main reasons, one theoretical and one technical. From a theoretical point of view, this analytical framework can be considered as a branch of the vertical integration approach (Pasinetti 1973) based on Sraffa’s subsystem notion (Sraffa 1960) and the principle of the
circular flow of income (Leontief 1986a) as we will show in the following sections. From a technical point of view, measures of bilateral trade flows based on gross notions can lead to misleading results due to: the weight of domestic demand, relative price adjustments in bilateral trade balances (Johnson and Bems 2012; Bems 2014), and the rise of the number of inputs that cross the border more than once during the production process (Johnson 2014; 2018; Javorsek and Camacho 2015). By contrast, in the demand-driven trade in value added framework, the problem of double counting, associated with gross trade, vanishes.

In accounting terms, the value added is calculated as a residual. In other words, the value added of a country-industry is equal to the total production minus the intermediate inputs required for production. In turn, the value added generated by a country-industry is equal to the sum of workers' compensation and capitalists' profit (Johnson 2014). Therefore, the amount of value added, or income generated by a country-industry, is highly conditioned by the institutional factors and power relations that affect international income distribution.

Consequently, value added should be understood as an income measure. It may be the case that the technical conditions in a German and a Czech car assembly plant to produce a unit of product are the same. Nevertheless, the income obtained from the final product may differ between both economies since it is also influenced by exogenous factors such as the labour markets and the international position of each of these countries. For these reasons, we consider it more appropriate to base our GVCs analysis on physical labour units following Pasinetti (1973)'s theoretical approach.

Despite the importance of GVCs in the changes given in the international division, the literature on GVCs has paid little attention to this problem. This thesis aims to shed light on this problem by analysing the distribution of physical production and its asymmetries with the distribution of wage compensation across supply chains. The following sections will emphasise the main theoretical and analytical implications of the vertical integration approach and its applicability to addressing the research objectives of this work.

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3 In this sense, we could highlight the work of Timmer et al. (2013) and Foster-McGregor et al. (2013).
3.4 The composition of the vertically integrated final export demand

The first aim of this research is to identify the main drivers of the final export growth in the EU core and peripheral GVCs, represented analytically as economic subsystems. The global export system of \( n \) subsystems that produce \( j \) goods in \( m \) countries at period \( t \) is estimated as follows. Starting from a Multi-Regional Input-Output framework, we define the following equations:

\[
\begin{align*}
q &= \hat{p} \cdot \tilde{q} \\
\hat{x} &= \hat{p} \cdot \tilde{x} \\
\hat{f} &= \hat{p} \cdot \tilde{f} \\
A &= Z \cdot \hat{q}^{-1} = \hat{p} \cdot \tilde{A} \cdot \hat{p}^{-1} \\
\tilde{a}_i^T &= I_q^T \cdot \tilde{q}^{-1} = I_q^T \cdot (\hat{p} \cdot \tilde{q})^{-1} \\
\tilde{a}_w^T &= w_q^T \cdot \tilde{q}^{-1}
\end{align*}
\]

where \( q \) is the \( n \times 1 \) vector of gross output in current dollars, \( x \) is the \( n \times 1 \) vector of gross exports in current dollars, and \( f \) is the \( n \times 1 \) vector of final exports in current dollars. \( Z \) is the \( n \times n \) matrix of interindustry sales in current dollars. Each row describes quantities of other industries that are, on average, necessary to produce a unit in a particular subsystem. Multiplying \( Z \) by \( \hat{q}^{-1} \), we obtain the matrix of technical coefficients (\( A \)). Each element \( a_{ij}^{rm} \) represents the weight of the direct intermediate inputs from industry \( i \) of country \( r \) to industry \( j \) in country \( m \) (\( a_{ij}^{rm} = z_{ij}^{rm} \cdot q_j^m \)) (Miller and Blair 2009). The \( n \times 1 \) global vector of direct labour requirements per unit of total output (\( a_l \)) is defined as the total labour vector required by each industry (\( I_q \)) times \( \hat{q}^{-1} \), and the \( n \times 1 \) global vector of direct nominal wages per unit of total output (\( a_w \)) as the vector of global nominal wages (\( w_q \)) times \( \hat{q}^{-1} \) (Pasinetti 1973). All the equations can be defined as the prices (\( p \)) times the physical volume at a period \( t \).

---

4 The total number of subsystems is \( n \) which is equal to \( j \) subsystems times \( m \) countries \( n = m \times j \).

5 Regarding notation, capital letters describe matrices, bold lowercase letters describe vectors, and italic letters describe scalars. All vectors are column vectors; when they are transposed this is indicated by superscript T. The symbol (\( \cdot \)) refers to the diagonalisation of a vector, (\( \cdot^{-1} \)) indicates a volume vector or matrix, (\( \cdot^{-1} \)) the inverse of a matrix or diagonalised vector. \( I \) is an identity matrix. The sign \( \ast \) refers to scalar products and \( \div \) to scalar quotients. All the variables are expressed in the current period \( t \), except to it is explicitly specified.

6 \( Z = \hat{p} \cdot Z \), and \( A = Z \cdot \hat{q}^{-1} = \hat{p} \cdot \tilde{A} \cdot \hat{p}^{-1} \).
From Equations 3.02, 3.03 and 3.04, we obtain the volume gross exports for the whole economy:

$$\bar{x} = \hat{\beta} \cdot \vec{A} \cdot \hat{\beta}^{-1} \cdot \bar{x} + \bar{f}$$  \hspace{1cm} (3.07)

Following a few manipulations $\bar{x}$ can be defined as:

$$\bar{x} = \hat{\beta} \cdot (1 - \vec{A})^{-1} \cdot \hat{\beta}^{-1} \cdot \bar{f} = \hat{\beta} \cdot \vec{B} \cdot \hat{\beta}^{-1} \cdot \bar{f}$$  \hspace{1cm} (3.08)

Consequently, the gross exports can be expressed as the Leontief inverse ($\vec{B}$) times the final exports. $\vec{B}$ describes the total physical output of all subsystems in all economies needed to produce one extra unit of final exports. Each element $\bar{b}_{ij}^{rm}$ embodies the total, direct and indirect, technical requirements from the industry $i$ of country $r$ demanded for the global economy to produce a unit of final output in subsystem $j$ of country $m$. As a consequence, the structural changes given in the global economic system can be measure through the relative changes in the elements $\bar{b}_{ij}^{rm}$ of matrix $\vec{B}$ (Leontief 1986a; Pasinetti 1978).

Multiplying $\vec{a}_1$ by the Leontief inverse, we obtain the vector of vertically integrated labour ($\vec{v}$) (Pasinetti 1973):

$$\vec{v}^T = \vec{a}_1^T \cdot \hat{\beta} \cdot (1 - \vec{A})^{-1} \cdot \hat{\beta}^{-1} = \vec{a}_1^T \cdot \hat{\beta} \cdot \vec{B} \cdot \hat{\beta}^{-1} = \bar{v}^T \cdot \hat{\beta}^{-1}$$  \hspace{1cm} (3.09)

where each element $v_i^r = \bar{v}_i^r \cdot \frac{1}{p_i}$ involves the total required labour from the global economic system to produce one extra output unit in the subsystem $i$ of country $r$, i.e., it allows us to measure the technical conditions in physical units across the GVCs without being affected by income differential between economies\(^7\). Thus, the global labour required to produce the total final export in the global economic system ($l_v$) can be defined as (Pasinetti 1973):

$$l_v = \bar{v} \cdot \bar{f} = \bar{v} \cdot \hat{\beta}$$  \hspace{1cm} (3.10)

Each element $l_v^r = \bar{v}_i^r \cdot \bar{f}_i^r$ measures the direct and indirect labour required by the subsystem $i$ from country $r$ to produce the total net exports at year $t$. The linearity of the system guarantee that $\sum_{r=1}^{m} \sum_{i=1}^{j} l_v^r = l_v = l_f$ where $l_f$ is a scalar that aggregates the total

\(^7\) Despite the important implications of GVCs in both labour market, production structure, and policy implications, the vertically integrated approach is not very extended in the literature which brings to the light the need of contributing to this field. Examples of the potential of vertically integrated analysis can be found in Montresor & Marzetti (2011), Garbellini, Marelli, & Wikierman (2014), Timmer et al (2015), Portella-Carbó (2016), Antonioli et al. (2020) and Villani & Fana (2020).
labour provided by all the industries that form the economic system to produce final exports\(^8\) (De Juan and Febrero 2000). Therefore, the Leontief inverse may be understood as an analytical bridge between Sraffa's theory of subsystems and the Multiregional Input-Output approach (Pasinetti 1973; Miller and Blair 2009). From 3.10, we can express the final demand in current dollars as:

\[
\mathbf{f} = \hat{\mathbf{p}} \cdot (\hat{\mathbf{v}})^{-1} \cdot \mathbf{l}_v \quad (3.11)
\]

In national accounts, we cannot measure the prices; we can only measure the change in the prices in relation to a base year \((t_b)\) through the index pricing (Reich 2016):

\[
(\hat{\mathbf{p}} \cdot \hat{\mathbf{q}}(t_b)) \cdot (\hat{\mathbf{p}}(t_b) \cdot \hat{\mathbf{q}}(t_b))^{-1} = \hat{\mathbf{p}} \cdot \hat{\mathbf{p}}^{-1}(t_b) = \hat{\Phi}(t_b) \quad (3.12)
\]

So, we need to modify our equations in order to express prices in relative terms. Multiplying both sides of Equation 3.11 by \(\hat{\mathbf{p}}^{-1}(t_b)\):

\[
\hat{\mathbf{p}}^{-1}(t_b) \cdot \mathbf{f} = (\hat{\mathbf{v}})^{-1} \cdot \hat{\mathbf{p}}^{-1}(t_b) \cdot \mathbf{l}_v \\
\mathbf{f} = (\hat{\mathbf{v}})^{-1} \cdot \hat{\Phi}(t_b) \cdot \mathbf{l}_v \quad (3.13)
\]

Each \(f_i^r\) element shows the composition of the final exports for the subsystem \(i\) of country \(r\): \(f_i^r = \frac{p_i^r(t_b)}{v_i^r} + \frac{p_i^r}{p_i^r} \cdot l_i^r\). We also know from (3.09) that vertically integrated labour can be expressed as \(v_i^r = \hat{v}_i^r + \frac{1}{p_i^r}\), and consequently \(\hat{v}_i^r = v_i^r - p_i^r\). Therefore, the physical total labour productivity (TLP) or physical vertically integrated labour productivity in the subsystem \(i\) of country \(r\) can be formalised as \(\frac{1}{v_i^r} = \frac{1}{v_i^r + p_i^r}\). Multiplying both sides by \(p_i^r(t_b)\) again, we obtain:

\[
\frac{p_i^r(t_b)}{\hat{v}_i^r} = \frac{p_i^r(t_b)}{v_i^r - p_i^r(t_b)}.
\]

Since \(\frac{p_i^r(t_b)}{v_i^r} = \frac{1}{v_i^r + \phi_i(t_b)}\), we can substitute it in the equation of final exports 3.13 (De Juan and Febrero 2000). At economic system level, from 3.09, we can define the physical vertically integrated labour productivity as a diagonalised matrix:

---

\(^8\) The term \(l_{vi}^r\) should not be confused with \(l_{fi}^r\) elements. The vector of total labour in each final export industry of the economic system is defined as \(l_{vi}^r = a_i^r \cdot (1 - \Lambda)^{-1} \cdot (1 - \bar{\Lambda}) \cdot \bar{x} = l_{vi}^r \cdot \hat{q}_i^{-1} \cdot \hat{x}\), where each \(l_{fi}^r\) refers to the total labour provided by the industry \(i\) in country \(r\). Consequently, \(l_{fi}^r\) can be partially destined to whichever subsystem of the global economy that required inputs from industry \(i\) in country \(r\). Mathematically, adding all the elements in \(l_v^r\) and \(l_{fi}^r\), we obtain the same result: the global labour needed for producing the total final export in the economy \(\sum_{r=1}^{n} \sum_{i=1}^{l_{vi}^r} = \sum_{r=1}^{n} \sum_{i=1}^{l_{fi}^r}\), but the elements of both vector represents different economic interdependences \(l_{vi}^r \neq l_{fi}^r\) (Pasinetti 1973; De Juan and Febrero 2000).
(\bar{\psi})^{-1} = (\bar{\psi})^{-1} \cdot \bar{\psi}^{-1} \quad (3.14)

Multiplying both sides of Equation 3.14 by \bar{\psi}_t, we obtain the vector of vertically integrated labour productivity in volume terms (\bar{\alpha}):

(\bar{\psi})^{-1} \cdot \bar{\psi}_t = (\bar{\psi})^{-1} \cdot \bar{\psi}_t 

(\bar{\psi})^{-1} \cdot \bar{\psi}_t = (\bar{\psi})^{-1} \cdot (\bar{\psi}_t)^{-1} = \bar{\alpha} \quad (3.15)

Here it is important to highlight the analytical characteristics of total labour productivity. Each \( \alpha^*_i \) element must be considered as a technological indicator. It aggregates the technological conditions given in all inputs that participate in the production process of any good\(^9\). Therefore, the physical vertically integrated labour productivity reflects the structural interrelationships among industries, and it takes into account the transfers of productivity from the cutting-edge subsystems to those demanding their inputs, either directly or indirectly (De Juan and Febrero 2000). In contrast with some productivity measures grounded in value added or net income, such as the total factor productivity (TFP)\(^{10}\), the physical vertically integrated labour productivity does not alter when changes happen in distribution, as pointed out by Elmslie and Milberg (1996), Rampa (1981) and Hsieh (1999).

---

\(^9\) Each \( \alpha^*_i \) accounts all the innovations introduced across the GVCs and not only the direct ones. It may happen that the labour productivity drops in one input, for example, domestic direct labour, but this loss will be compensated with gains in the labour productivity improvements of other inputs, belonging to circulating or fixed capital (De Juan and Febrero 2000). That is, changes in a subsystem productivity can be motivated by changes in its direct management, labour qualification, applied techniques, etc., or changes given in their required inputs.

\(^{10}\) The typical empirical setup for Neoclassical growth accounting assumes that an economy's production function is a constant returns to scale Cobb-Douglas function of the form: \( Y = A(L^\alpha K^{1-\alpha}) \), where \( Y, L \) and \( K \) are the aggregate output, labour, and capital, respectively, \( \alpha \) represents the wage share, and \( A \) is a parameter which should, in a competitive general equilibrium, reflect the level of technological development. So, total factor productivity (TFP) becomes equivalent to the Solow residual (Solow 1957). In logarithm terms, it can be expressed as \( TFP = lnA = lnY - \alpha lnL - (1 - \alpha)lnK \). As pointed out by Elmslie and Milberg (1996, 159–62), the production function has been the object of severe critique. Firstly, it does not take into account that the capital stock depends on the income distribution between wages and profits. Consequently, the capital stock cannot be determined without previously determining the profit rate, but, at the same time, the profit rate cannot be known in advance of a value for the aggregate capital stock (Sraffa 1960). As a result, its use in empirical work is subject to problems of potential bias, since capital stock data do not consider the role of distribution in its determination and might be misinterpreted as an outcome. Finally, the total factor productivity growth (TFPG) is described as the growth of output not explained by the growth in labour and capital, \( TFPG = \dot{Y} - \alpha \dot{L} - (1 - \alpha) \dot{K} \), with \( \dot{x} \) being the time derivative of the log of variable \( x \), and \( \alpha \) a constant with respect to time. By the same token, its dual formulation (Hsieh 1999) measures changes in factor prices. That is, the Solow residual actually reflects distributional changes linked to the growth rate of output. So, it needs to be interpreted as a measure of cross-country disparities in functional income distribution rather than of technical progress (for details, see Elmslie and Milberg (1996), Rampa (1981) and Hsieh (1999)).
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output composition, and other reasons not linked to technical conditions such as institutional changes (De Juan and Febrero 2000; Brondino 2019).

Substituting 3.15 in 3.13, we can express the final exports in terms of the relative prices, the productivity in volume, and the scale of labour.

\[
f = \hat{\Phi}_{(tb)} \cdot (\hat{v} \cdot \hat{\Phi}_{(tb)})^{-1} \cdot l_v = \hat{\Phi}_{(tb)} \cdot \hat{\alpha} \cdot l_v \quad (3.16)
\]

We can also disaggregate the price effect in the change relative prices and the exchange. Defining \(\varepsilon\) as a \(n \times 1\) vector in which the exchange rate for the subsystems belonging to the same country is repeated:

\[
f = \hat{\varepsilon} \cdot \hat{\Phi}_{(tb)} \cdot \hat{\alpha}^* \cdot l_v \quad (3.17)
\]

Now the physical vertically integrated labour productivity is represented in constant local currency, \(\hat{\alpha}^*\):

\[
\hat{\alpha}^* = (\hat{\Phi}_{(tb)} \cdot \hat{\varepsilon} \cdot \hat{v})^{-1} \quad (3.18),
\]

where each element\(^{11}\) is described as \(\alpha_i^r = \frac{p_i^r(t_b)}{v_i^r} = \frac{1}{v_i^r \cdot \phi_i^r (t_b) \cdot \varepsilon^r}\). Therefore, each element of Equation 3.17 is now formulated as:

\[
f_i^r = \varepsilon^r \cdot \phi_i^r (t_b) \cdot \frac{1}{v_i^r \cdot \phi_i^r (t_b) \cdot \varepsilon^r} \cdot l_{v_i}^r = \varepsilon^r \cdot \phi_i^r (t_b) \cdot \alpha_i^r \cdot l_{v_i}^r.
\]

So, the final export demand in current dollars of the subsystem \(i\) of country \(r\) \((f_i^r)\) can be expressed in terms of the ratio of current US dollar to current local currency \((\varepsilon^r)\), the price index in local currency \((\phi_i^r (t_b))\), the labour productivity expressed as output per unit of labour in constant local currency prices \((\alpha_i^r)\), and the total labour required by the subsystem \((l_{v_i}^r)\).

3.5 Vertically integrated wage rate

The second research objective is to identify the changes in labour cost structure associated with the labour organization in the EU GVCs. Despite there being an extensive literature based on the role of labour costs as a primary cause of delocalization and the surfacing of

\[\begin{align*}
11 v_i^r & = \frac{p_i^r}{p_i^r \cdot \varepsilon^r} \quad \text{and} \quad v_i^r = \frac{1}{v_i^r \cdot \phi_i^r (t_b) \cdot \varepsilon^r} \rightarrow \hat{v}_i^r = v_i^r \cdot \phi_i^r (t_b) \cdot \varepsilon^r \\
& = \frac{1}{v_i^r \cdot \phi_i^r (t_b) \cdot \varepsilon^r} \rightarrow \text{Multiplying by } p_i^r(t_b) \rightarrow \\
& = \frac{p_i^r(t_b)}{v_i^r \cdot \phi_i^r (t_b) \cdot \varepsilon^r} \rightarrow \frac{p_i^r(t_b)}{v_i^r} = \frac{1}{v_i^r \cdot \phi_i^r (t_b) \cdot \varepsilon^r}.
\end{align*}\]
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GVCs (Pavlínek 2010; Baldwin and Evenett 2015; Rodrik 2018), estimations about the net saving caused by labour offshoring in GVCS are scarce. This work makes use of a vertical integration approach to propose a new tool to quantify the impact of fragmentation on GVCs’ labour cost structure. Our proposal has two main analytical advantages. Firstly, it suggests the estimation of a vertically integrated nominal wage rate in each subsystem from which it is possible to capture the change in labour compensation instigated by the production fragmentation across the period. Secondly, the vertically integrated nominal wage rates can be decomposed by geographical origin. That is, it allows the identification of regions contributing the most to the decrease or increase in the vertically integrated wage rate.

Starting from the accounting framework developed in section 3.2, the basic identities can be built as a two-region system formed by a country r and a region s representing the rest of the countries in the world. Region s can be disaggregated in as many regions as countries are considered in the MRIO tables, allowing us to identify the geographical origin of vertically integrated physical labour and nominal wages. Keeping this approach simple, the vector of physical labour requirements per unit of total output \(a_l\), Equation 3.05, can be expressed as the vector of direct physical labour per unit of total output in country r \((a_l^r)\) and for the rest of the world region s \((a_l^s)\), respectively:

\[
a_l^T = l_q^T \cdot q^{-1} = [a_l^r \ a_l^s]^T = [l_q^r \ l_q^s]^T \begin{bmatrix} \hat{q}_r^{-1} \\
\hat{q}_s^{-1} \end{bmatrix}
\]  

(3.19)

The Leontief inverse may be defined as the set of square submatrices covering all, direct and indirect, intermediate inputs required to produce an extra output unit in each subsystem. In other words, the submatrix \(\tilde{B}^{rr}\) contains all the domestic technical requirements \((\tilde{b}_{ij}^{rr})\) demanded by country r from itself to produce a final unit in each subsystem, whereas the submatrix \(B^{sr}\) embodies the foreign technical requirements \((b_{ij}^{sr})\) needed from country r. Similar reasoning is followed for the region s. Therefore, the vector of vertically integrated physical labour can be expressed as:

\[
v^T = a_l^T B = [v_r \ v_s]^T = [a_l^r \ a_l^s]^T \begin{bmatrix} B^{rr} & B^{rs} \\
B^{sr} & B^{ss} \end{bmatrix} = [a_l^r \tilde{B}^{rr} + a_l^s B^{sr} \ a_l^r B^{rs} + a_l^s B^{ss}]^T
\]  

(3.20),

---

12 Since, a wider disaggregation would not modify the reasoning, we will keep the two-region system in our argument. Nonetheless, in Appendix A an example of a three-region system is provided.
where $v^r$ can be described as the sum of the total physical labour required from country $r$ and region $s$. Using the hypothetical extraction method (Los, Timmer, and De Vries 2016) specified in Appendix A, we can disaggregate the total physical labour required by each subsystem according to its geographical origin. That is, at the subsystem level, we can express the total labour required to produce one unit of total output ($v^r_i$) in terms of domestic ($\tilde{v}^r_i$) and foreign labour ($v^{sr}_i$):

$$v^r_i = (a^r_i)^TB^{rr}e_i + (a^r_i)^TB^{sr}e_i = (a^r_i)^T\tilde{b}^{rr} + (a^r_i)^Tb^{sr} = \tilde{v}^r_i + v^{sr}_i$$

(3.21)

In MRIO models, the domestic submatrices $\tilde{B}^{rr}$ and $\tilde{B}^{ss}$ capture all the domestic technical requirements demanded for country $r$ and region $s$. Taking country $r$ and subsystem $i$ as an example, $\tilde{b}^{rr}_i$ describes those domestic technical requirements that never leave country $r$ before being embodied in the final product $i$ and those that leave the country, are engrossed in foreign intermediate inputs that are imported by country $r$. So, $\tilde{B}^{rr}$ needs to be differentiated from the traditional or national Leontief inverse $B^{rr}$. This latter is calculated from national input-output tables, representing the supply and demand flows between producers and consumers within an economy without considering the rest of the world (Miller and Blair 2009). As a result, we can define ($T^{rr}$) as the domestic intermediate inputs that leave the country and return engrossed in imported intermediate inputs (Arto, Dietzenbacher, and Rueda-Cantuche 2019). Mathematically:

$$T^{rr} = \tilde{B}^{rr} - B^{rr}$$

(3.22)

Considering $\tilde{B}^{rr} = B^{rr} + T^{rr}$, we can distinguish between the domestic technical requirements that never leave ($B^{rr}$), and those that leave the country and return embodied in imported intermediate inputs ($T^{rr}$). At the subsystem level, the vertically integrated physical labour can be re-expressed as:

$$v^r_i = (a^r_i)^TB^{rr}e_i + (a^r_i)^TT^{rr}e_i + (a^r_i)^TB^{sr}e_i = (a^r_i)^T\tilde{b}^{rr} + (a^r_i)^Tb^{sr} + (a^r_i)^Tb^{sr} = v^{rr}_i + v^{sr}_i + v^{sr}_i$$

(3.23)

---

13 $e_i$ is a column vector where all elements are unity.

14 For more details see the STAN Input Output Database or the WIOD database.
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in which the total domestic employment is divided between internationalised \((v_i^{rs})\) and inward \((v_i^r)\) employment before it has been incorporated into the final product.

The same reasoning is followed to calculate the vertical integrated nominal wages across subsystems disaggregated by geographical destination:

\[
\mathbf{a}_w^T = \mathbf{w}_q^T \cdot \mathbf{q}^{-1} = [\mathbf{a}_w^r \mathbf{a}_w^s]^T = [\mathbf{w}_q^r \mathbf{w}_q^s]^T \begin{bmatrix} \mathbf{q}_r^{-1} \\ \mathbf{q}_s^{-1} \end{bmatrix}
\]

\((3.24)\)

\[
\mathbf{v}_w^T = \mathbf{a}_w^T \mathbf{B} = [\mathbf{v}_w^r \mathbf{v}_w^s]^T = [\mathbf{a}_w^r \mathbf{a}_w^s]^T \begin{bmatrix} \mathbf{B}_{rr} & \mathbf{B}_{rs} \\ \mathbf{B}_{sr} & \mathbf{B}_{ss} \end{bmatrix} = [\mathbf{a}_w^r \mathbf{B}_{rr} + \mathbf{a}_w^s \mathbf{B}_{rs} \mathbf{a}_w^r \mathbf{B}_{rs} \mathbf{a}_w^s \mathbf{B}_{ss}]^T
\]

\((3.25)\)

We have \(\mathbf{a}_w^r\) and \(\mathbf{a}_w^s\), the vectors of direct nominal wages per unit of total output paid by countries \(r\) and \(s\); and \(\mathbf{v}_w^r\) and \(\mathbf{v}_w^s\), the vectors of vertically integrated nominal wages paid by countries \(r\) and \(s\) across their subsystems, respectively.

As in the case of vertically integrated physical labour, at the subsystem level, it is now possible to disaggregate the total nominal wages per unit of output paid across each subsystem by geographical destination:

\[
v_{wi}^r = (\mathbf{a}_w^r)^T \hat{\mathbf{B}}_{ri} \mathbf{e}_i + (\mathbf{a}_w^r)^T \mathbf{B}_{rs} \mathbf{e}_i = (\mathbf{a}_w^r)^T \hat{\mathbf{b}}_{ri}^{rr} + (\mathbf{a}_w^s)^T \mathbf{b}_{si}^{sr} = \hat{\mathbf{v}}_{wr}^{rr} + v_{wi}^{sr}
\]

\((3.26)\)

Following the same procedure as in Equations 3.22 and 3.23, the domestic vertically integrated nominal wage per unit of product can be decomposed into traditional domestic wages (those nominal wages that never leave the country), \(v_{wi}^{rr}\), and internationalised domestic wages (those nominal wages that leave the country embodied in intermediate inputs that are reimported engaged in intermediate inputs), \(v_{wi}^{rs}\):

\[
v_{wi}^r = (\mathbf{a}_w^r)^T \hat{\mathbf{B}}_{ri} \mathbf{e}_i + (\mathbf{a}_w^r)^T T_{rii} \mathbf{e}_i + (\mathbf{a}_w^s)^T \mathbf{B}_{sr} \mathbf{e}_i = (\mathbf{a}_w^r)^T \hat{\mathbf{b}}_{ri}^{rr} + (\mathbf{a}_w^r)^T T_{ri}^{rr} + (\mathbf{a}_w^s)^T \mathbf{b}_{si}^{sr} = v_{wi}^{rr} + v_{wi}^{rs} + v_{wi}^{sr}
\]

\((3.27)\)
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Dividing Equation 3.27 between Equation 3.23, we obtain the average nominal vertically integrated unitary wage rate \( w^r_i \) disaggregated by geographical origin\(^{15}\).

\[
\begin{align*}
  w^r_i &= \frac{v^w_i}{v^r_i} = \frac{(a^w_i)^T b^r_i}{(a^w_i)^T b^r_i + \omega^r_i T b^r_i} + \frac{(a^w_i)^T t^r_i}{(a^w_i)^T t^r_i + \omega^r_i T t^r_i} + \frac{(a^w_i)^T b^r_i}{(a^w_i)^T b^r_i + \omega^r_i T b^r_i} \\
  &= \frac{(a^w_i)^T b^r_i}{(a^w_i)^T b^r_i + \omega^r_i T b^r_i} + \frac{(a^w_i)^T t^r_i}{(a^w_i)^T t^r_i + \omega^r_i T t^r_i} + \frac{(a^w_i)^T b^r_i}{(a^w_i)^T b^r_i + \omega^r_i T b^r_i}
\end{align*}
\]

(3.28)

Therefore, using hypothetical extraction, we can identify the average nominal vertically integrated unitary wage rate per geographical origin:

\[
\begin{align*}
  w^{rr}_i &= \frac{v^{rr}_i}{v^r_i} \\
  w^{rst}_i &= \frac{v^{rst}_i}{v^r_i} \\
  w^{sr}_i &= \frac{v^{sr}_i}{v^r_i}
\end{align*}
\]

(3.29) (3.30) (3.31)

Multiplying each component of Equation 3.28 \( w^r_i \)\(^{16}\) by the labour distribution, as a weighted average, we can decompose \( \omega^r_i \) into the previous three components:

\[
\begin{align*}
  w^r_i &= \left[ w^{rr}_i \frac{v^{rr}_i}{v^r_i} \right] + \left[ w^{rst}_i \frac{v^{rst}_i}{v^r_i} \right] + \left[ w^{sr}_i \frac{v^{sr}_i}{v^r_i} \right]
\end{align*}
\]

(3.32)\(^{17}\)

Exchanging the share of labour distribution from the share of labour distribution in the year 0, we obtain a proxy of the labour cost structure if the technical requirement has been fixed or given during the period:

\[
\begin{align*}
  w^r_i &= \left[ w^{rr}_i \frac{v^{rr}_i}{v^r_i} \right] + \left[ w^{rst}_i \frac{v^{rst}_i}{v^r_i} \right] + \left[ w^{sr}_i \frac{v^{sr}_i}{v^r_i} \right]
\end{align*}
\]

(3.33)

\(^{15}\) Note, as explained in Section 3.4, note 6, for Equation 3.10, \( [a^w_i a^w_i]^T [a^{-1}_i a^{-1}_i] \neq [w^r w^r]^T [w^{-1}_i w^{-1}_i] \neq [\omega^r \omega^r]^T \). Each element \( a^w_i a^w_i \) describes the domestic average wage rate per unit of output in each industry. Each element \( a^r_i \) represents the average wage rate per unit of output in each subsystem, that is, it involves nominal wages and labour requirements from all the industries and countries that participate in the production of one unit of output.

\(^{16}\) Equations 3.29, 3.30 and 3.31.

\(^{17}\) \( w^r_i = \left[ \frac{v^{rr}_i}{v^r_i} \right] + \left[ \frac{v^{rst}_i}{v^r_i} \right] + \left[ \frac{v^{sr}_i}{v^r_i} \right] = \frac{v^{rr}_i}{v^r_i} + \frac{v^{rst}_i}{v^r_i} + \frac{v^{sr}_i}{v^r_i} \)
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Finally, we can estimate the changes in the cost structure of GVCs associated with changes in the labour distribution over a current year \( t \):

\[
\frac{\Delta w_i^r}{w_i^r} = \frac{(w_i^r - w_i^r)}{w_i^r}
\]

(3.34)

In addition, to complement the empirical analysis of the impact of labour distribution in GVCs’ labour cost structure, from Equations 3.23, 3.26 and 3.29, the changes in the average wage rate per product across the GVC can be decomposed into changes in wage per worker and changes in the nominal productivity by geographic origin. For a particular subsystem, the vertically integrated traditional domestic wage per output for years 0 and year \( t \) can be defined as \( v_{w_i(t_0)}^r = w_{i(t_0)}^r \) and \( v_{w_i}^r = w_{i}^r * v_{i}^r \), respectively. The difference in the domestic wage by output in the period as:

\[
v_{w_i}^r - v_{w_i(t_0)}^r = (w_i^r * v_{i}^r) - (w_{i(t_0)}^r * v_{i(t_0)}^r) = (w_i^r * v_{i}^r) - (w_{i(t_0)}^r * v_{i(t_0)}^r) + (w_{i(t_0)}^r * v_{i(t_0)}^r) - (w_{i(t_0)}^r * v_{i(t_0)}^r)
\]

Dividing both parts by \( v_{w_i(t_0)}^r \) we get the percentage change in the period:

\[
\frac{v_{w_i}^r - v_{w_i(t_0)}^r}{v_{w_i(t_0)}^r} = \frac{(w_i^r - w_{i(t_0)}^r)}{v_{w_i(t_0)}^r} v_{i}^r + \frac{(v_{i}^r - v_{i(t_0)}^r)}{v_{w_i(t_0)}^r} w_{i(t_0)}^r
\]

(3.35)

If we substitute \( v_{w_i(t_0)}^r = w_{i(t_0)}^r * v_{i(t_0)}^r \) into each component, the change in the vertically integrated traditional domestic nominal wage per product can be expressed as:

\[
\frac{v_{w_i}^r - v_{w_i(t_0)}^r}{v_{w_i(t_0)}^r} = \left(\frac{w_i^r - w_{i(t_0)}^r}{w_{i(t_0)}^r}\right) \frac{w_{i(t_0)}^r}{v_{i(t_0)}^r} + \left(\frac{v_{i}^r - v_{i(t_0)}^r}{v_{w_i(t_0)}^r}\right) \frac{w_{i(t_0)}^r}{v_{i(t_0)}^r} = \Delta w_i^r \frac{w_{i(t_0)}^r}{v_{i(t_0)}^r} + \Delta v_i^r \frac{w_{i(t_0)}^r}{v_{i(t_0)}^r}
\]

(3.36)

We can also express \( v_{w_i}^r - v_{w_i(t_0)}^r \) as:

\[
v_{w_i}^r - v_{w_i(t_0)}^r = (w_i^r * v_{i}^r) - (w_{i(t_0)}^r * v_{i(t_0)}^r) + (w_{i(t_0)}^r * v_{i(t_0)}^r) - (w_{i(t_0)}^r * v_{i(t_0)}^r)
\]

(3.37)

And therefore,
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\[
\begin{align*}
\frac{v^{rr}_{wi} - v^{rr}_{wi(t_0)}}{v^{rr}_{wi(t_0)}} &= \frac{v^{rr}_{i} - v^{rr}_{i(t_0)}}{v^{rr}_{i(t_0)}} \frac{w^{rr}_{i} - w^{rr}_{i(t_0)}}{w^{rr}_{i(t_0)}} + \frac{v^{rr}_{i} - v^{rr}_{i(t_0)}}{v^{rr}_{i(t_0)}} \frac{w^{rr}_{i} - w^{rr}_{i(t_0)}}{w^{rr}_{i(t_0)}} \frac{v^{rr}_{i} - v^{rr}_{i(t_0)}}{v^{rr}_{i(t_0)}}
\end{align*}
\]

We thus define the change in the vertically integrated traditional domestic nominal wage per product as:

\[
\frac{\Delta v^{rr}_{wi}}{v^{rr}_{wi(t_0)}} = \frac{v^{rr}_{wi} - v^{rr}_{wi(t_0)}}{v^{rr}_{wi(t_0)}} = \frac{\Delta w^{rr}_{i} + \Delta v^{rr}_{i} - \Delta v^{rr}_{i(t_0)}}{v^{rr}_{i(t_0)}} + \frac{\Delta w^{rr}_{i} + \Delta v^{rr}_{i} - \Delta v^{rr}_{i(t_0)}}{v^{rr}_{i(t_0)}}
\]

wage per worker component + labour per output component

(3.39)

The changes in the structural decomposition of the vertically integrated internationalised domestic nominal wage per product and the vertically integrated imported nominal wages per product, across the period, are calculated following the same procedure.

In summary, the combination of the hypothetical extraction method and the vertical integration approach makes it possible to estimate the labour cost structure across subsystems through the average nominal vertically integrated unitary wage rate \( (w^{rr}_{i}) \). This measure has three main analytical advantages. Firstly, it allows us to identify changes in the total nominal wages paid per worker in each country or region participating in the subsystem.

As will show in Chapter 5, we disaggregate regions into four different groups depending on if the countries were members of the EU and their income level. The distinction between BTT and TTT also allows us to distinguish between the internationalised and inward domestic technical requirements. Secondly, it enables us to analyse the technical changes across the subsystem and the performance of the different regions through the labour distribution's component. And thirdly, it permits measuring the changes in each subsystem’s labour cost structure during the period.

3.6 The relative vertically integrated unitary labour costs and their components

The third research objective of this thesis is to contribute to the international competitiveness literature by assessing the impact of GVCs on the subsystems' cost competitiveness. We pay particular attention to the relative levels of unit labour costs and their impact on the dynamics of costs competitiveness. As described analytically below, the
unitary labour costs (ULC) measure is a ratio between the leading cost category, labour compensation, and the final net output in the production process. Thus, the link between ULC and international competitiveness can be understood better if we define it in terms of the ratio of labour compensation per unit of work and the physical labour productivity (Ark, Stuivenwold, and Ypma 2005; Bournakis 2014).

A change in ULC has two main economic implications. On the one hand, a fall of ULC in a particular subsystem, for instance, that associated with French automotive final exports, may cause a drop in the employment levels in the short term. However, this loss of jobs may be reversed in the long run because the gain of share in the international market may provoke a growth of final demand for French automotives. On the other hand, a drop in ULC does not mean a drop in labour costs; it also can be the result of an improvement in labour productivity. In summary, changes in ULC can be motivated by different strategies focused on wage-cutting, improvements in labour productivity, or exogenous shocks in final demand (Ark, Stuivenwold, and Ypma 2005).

The main literature bases its analysis on the industry level, with direct domestic ULC, i.e., they consider the ULC generated directly by the industry itself as the primary indicator of cost competitiveness (Artto 1987; Di Mauro and Forster 2008; Wolfmayr 2012; Hooper and Larfn 1989; Ark, Stuivenwold, and Ypma 2005; Felipe and Kumar 2011; Carlin, Glyn, and Reenen 2001; Bournakis 2014). However, the emergence of GVCs across the world has broken the traditional production scheme in which more activities were accomplished domestically. The ULC generated by an industry $i$ of country $r$ can be embodied in the final exports of the subsystem $j$ of country $m$ (Koopman, Wang, and Wei 2014; Gereffi 2014). As a consequence, there is a clear need to develop a new ULC measure that includes the impact of GVCs on cost competitiveness, a measure of vertically integrated unit labour cost ($viulc$).

Despite the relevance of this issue, the literature specialised in cost competitiveness in a GVCs context is still in an incipient stage. We found two works that deserve to be underlined in this field. Grodzicki & Skryzpek (2020) attempt to transform the traditionally ULC measure in a $viulc$, adjusting the former using the vertically integrated real value-added as a weighted measure to determine the share of each country-industry in the ULC of the automotive industry in a particular country, for example in the French automotive industry. They analyse the average contributions to ULCs of all the country-industries that participated in the GVCs of the main EU economies' final automotive goods and disaggregated domestic and foreign resources cost. Following a very similar approach and goals, Marczak & Beissinger (2021) suggest an 'embodied unit labour costs' (EULC) measure for individual sectors or sectoral
aggregates that consider both domestic and imported ULC using the value-added contributions of each country-industry as a weighted variable. The main difference between both approaches is that the former is based on real value-added deflated by the Purchasing Power Parities (PPP), and the latter is presented in nominal categories.

Although both studies make a concerted effort to take into account the role of GVCs in their analysis, we find that some of their assumptions might be problematic. In both studies, the ULC is calculated at the industry level, based on the direct labour costs and productivity, and they are being converted into a vertically integrated measure through a proxy based on a standardised element of the GVC matrix. In other words, they combine a measure at the industry level (ULC) with a measure at the subsystem level (the vertically integrated value added), which does not precisely respond to the subsystem's definition and may generate inaccurate results. Moreover, by relating the ULC to the value added, both papers have linked both components of ULC, nominal labour compensation and physical productivity, to the income distribution, which is not necessarily connected to the production of physical output (De Juan and Febrero 2000). In the case of Grodzicki & Skryzpek (2020), they introduce the notion of real value added in their proxy measures, which may generate a measurement precision problem from our perspective. In National Accounts, the value added is estimated as the difference between the gross output and the intermediate consumption (inputs). The value added is a remainder in nominal terms; therefore, deflating it for a value added's price index is imprecise because each does not reflect the value added's purchasing power.

To fill this research gap, I redefine ULC in a novel vertically integrated unitary labour costs (viulc) measure that considers the role of production fragmentation in the production of final exports. In contrast to previous works, our notion of viulc is based on a subsystem perspective that considers the role of production fragmentation in the production of final exports. In contrast to previous works, our notion of viulc is based on a subsystem perspective (Pasinetti 1973; Sraffa 1960; Halevi 1996). Thus, rather than a weighted sum of the national, industry-level ULCs using an income measure such as value added, I focus on units of final output exported as an indicator of net output. This conceptual difference is essential because, as will be shown below, it allows us to build a viulc measure which consistently separates between a vertically integrated nominal wage rate and total labour

---

18 In the development of Equation 3.10 and the note 8, we explain the difference between the analysis at subsystem or industry level. For more details see Pasinetti (1973).
productivity (expressed in prices of a base year). Hence, it may adequately capture (and distinguish between) changes in technical conditions (De Juan and Febrero 2000; Elmslie and Milberg 1996; Garbellini and Wirkierman 2014b) and wage rate dynamics. This is in sharp contrast to indicators of ULC based on notions of productivity change pivoting around value added (such as real value-added per worker or TFP growth).

Following the same procedure that in Equation 3.10, we can define the vector of vertically integrated nominal wages per final exports in the global economy as ($\mathbf{l}_w^T$):

$$\mathbf{l}_w^T = \mathbf{a}_w^T \cdot \mathbf{B} \cdot \mathbf{f}$$ (3.40)

where each element $l_{w_i}^r$ is the global nominal wage bill -direct and indirect labour compensation- paid for the subsystem $i$ of country $r$ in US current dollar. The average wage per worker across the GVCs is defined as $w_i^r = \frac{l_{w_i}^r}{w_i}$. In addition, $l_i^r$ can be redefined as $l_i^r = \frac{l_{w_i}^r}{w_i}$. Therefore, the global labour required is equal to the total wage bill divided by the average wage per worker in current dollars across the GVCs:

$$\mathbf{l}_v^T = \mathbf{l}_w^T \cdot (\mathbf{\bar{w}})^{-1}$$ (3.41)

Introducing Equation 3.41 in 3.17, we have the vector of total required labour in nominal US dollar wages:

$$\mathbf{f}^T = [\mathbf{l}_w^T \cdot (\mathbf{\bar{w}})^{-1}] \cdot \mathbf{\bar{v}} \cdot \mathbf{\bar{\phi}}(t_b) \cdot \mathbf{\bar{\alpha}}^*$$ (3.42)

The final exports in current dollars ($f_i^r = \frac{l_{w_i}^r}{w_i} * \mathbf{\bar{\mu}}^r * \mathbf{\bar{\phi}}(t_b) * \mathbf{\bar{\alpha}}^*$) is now explained by the product of wages in nominal current US dollars, the exchange rate, the index prices, and the productivity in physical units$^{19}$. Transferring $\mathbf{\bar{\mu}}^r$ and $\mathbf{\bar{\phi}}(t_b)$ to the left-hand side of the equation$^{20}$, the final exports in physical units can be defined in terms of wages and physical labour productivity, $\frac{f_i^r}{l_i^r * \mathbf{\bar{\phi}}(t_b)} = \frac{\mathbf{\bar{f}}_i^r}{l_i^r} = \frac{l_{w_i}^r}{w_i} * \mathbf{\bar{\alpha}}^*$:

$$\mathbf{\bar{f}}^T = [\mathbf{l}_w^T \cdot (\mathbf{\bar{w}})^{-1}] \cdot \mathbf{\bar{\alpha}}^*$$ (3.43)

$^{19}$ Output per unit of labour in constant local currency prices

$^{20}$ That is, defining the final exports in constant prices at local currency, $\bar{f}_i^r = f_i^r = \frac{f_i^r}{\mathbf{\bar{\mu}}^r * \mathbf{\bar{\phi}}(t_b)} = \frac{l_{w_i}^r}{l_i^r} * \mathbf{\bar{\mu}}^r * \mathbf{\bar{\phi}}(t_b) * \frac{1}{\mathbf{\bar{\mu}}^r}$
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Operating\(^{21}\) in both sides of \(\bar{f}_i = \frac{t_{\omega i}}{\omega_i} \cdot \alpha_i^r\), we can express the \(viulc\) in terms of the average vertically integrated nominal wage per worker in current US dollar and the vertically integrated unitary labour productivity in physical terms, \(viulc^r_i = \frac{t_{\omega i}}{\bar{f}_i} = \frac{w_i^r}{\alpha_i^r} :\)

\[
\text{viulc}^T = \mathbf{w}^T \cdot (\frac{\mathbf{f}}{\bar{f}})^{-1} = \mathbf{w}^T \cdot (\frac{\mathbf{v}_i}{\alpha_i^r})^{-1} \tag{3.44}
\]

As observed in 3.44, the notion of \(viulc\) respond to the exact definition of the traditional ULC indicator. It can be measured as functional distribution of the income in each subsystem, the share of wages over the total income, \(\bar{f}_i / \mathbf{f}_i\); or as the ratio wages per worker to labour productivity, i.e., how much workers are paid in relation to how productive they are, \(w^r_i / \omega_i^r\) (Felipe and Kumar 2011). As in ULC, in \(viulc\), the labour costs (the numerator) is expressed in nominal terms, while the final exports or labour productivity (the denominator) is expressed in real terms or physical units. This means that when the ULC of two subsystems of the same industry, but different countries, are compared, the nominal average wages per worker behaves as the arbitrage cost element. Rather, the final exports related productivity refers to a volume measure, since it resembles a quantity of final exports (Ark, Stuivenwold, and Ypma 2005). As a contribution, the notion of \(viulc\) considers the nominal wages and physical labour productivity across the whole GVCs, including all the industries that participate in the process of production.

Nevertheless, although consistent and extensively applicable, the notion of \(viulc\) defined in this chapter also presents certain limitations. Firstly, the vector of average vertically integrated nominal wage per worker (\(\mathbf{w}(t_i)\)) operates under many exchange rates as countries participate in the GVCs of each subsystem. Hence, it is not possible to distinguish the exchange rate from the nominal wage, as has been done with the traditional measure of ULC (Carlin, Glyn, and Reenen 2001; Hooper and Larfn 1989; Ark, Stuivenwold, and Ypma 2005). Secondly, our analysis concentrates only on \(viulc\), i.e., workers’ side, leaving aside other determinants of cost competitiveness such as unitary capital costs (UKC)\(^{22}\) which, might affect cost competitiveness from the capital side (Felipe and Kumar 2011). It could happen that a decrease in ULC triggered an increase in profit rate rather than an improvement in cost

\[^{21}\bar{f}_i = \frac{1}{\mathbf{f}_i} = \frac{1}{\mathbf{w}_i} \cdot \frac{1}{\omega_i^r}\]

\[^{22}ukl_i^r = \left(\frac{\pi^r \cdot \mathbf{k}_i}{\mathbf{v}_a^r} \cdot \phi(t_i)\right)\text{ where } ukl \text{ is the unit capital cost, } \pi \text{ is the ex post nominal profit rate, } v_a \text{ is nominal value-added, and } k \text{ is the capital stock and } \phi \text{ the price index (Felipe and Kumar 2011).} \]
It is necessary to emphasize that the viulc of each subsystem is constructed from using its local currency. This allows us to analyze only changes in viulc, not of levels. The latter would involve having all the elements in a common currency. In accordance with this approach, we express viulc as an index that permits us to study the viulc dynamics across time, i.e.

\[ I_{\text{viulc}}(t) = \frac{\text{viulc}(t)}{\text{viulc}(t_0)} \]

in which the viulc for the subsystem of the economy at year \( t \) is related to the viulc for the subsystem of the economy in the year 0 (\( t_0 \)).

\[ I_{\text{viulc}} = \text{viulc} \cdot \left(\frac{\text{viulc}(t_0)}{\text{viulc}(t_0)}\right)^{-1} \] (3.45)

Following the same reasoning, we can calculate the indexes of the average vertically integrated unitary nominal wages (\( I_{\text{viunw}} \)) and labour productivity in physical terms (\( I_{\text{viulp}} \)):

\[ I_{\text{viunw}} = \text{lw} \cdot \left(\frac{\text{lw}(t_0)}{\text{lw}(t_0)}\right)^{-1} \] (3.46)

\[ I_{\text{viulp}} = \alpha^T \cdot \left(\frac{\alpha^T(t_0)}{\alpha^T(t_0)}\right)^{-1} \] (3.47)

In summary, we propose a new notion of viulc that involves the whole production process. Starting from an accounting scheme grounded in Multi-Regional Input-Output tables, this approach pays special attention to distinguishing between the role of prices and quantities as a component of the final export demand. It also allows us to distinguish between changes in labour costs and changes in the physical quantity of production related to technological changes across GVCS, avoiding interferences of income variables in this latter.

3.7 Summary

This chapter outlines the analytical model needed to analyse the role of global value chains in the EU final export performance. We build an analytical framework compatible with a

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23 As it has been highlighted by the literature previously (Carlin, Glyn, and Reenen 2001).
24 Base year (\( t_b \)) and year 0 do not have to coincide. In our dataset, the base year is 2010, while the year 0 is 2000.
global closed economic system, starting from a Multi-Regional Input-Output (MRIO) scheme and a vertical integration approach.

The model's consistency with the structure of the national accounts has two main advantages. On the one hand, it avoids the double counting generated by the multiple accounting of certain intermediate inputs based on gross flows (value added in trade models). On the other hand, the notion of subsystem offers the necessary flexibility to adapt the analytical framework to different research objectives. First, we define the growth of final exports as a function of monetary variables (exchange rate and price changes) and two real variables (productivity and scale of labour). Second, we provide a decomposition of the vertically integrated nominal wage rate decomposed by geographical origin, which calculates the cost structure of each subsystem and the effects of offshoring and the new international division of labour on it. And third, we develop a new indicator of vertically integrated unit labour costs based on physical units, which avoids the distortions caused by variables such as value added, more related to the distribution of income than to the current production conditions.
Chapter 4: What are the determinants of final export dynamics in the GVCs of EU countries?

4.1 Introduction
This chapter aims to distinguish between core and periphery regions using the subsystem approach. It addresses objective 1 of this research, i.e., identifying the main drivers of export growth for EU subsystems in core and peripheral regions and by product types between 2000 and 2014. This analysis is based on the discussion about the role of production fragmentation and the new international division of labour (Ricci 2021) on the inequalities in the EU production structures (Stöllinger 2016), as considered in Chapter 2; and the novel final export decomposition linked to Pasinetti's subsystem notion (Pasinetti 1973), detailed in Section 3.4 of Chapter 3.

In particular, the chapter focuses on the following research questions: What are the determinants of final exports dynamics in the GVCs of core and peripheral countries? Which are the main differences between product types? Are the final export dynamics stable across the period? Do the final export dynamics impact the market share of each region? Has this impact been uniform between product types? The obtained results have motivated the analysis of offshoring and labour income distribution in Chapter 5 (objective 2) and on EU competitiveness in Chapter 6 (objective 3).

The structure of the chapter is as follows. Section 4.2 summarises the main features of the final export equation developed in Section 3.4 of Chapter 3 and its transformation into logarithms to study the dynamics of changes. Section 4.3 describes the databases used and a preliminary survey of the data on which the empirical analysis of this chapter and the following two chapters (Chapters 5 and 6) will be based. In Section 4.4, the main empirical results of final export dynamics are discussed, distinguishing between the EU core and peripheral region and product types. Finally, Section 4.5 highlights the main conclusions of the chapter.

4.2 The equation of final exports
In order to address research objective 1, the demand for final exports is decomposed based on Pasinetti’s method of vertical integration (Pasinetti 1973), as considered in Chapter 3. The main advantage of decomposing final exports in this way is that it allows us to estimate the direct and indirect effects of each of the real variables on final exports. Thus, we take into
account, for example, the effects of direct domestic labour productivity and the indirect labour productivity generated through the GVCs also embodied in the intermediate inputs (Pasinetti 1973).

The derivation of the vertically integrated final exports equation (Equation 3.17) is a novelty contribution of this thesis, as explained in section 3.4 of chapter 3. By way of summary, it can be said that, based on an MRIO framework, final exports are decomposed as the product of two monetary variables (exchange rate – \( \hat{\varepsilon} \) – and price index – \( \hat{\varphi}(t_b) \)) and two real variables (vertically integrated labour productivity and required quantity of labour) (Equation 3.17):

\[
f = \hat{\varepsilon} \cdot \hat{\varphi}(t_b) \cdot \mathbf{\alpha}^* \cdot \mathbf{l}_v
\]

where \( \hat{\varepsilon} \) is the diagonal nominal exchange rate matrix, in which each element represents the ratio of the US dollar to the local currency of a final exporting subsystem. The diagonal matrix \( \hat{\varphi}(t_b) \) contains the price indices of each final exporting subsystem for the base year 2010. \( \mathbf{\alpha}^* \) is the diagonal matrix of physical vertically integrated labour productivity, where each element \( \alpha^*_i = \frac{p^i(t_b)}{\theta^i} = \frac{1}{v^i \cdot \phi^i(t_b) \cdot e^r} \) indicates set of total technical conditions, given in the country’s own subsystem i of the country r, and indirect changes, i.e., those occurring in the industries that provide it with intermediate inputs. And the vector \( \mathbf{l}_v \) measures the direct and indirect labour required by the economic system as a whole i from country r to produce the total net exports, that is, the induced employment by the foreign demand.

As is explained in Chapter 3, the different components of final demand are expressed in different units of measurement and show a multiplicative relationship between them. Therefore, in order to estimate the impact of each of them on the dynamics of final demand, it is necessary to express each subsystem of Equation 3.17 in logarithmic terms:

\[
\ln(f^*_i) = \ln(e^r) + \ln(\phi^i(t_b)) + \ln(\alpha^*_i) + \ln(l^*_v)
\]

(4.01)
Therefore, the average annual proportional change between t=1 and t=T for each component’s subsystem is calculated as follows:

\[
\left( \frac{\ln(f_i^T) - \ln(f_i^1)}{T - 1} \right) = \\
\left( \frac{\ln(e^1_r) - \ln(e^T_r)}{T - 1} \right) + \left( \frac{\ln(\phi_i^T) - \ln(\phi_i^1)}{T - 1} \right) + \left( \frac{\ln(\alpha_i^T) - \ln(\alpha_i^1)}{T - 1} \right) + \left( \frac{\ln(l^1_i) - \ln(l^T_i)}{T - 1} \right)
\]

(4.02)

In short, Equation 4.02 represents the growth dynamic of each subsystem disaggregated in the evolution of the four components: exchange rate, relative prices, physical labour productivity and labour induced by the foreign demand. This decomposition is important, since it allows to separate prices and quantities as determinants of final export growth. Within prices, it separates domestic price dynamics from fluctuating exchange rate developments. Within quantities, it distinguishes whether growth is predominantly explained by a productivity or a scale effect.

4.3 Preliminary Data description

Before introducing the empirical results, the sources used and a preliminary data analysis must be described. Since this thesis’s explicit purpose is to explore the impact of GVCs on the final export performance and cost structure in the EU, the first step to follow is to highlight the most relevant exporter subsystems and how their cost competitiveness patterns have changed during the period.

The principal data set used in this work was obtained from the World Input-Output Database (WIOD). The second release of the dataset, WIOD-2016, provides three complementary databases: World Input-Output Tables (WIOTs), the table of exchange rates and Socio-Economic Accounts (SEA)\(^{25}\). The WIOTs are a time-series of national symmetric input-output tables covering 28 EU economies\(^ {26} \) and 15 other major economies for 56 industries\(^ {27} \) from

\(^{25}\) All the details can be found in [https://www.rug.nl/ggdc/valuechain/wiod/wiod-2016-release](https://www.rug.nl/ggdc/valuechain/wiod/wiod-2016-release) (Accessed 13th February 2022).

\(^{26}\) The UK is included, since the data is from 2000 to 2014.

\(^{27}\) The whole list of industries and their codes can be consulted in Appendix B.
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2000 to 2014, following the International Standard Industrial Classification Revision 4 (ISIC Rev. 4) (Dietzenbacher, Los, et al. 2013). WIOTs also estimate flows for the rest of the world (RoW), allowing us to work with an endogenous global economic system. The Socio-Economic Accounts (SEAs) and the table of exchange rates complement the industrial classification of WIOTs, providing, among other magnitudes, industry-level data relating to employment, labour compensation, price levels, and the exchange rate, making the WIOD dataset useful for structural change analysis. The output price index it provides takes 2010 as the base year.

The main limitation of SEAs is that it does not cover the RoW, which hinders the realisation of an analysis that would consider the global economic system. In order to be able to work with the entire economic system as a whole, this study provides an original estimation of the vectors of the number of employees, labour compensation, price indices and exchange rates for the RoW compatible with SEAs, using ILOSTAT and SEAs as primary sources. The applied method is explained in Appendix C. After estimating the data for RoW, the number of subsystems was reduced from 56 to 54. The subsystems of other service activities (54OSERV), activities of households as employers (55HHSERV), and activities of extraterritorial organisations and bodies (56EXORG) were aggregated, since they were very small, and there was a lack of data, particularly in the cells of intermediate inputs.

Certain decisions were made in order to focus the analysis. Firstly, the six subsystems that belong to the industries related to trade and transport margins were removed from this panel data: wholesale trade, except motor vehicles and motorcycles (29WTRADE), retail trade, except motor vehicles and motorcycles (30RTRADE), land transport and transport via pipelines (31LANDTR), water transport (32WATERTR), air transport (33AIRTR) and insurance, reinsurance, and pension funding (42INSUR). This is due to the fact that these subsystems provide trade and transport services essentially dependent on trade in other goods. Their explicit recognition as components of final output is due to the analytical separation between valuation at consumer prices and at basic prices (Eurostat 2008).

Figure 4.1 presents the real final exports’ structure in the EU and how it changes during the considered period. The international relevance of the 48 analysed subsystems has been stable across the period. Figure 4.1 also shows two interesting characteristics of the EU economies.
international performance. On the one hand, the international performance is driven by manufacturing subsystems, which have held their relative international position across the period. On the other hand, the EU export activity is very concentrated in a few industries, which represent most of EU international trade.

Figure 4.1. Real final Export market shares of each EU subsystem over the total EU final exports

Source: Author’s calculations based on WIOD

In order to figure out the most important EU subsystems in terms of final export, Table 4.1 presents the weight of the top 15 subsystems at constant prices and their cumulative weight for both constant and current prices in 2014. What immediately stands out is that the cumulative share of the first five subsystems represents more than 50% of EU final exports, the top 10 around 75% and the top 15 more than 85%. The same top 15 subsystems represent around 86% of the total real final exports in 2000. Therefore, we can consider the levels of 2014 to be representative for the period. Furthermore, real and nominal measures do not
largely differ. Therefore, the relative relevance of the subsystems over the total EU final exports is not affected by changes in prices.

Table 4.1. Global market share of total EU final exports in decreasing order. Year 2014

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Constant USD</th>
<th>Accum. Constant USD</th>
<th>Accum. Current USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>20VEHIC</td>
<td>17.33</td>
<td>17.33</td>
<td>17.03</td>
</tr>
<tr>
<td>05FOOD</td>
<td>12.79</td>
<td>30.12</td>
<td>30.37</td>
</tr>
<tr>
<td>19MMACHEQ</td>
<td>12.05</td>
<td>42.17</td>
<td>42.57</td>
</tr>
<tr>
<td>17ICTEQ</td>
<td>6.61</td>
<td>48.77</td>
<td>48.67</td>
</tr>
<tr>
<td>12PHARMA</td>
<td>5.81</td>
<td>54.58</td>
<td>54.21</td>
</tr>
<tr>
<td>21TREQ</td>
<td>4.96</td>
<td>59.54</td>
<td>59.16</td>
</tr>
<tr>
<td>06TEXT</td>
<td>4.50</td>
<td>64.04</td>
<td>63.81</td>
</tr>
<tr>
<td>22OMAN</td>
<td>4.14</td>
<td>68.18</td>
<td>68.15</td>
</tr>
<tr>
<td>18ELECEQ</td>
<td>3.48</td>
<td>71.66</td>
<td>71.55</td>
</tr>
<tr>
<td>40ICTPROG</td>
<td>2.81</td>
<td>74.47</td>
<td>74.39</td>
</tr>
<tr>
<td>41FINANCE</td>
<td>2.60</td>
<td>77.07</td>
<td>77.10</td>
</tr>
<tr>
<td>11CHEM</td>
<td>2.45</td>
<td>79.52</td>
<td>79.65</td>
</tr>
<tr>
<td>10REFPETR</td>
<td>2.41</td>
<td>81.92</td>
<td>81.96</td>
</tr>
<tr>
<td>01AGRIC</td>
<td>2.07</td>
<td>83.99</td>
<td>84.02</td>
</tr>
<tr>
<td>16METPRDS</td>
<td>1.76</td>
<td>85.75</td>
<td>85.75</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD

As hinted by Table 4.1, these top 15 subsystems are the heart of EU real final exports, thus it can be assumed that they define the behaviour of EU competitiveness. Consequently, it is reasonable to confine our empirical analysis to them. Nevertheless, some countries’ lack of data for manufacturing coke and refined petroleum products (10REFPETR) has forced us to remove it and focus on the 14 remaining subsystems.

As pointed out by the Marxist schools of development and dependency, the dynamic of international competition and the new division of production into GVCs has stimulated the consolidation of certain EU economies in semi-peripheral positions within the international division of labour\textsuperscript{30}. Although these facts have provoked an increase in academic contributions about the EU core-periphery dynamics\textsuperscript{31}, there is no consensus about the

\textsuperscript{30} See Sections 2.2. and 2.4, Chapter 2.
\textsuperscript{31} Although considering the socio-economic characteristics of the EU, it might be more appropriate to speak about core and semi-peripheral countries (Arrighi and Drangel 1986), for simplicity, most of the literature has adopted the notions of core and periphery in the EU framework, including this thesis.
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Some studies have focused on particular regions. For example, Simonazzi et al. (2018) analyse the uneven interrelationships between the Southern European economies (including France) with Germany as the core. They argue that, although France is the second most important economy in the EU, the obstacles imposed by the EU to invest in industrial upgrading through liberal industrial and financial policies has also provoked a significant setback in its export competitiveness in favour of Germany. Moreover, these policies also promote speculative practices that increase private debt and reproduce structural problems and the prevailing core-periphery relationships.

The works developed by Gräbner and Hafele (2020) make similar claims to Simonazzi et al. (2018). They link the core economies to export-driven growth and the periphery to a debt-driven model motivated by non-price competitiveness, which depends on the technical conditions and their political power inside the EU. These authors open the analysis to the whole EU, distinguishing between a core (Austria, Belgium, Denmark, Finland, France, Germany and Sweden), two peripheries (Southern: Cyprus, Greece, Italy, Portugal, and Spain; and East: Bulgaria, Romania, Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Slovenia, Slovakia), and financial (Luxembourg, Netherlands, Malta, and Ireland)\(^\text{32}\). However, they recognise that considering some countries, such as Italy, as part of the periphery is undoubtedly controversial. Although Italy has a high public debt and relatively high unemployment rates, its political influence and highly innovative and international specialisation in some industries may make it possible to consider it as a core economy.

\(^{32}\) Previously, Gräbner et al. (2019) develops the idea of different accumulation dynamics of the EU economies’ technical capabilities as elemental drivers in the divergences in their development; and considers how the strategy of economic openness has aggravated the structural EU polarization, distinguishing between the same core-periphery groups but including France as part of the Southern periphery.
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Adopting a New Economic Geography (NEG) framework (Krugman 1999). Caraveli (2017) studies the process of regional polarisation within the EU. Caraveli distinguishes between three peripheries: Southern periphery (Cyprus, Greece, Italy, Portugal and Spain); CEECs (Bulgaria, Czech Republic, Hungary, Romania, Slovak Republic, Slovenia and Poland); and The Baltics (Lituania, Latvia and Estonia). She concludes that the strong linkages between the core- South periphery may limit the convergence of CEECs and Baltic peripheries.

Grodzicki and Geodecki (2016) analyse the core-periphery relationship from an international division of labour. They justify that their categorisation of EU economies according to ‘the colloquial meaning of the internal differentiation of the EU member-states’ (Grodzicki and Geodecki 2016, 388): ten core North-Western European countries (Austria, Belgium, Denmark, Finland, France, Germany, Ireland, the Netherlands, Sweden and the United Kingdom), four peripheral Southern economies (Italy, Greece, Spain, Portugal) and ten Central and East countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia)33.

It may be thus concluded, from this review, that the heterogeneity of the core-periphery studies in the EU prevent having a unique classification applicable for the different EU challenges. For the objectives of this thesis, I consider it more appropriate to classify the different EU economies, following Braun’s unequal exchange approach, that is, using the level of domestic nominal wages as a key element to distinguish between core and periphery economies. Figure 4.2 illustrates the average direct nominal domestic wages per worker for the top 14 final export subsystems. The red horizontal line shows the average across subsystems, highlighting a clear division in worker income between the EU core subsystems from north-central Europe, Italy and Spain (Denmark, Belgium, France, Ireland, Iceland, the UK, Netherlands, Sweden, Finland, Austria, Germany, Italy and Spain), and the EU peripheral group constituted by the Central-Eastern plus Portuguese and Greek subsystems (Slovenia, Greece, Portugal, Estonia, Slovakia, Czech Republic, Latvia, Lithuania, Poland, Hungary, Hungary, Hungary, Hungary).

33 Other relevant core-periphery works are: Esposito et al. (2019) based on the geographical location; Becker et al (2015) focuses on level of integration and industrialisation; Thomas (2013) studies the EU convergence; Farole et al. (2011) focuses on the geographical dynamics of economic development. Finally, studies by Bartlett and Price (2016; 2017), and Kersan-Škabić (2020) are based on structural imbalance in the EU. Nevertheless, as is explained in Sections 3.3 and 3.4 of Chapter 3, most of EU core-periphery works base their countries’ classification in the analysis of technical conditions on the value added to measure upgrading, which presents severe theoretical and empirical issues and may provoke inaccuracies in the core-periphery categorisation.
Romania and Bulgaria. As noted, the average subsystems’ direct domestic wages of Cyprus, Malta and Luxembourg were removed from Figure 4.2. The reason is that these three economies have a particular production structure based on tax headquarters, and their inclusion does not provide relevant information about EU real export performance.

**Figure 4.2. Average Domestic Direct Nominal Wages per Worker in The Top14 Final Export Subsystems, Thousands Of USD, 2014**

Source: Author’s calculations based on WIOD

To sum up, this chapter and the following two empirical chapters (Chapters 5 and 6) will be based on the WIOD database complemented with the ILO database to estimate the SEAs variable for RoW. They will focus on the EU’s top 14 exporter industries, representing more than 83% of the total EU final export. Excluding Cyprus, Malta and Luxembourg, the EU members were classified into core and peripheral countries according to their average level of domestic nominal wages.

### 4.4 Main findings

This section presents the empirical results obtained from WIOD and ILOSTAT data for the top fourteen EU exporting industries between 2000 and 2014. The core and peripheral-country subsystems were grouped applying a simple mean wage, except in the market share cases, which were calculated as a sum of elements, to be considered later.
The first look at the results is summarised in Table 4.2, which shows the dynamics of current final exports and their components as the average annual proportional change across the period (empirical results of Equation 4.02). The data are shown for a pre-crisis (2000-2008), a post-crisis sub-period (2008-2014) and the full period of 15 years (2000-2014). The growth of peripheral-country subsystems was, on average, 2.85 times higher than that of core-country subsystems. In both types of subsystems, the highest levels of growth are concentrated in the pre-crisis period, while in the post-crisis period, total final exports even decreased in core subsystems.

Table 4.2. Average annual proportional change of current final exports and their components: exchange rate, relative prices, labour productivity and induced labour, 2000-2014 (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Core Final Exports</th>
<th>Core Ex. Rate</th>
<th>Core Rel. Price</th>
<th>Core Ptvty</th>
<th>Core Ind. Labour</th>
<th>Periphery Final Exports</th>
<th>Periphery Ex. Rate</th>
<th>Periphery Rel. Price</th>
<th>Periphery Ptvty</th>
<th>Periphery Ind. Labour</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-08</td>
<td>10.27</td>
<td>5.40</td>
<td>1.15</td>
<td>0.79</td>
<td>2.93</td>
<td>23.73</td>
<td>5.69</td>
<td>3.53</td>
<td>4.86</td>
<td>9.66</td>
</tr>
<tr>
<td>2008-14</td>
<td>-1.31</td>
<td>-1.64</td>
<td>1.42</td>
<td>-0.66</td>
<td>-0.44</td>
<td>3.68</td>
<td>-2.58</td>
<td>1.73</td>
<td>1.11</td>
<td>3.42</td>
</tr>
<tr>
<td>2000-14</td>
<td>5.30</td>
<td>2.39</td>
<td>1.27</td>
<td>0.17</td>
<td>1.49</td>
<td>15.14</td>
<td>2.14</td>
<td>2.76</td>
<td>3.25</td>
<td>6.99</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

To understand the role of monetary and real variables in final export growth dynamics, Figure 4.3 shows the proportional change in monetary factors (i.e., exchange rate and price index), and in real factors (i.e., productivity and required labour) in the final export-country subsystems for core and peripheral GVCs. The first aspect to highlight is the very different composition of the current growth in core and peripheral final exports’ GVCs. In core-country subsystems, the monetary variables had a greater weight than in the periphery over the period, whereas in the EU periphery the real variables led the final export growth.
Figure 4.3 also shows an asymmetry between the expansive and the recession period. The growth of final exports was motivated by monetary variables in 2000-2008, while the slowdown was led by real variables between 2008 and 2014. On the other hand, in the peripheral subsystems, not only the growth of final exports was driven by real variables, but also the positive performance of the real variable exceeded the negative effect on monetary variables also in the post-crisis period (2008-2014). Although the real growth rates went down from 14.56% to 4.53% after the crisis, the EU periphery maintained a moderate current rate of growth during the second period.

Focusing on monetary variables, the exchange rate (Table 4.2), is mainly composed of euro area countries in the core region, while in the peripheral region the basket of currencies is broader. However, both regions show a similar trend: an appreciation of the local currency during the pre-crisis period and a depreciation in the post-crisis phase. The nominal exchange rate depreciation between 2008 and 2014 has negatively impacted monetary factors during this period. Depreciations, even if they can help keep export market share in the short term, are associated with a drop in economies’ aggregate purchasing power. In low and middle economies such as the EU periphery, this occurrence is particularly harmful. It may constrain the upgrading process, since these economies are very sensitive to speculative market behaviour, and they are characterised by weak domestic demand, a high volume of foreign debt payments, and outflows of dividends and profit remittances (Grodzicki 2018; Soreg 2018).
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Prices have risen more rapidly in peripheral than in core subsystems. Most peripheral countries are new EU members, and their integration in the Union has fostered price-level convergence with the old EU members (Staehr 2010; Degler and Staehr 2021). When changes in price levels are parallel to changes in physical volume, such as in the EU periphery, price increases are interpreted as a natural consequence of the improvements in the income levels (Degler and Staehr 2021; Frensch and Schmillen 2013; Staehr 2010), and not as an inflation sign with adverse effects on the welfare. What's more, the literature shows that increases in prices and gains in nominal market shares together, specifically in low and middle economies, reflect that these economies are introducing innovations more rapidly and more efficiently than competitors. That is, these economies are upgrading or improving their international trade's position (Kaplinsky and Readman 2005; Grodzicki 2018).

Changes in core final exports' prices are more stable, showing moderate growth in both sub-periods. This may be related to production fragmentation. The offshoring of intermediate production processes has decreased labour costs across the core final export GVCs, moderating the price growth. The EU core competitive position depends on its ability to produce goods and services of a given quality at the same or lower price than competitors. Core firms can increase their efficiency and reduce labour costs through GVCs' integration (Braun 1973; Tsaliki, Paraskevopoulou, and Tsoulfidis 2018a). The core real variable performance suggests the latter way, as will be further discussed in Chapters 5 and 6.

Real factors have been the main determinants of growth in EU peripheral final export GVCs, supporting the EU periphery's upgrading hypothesis (Stöllinger 2019b; 2017). Particularly in the period of 2000-2008, growth in the induced labour was accompanied by significant growth in labour productivity, indicating that the peripheral export subsystems experienced an expansion of international demand for their products at the same time as the technical conditions of production were improving. In the post-crisis phase, the growth of both variables stabilised, specifically in labour productivity; although it has remained positive, the structural change seems to go slower.

In core GVCs, the impact of real variables on growth has been less favourable. The slight increase in the physical volume of sales has mainly been made up by an increase in the amount of required labour rather than by increases in labour productivity. The core region's development level is higher than that of the peripheral region (Grodzicki and Geodecki 2016), which can explain the lower rate of labour productivity, since it is harder to introduce structural changes in advanced economies. Nevertheless, the average annual growth of
labour productivity was below 1% during the pre-crisis period and closer to 0% between 2000 and 2014. These figures are low even for advanced economies and allow us to associate the decline in core real final exports with a wage-cutting deindustrialisation, motivated by labour offshoring rather than productivity-driven deindustrialisation, and the lack of industrial policy, which affects some core economies in the EU (Celi et al. 2018). Between 2000 and 2014, the core final export subsystems were immersed in an offshoring process in which intermediate production was moved to economies with a lower-cost labour force but less developed technical conditions (Villani and Fana 2020; Sarra, Di Berardino, and Quaglione 2019; Di Berardino and Onesti 2021). The offshoring process may have a positive impact on the cost structure but not on the subsystem's efficiency and production structure of core economies, as will be analysed in Chapter 5 in more detail.

Changes in the EU final export market share seem to be motivated by the gap in real variables, labour productivity and labour quantity between core and peripheral regions. Figure 4.4 illustrates the current share of core and peripheral regions over the 14 leading EU exporting subsystems, i.e., the changes in the international performance of both regions.

**Figure 4.4. Share of core and peripheral regions in the final exports of the EU’s top 14 exporting industries (in percentage points)**

Source: Author’s calculations based on WIOD and ILOSTAT

34 It will also affect the international competitiveness of the core region, as will be discussed in Chapter 6.
As a whole, the share of peripheral economies in the top 14 final exports has grown by 6.52 p.p.\(^{35}\). Considering that the total share was 6.26% in 2000, we can say that final peripheral exports have doubled their share in the 15 years analysed. Nevertheless, the catching-up of the peripheral-country subsystems was concentrated in the expansion period (5.23p.p.), while in 2008-2014, the gain of market share was very low. It is striking that the market share's stagnation in the post-crisis period for the peripheral subsystems coincided with the decrease in the core current final exports (-1.31% per year between 2008 and 2014). This indicates that the final export gap between the two regions still persists. Despite the periphery final exports' good performance, particularly in the pre-crisis phase, the core region continued to control approximately 85.58% of total EU final exports, compared to 12.78% of the periphery in 2014.

For a more detailed analysis, Table 4.3 presents the breakdown of final export subsystems' growth by product types in each region, core and periphery. The data show that external demand growth was higher in peripheral than in core-country subsystems. As a result, the EU periphery may be immersed in a development process in which the final exports play a very relevant role; moreover, the low initial point allows peripheral subsystems to keep a high annual rate of growth.

\[\text{Table 4.3. Average annual proportional change of final export subsystems and their components by product types (\%). Period 2000-2014}\]

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Core Final Exports</th>
<th>Core Ex. Rate</th>
<th>Core Rel. Price</th>
<th>Core Ptvtv</th>
<th>Core Ind. Labour</th>
<th>Periphery Final Exports</th>
<th>Periphery Ex. Rate</th>
<th>Periphery Rel. Price</th>
<th>Periphery Ptvtv</th>
<th>Periphery Ind. Labour</th>
</tr>
</thead>
<tbody>
<tr>
<td>01AGRIC</td>
<td>7.36</td>
<td>2.39</td>
<td>1.18</td>
<td>0.47</td>
<td>3.32</td>
<td>15.73</td>
<td>2.14</td>
<td>2.84</td>
<td>3.94</td>
<td>6.80</td>
</tr>
<tr>
<td>05FOOD</td>
<td>7.28</td>
<td>2.39</td>
<td>1.97</td>
<td>-0.03</td>
<td>2.96</td>
<td>16.68</td>
<td>2.14</td>
<td>3.39</td>
<td>3.03</td>
<td>8.11</td>
</tr>
<tr>
<td>06TEXT</td>
<td>1.78</td>
<td>2.39</td>
<td>1.52</td>
<td>-1.37</td>
<td>-0.76</td>
<td>3.39</td>
<td>2.14</td>
<td>2.59</td>
<td>-3.92</td>
<td></td>
</tr>
<tr>
<td>11CHEM</td>
<td>7.84</td>
<td>2.39</td>
<td>2.07</td>
<td>-0.68</td>
<td>4.06</td>
<td>18.34</td>
<td>2.14</td>
<td>3.59</td>
<td>2.21</td>
<td>10.40</td>
</tr>
<tr>
<td>12PHARMA</td>
<td>7.89</td>
<td>2.39</td>
<td>0.38</td>
<td>0.80</td>
<td>4.32</td>
<td>16.67</td>
<td>2.14</td>
<td>4.00</td>
<td>2.12</td>
<td>8.39</td>
</tr>
<tr>
<td>16METPRES</td>
<td>-0.42</td>
<td>2.39</td>
<td>-1.07</td>
<td>2.11</td>
<td>-3.85</td>
<td>14.92</td>
<td>2.14</td>
<td>-1.20</td>
<td>6.20</td>
<td>7.78</td>
</tr>
<tr>
<td>17TICEQ</td>
<td>2.79</td>
<td>2.39</td>
<td>1.38</td>
<td>-0.17</td>
<td>-0.80</td>
<td>12.65</td>
<td>2.14</td>
<td>1.80</td>
<td>4.08</td>
<td>4.62</td>
</tr>
<tr>
<td>18ELECEQ</td>
<td>-0.37</td>
<td>2.39</td>
<td>0.75</td>
<td>0.07</td>
<td>2.12</td>
<td>15.72</td>
<td>2.14</td>
<td>2.48</td>
<td>4.77</td>
<td>6.33</td>
</tr>
<tr>
<td>19MMCAHDEQ</td>
<td>-0.42</td>
<td>2.39</td>
<td>0.38</td>
<td>0.07</td>
<td>2.12</td>
<td>15.79</td>
<td>2.14</td>
<td>2.41</td>
<td>3.08</td>
<td>8.16</td>
</tr>
<tr>
<td>20VEHIC</td>
<td>5.99</td>
<td>2.39</td>
<td>0.87</td>
<td>0.35</td>
<td>-0.14</td>
<td>12.13</td>
<td>2.14</td>
<td>3.49</td>
<td>3.23</td>
<td>3.28</td>
</tr>
<tr>
<td>21TRECG</td>
<td>3.82</td>
<td>2.39</td>
<td>0.85</td>
<td>0.12</td>
<td>-0.63</td>
<td>13.86</td>
<td>2.14</td>
<td>2.61</td>
<td>3.30</td>
<td>5.81</td>
</tr>
<tr>
<td>22CIMAN</td>
<td>13.66</td>
<td>2.39</td>
<td>0.88</td>
<td>0.52</td>
<td>9.88</td>
<td>28.79</td>
<td>2.14</td>
<td>4.85</td>
<td>0.26</td>
<td>21.53</td>
</tr>
<tr>
<td>41FINANCE</td>
<td>5.56</td>
<td>2.39</td>
<td>1.11</td>
<td>1.09</td>
<td>0.97</td>
<td>12.79</td>
<td>2.14</td>
<td>2.77</td>
<td>3.31</td>
<td>4.56</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

\(^{35}\) The abbreviation p.p refers to percentual points.
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Chapter 4: What are the determinants of final exports dynamics in the GVCs of the EU countries?

Core-country subsystems had less homogeneous dynamics than peripheral ones across product types. Only in the GVCs related to agriculture (01AGRiC), pharmaceuticals (12PHARMA) and programming and consulting services (40ICTPROG), the real factors had greater weight than monetary factors, particularly for the employment induced by foreign demand. As we have pointed out, it is more challenging to reach high real growth rates in advanced economies, since the initial sales levels are already noticeable. As a result, product types such as chemicals (11CHEM), food processing (05FOOD), finance (41FINANCE) and machinery and equipment (19MMACHEQ) are led by monetary variables, although real variables have also contributed to the growth and should be classified as dynamic sectors in the core region. In all these types of subsystems, growth in the foreign demand has been covered by increases in the quantity of labour activated by the subsystems rather than labour productivity. Labour productivity growth has been practically zero or even slightly negative in all the core-country subsystems, excluding financial subsystems.

The core-country subsystems of textiles (06TEXT), electronics and optical products (17ICTEQ), fabricated metal products (16METPRDS), electrical machinery (18ELECEQ), other transport equipment (21TREQ) and manufacture of furniture (22OMAN) have, on average, experienced a fall in the physical volume of final exports. In the case of metal products (16METPRDS), other transport equipment (21TREQ) and electronics and optics (17ICTEQ), the drop in the final foreign demand was sorted out with a drop in the required labour, particularly in electronics and optics. Consequently, the increase in labour productivity has not compensated for the decrease in the amount of required labour in any of these subsystems. In the other three type of subsystems, furniture manufacturing (22OMAN), electronic products (18ELECEQ), and most markedly in textile products (06TEXT), there has been a fall in both labour productivity and the quantity of required labour, demonstrating the fragility and decline of these subsystems in the EU core economies.

Peripheral-country subsystems are characterised by a strong increase in labour productivity and employment activated by foreign demand. However, this does not seem to be the case for textile subsystems (06TEXT), where the contraction of the external demand led to a reduction in required employment, spuriously rising labour productivity. In fact, textile subsystems are the only product type in the periphery where monetary factors drove the dynamics of final exports.

Domestic price growth has outpaced exchange rate appreciation in peripheral economies, except for electronic and optical products (17ICTEQ) and electrical machinery (18ELECEQ).
The drop in the 17ICTEQ prices in both regions has an international explanation. In the last decades, final and intermediate electronic and optical products have moved from core to Asian economies with worse working conditions (Torsekar and Verwey 2019). Based on WIOD data, the Chinese 17ICETEQ market share expanded 32.37p.p. between 2000 and 2014, representing roughly 39.54% of the total export volume sold worldwide, becoming the largest exporter in the world. The hegemony of Asian peripheral economies in the international electronic and optic products market has driven a continuous decline in these products’ prices. The Chinese FDI explains the rise of the EU peripheral 17ICETEQ export industry in this region (Cieślik 2019).

The evolution of core and peripheral programming and consulting subsystems (40ICTPROG) suggests that Baumol’s cost disease (1967; 1985) is still ongoing. According to Baumol et al. (1985), certain service subsystems, very intensive in knowledge and technology, tend to suffer an asymptotical stagnation. In their nascent stage, these subsystems stand out for sharp productivity growth, motivated by the investment in capital equipment, but they keep the same labour division paradigms, thus complicating upsurges in the output per employed worker in the long run. Table 4.3 suggests that programming and consulting services subsystems (40ICTPROG) have experienced the most robust growth of final exports in core and peripheral economies. However, the growth in 40ICTPROG subsystems is activating a large quantity of labour but not motivating the introduction of new technologies. As a result, labour productivity has remained stagnant. This suggests that those subsystems are undergoing a foreign demand explosion, and their gradual integration in GVCs has not mended the ‘growth disease’ in which they are immersed (Hartwig and Krämer 2019).

The remarkable growth of final exports has improved the peripheral economies’ export performance, although the intensity varies between product types. Figure 4.5 illustrates the changes in the share of core and peripheral-country subsystems’ final exports by product types.

Overall, the share of peripheral countries in the final exports of each sector increased between 2000 and 2008. However, the increase slowed down between 2008 and 2014. This reflects the level gap between core and peripheral-country subsystems across product types. The peripheral-country subsystems that gained more market share are electronics and optical products (17ICTEQ), metal products (16METPRDS), electrical machinery (18ELECEQ), vehicles (20VEHIC) and furniture manufacturing (22OMAN). The data also reveal that the gap in absolute terms between core and peripheral final exports conditioned the gain of market
Chapter 4: What are the determinants of final exports dynamics in the GVCs of the EU countries?

The share of peripheral-country subsystems across product types. Final export products in which the EU periphery gained more market share correspond to those laggard core-country subsystems, where the pace of growth was considerable below average for core-country subsystems.

In those product types where core-country subsystems maintained an average relative high growth, such as programming and professional services (40ICTPROG) and finance (41FINANCE), the improvement of the peripheral market share was more moderate. For instance, in finance (41FINANCE), the peripheral region's share only grew by 0.62p.p. over the period. Final exports of other transport equipment (21TREQ) involves the production of large transport equipment, which has high capital requirements and a long production process that obstruct the entry for new international players such as the EU periphery.
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Figure 4.5. Share of core and peripheral regions in the EU final exports by product types\(^{36}\) (%)

Note that Cyprus, Malta and Luxembourg were excluded from the analysis. Therefore, the sum of the market shares of the rest of the 24 EU countries cannot reach 100%. This fact is particularly visible in programming and professional (40ICTPROG) and financial services (41FINANCE) in which Luxembourg has a strong specialisation.

Source: Author’s calculations based on WIOD and ILOSTAT

\(^{36}\) Note that Cyprus, Malta and Luxembourg were excluded from the analysis. Therefore, the sum of the market shares of the rest of the 24 EU countries cannot reach 100%. This fact is particularly visible in programming and professional (40ICTPROG) and financial services (41FINANCE) in which Luxembourg has a strong specialisation.
Finally, it can be highlighted that the peripheral textile subsystem (06TEXT), with the largest peripheral market share at the beginning of the period, lost market share across the period (-1.54p.p.). This happened despite the fact that the core textile industry showed the lowest average annual growth (1.78%p.p.), after electronics and optical products (17ICTEQ). Globalisation and the new international division of labour have restructured the textile industry. As a medium-low tech industry with relatively low capital-intensive requirements, the EU textile subsystems have experienced significant competitive pressure in low-wage labour economies since the 1980s. This has motivated the textile manufacturing offshoring from the EU to peripheral economies with lower labour costs (Taplin 2006). The integration of the EU in GVCs started earlier in core economies; however, it has also affected the EU periphery recently. Despite the EU periphery being very specialised in textile production during the 1990s (Grodzicki & Geodecki, 2016), the development of the textile industry in other global peripheries, such as East Asian economies, made the EU periphery less competitive. The textile market share’s bad performance may indicate the export industry’s vulnerability to the middle-income EU economies that will be analysed in Chapter 5.

4.5 Summary
This chapter provides a descriptive analysis of EU export dynamics, distinguishing between core and periphery regions during the 2000-2014 period for the top 14 exporting industries. This is fundamental to address the main drivers of export growth in European final export subsystems between 2000 and 2014, which is the first research objective. To the best of our knowledge, this is the first study to disaggregate final exports into four vertically integrated components capable of accounting for changes across the entire global production chain, and not only at the domestic level. These components can be divided into monetary variables, exchange rate and price index changes, and real variables, productivity and labour induced by foreign demand.

What emerges from the descriptive analysis is a loss of weight of final exports from the core region in favour of the periphery, particularly in the run-up to the financial crisis, 2000-2008. This is mainly due to the underperformance of real variables, particularly productivity, in the subsystems of the core region, whose growth was mainly driven by monetary variables, with the behaviour of real variables being even negative in the post-crisis period of 2008-2014. In contrast, peripheral exports were driven by increases in real variables, i.e., they experienced steady increases in their physical sales volumes, particularly during the pre-crisis period.
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Despite this, the export boom in the peripheral industry led to price increases associated with income increases, and the exchange rate is more volatile than in the core region due to its greater financial vulnerability.

Comparing the subsystems by product types, there are certain differences in the behaviour of final exports. In the core region, the asymmetries were more accentuated. Only the subsystems of agriculture (01AGRIC), pharmaceuticals (12PHARMA) and programming services (40ICTPROG) experienced higher growth in real variables, especially employment induced by foreign demand, than in monetary variables. The subsystems for chemicals (11CHEM), food processing (05FOOD), finance (41FINANCE) and machinery and equipment (19MMACHEQ) also showed positive developments in real variables over the period. On the other hand, in the core-country subsystems of textiles (06TEXT), electronics and optical products (17ICTEQ), fabricated metal products (16METPRDS), electrical machinery (18ELECEQ), other transport equipment (21TREQ) and manufacture of furniture (22OMAN), the real exports dropped. A focal point here is that the loss of market share and the bad performance of labour productivity affect low-tech subsystems, but also medium-high and high-tech export subsystems, which may be related to production fragmentation, as will be analysed in Chapter 5.

Except in the textile products (06TEXT) subsystems, all type of subsystems in the EU periphery experienced a significant increase in both productivity and labour induced by rises in foreign demand, which is justified by the low starting point at the beginning of the period. Growth was particularly high in programming and consulting service subsystems (40ICTPROG). As in the core region, the increase in demand generated strong employment growth in 40ICTPROG subsystems; however, labour productivity was stagnant, which suggests that they are ruled by Baumol’s cost disease (Baumol 1967). Despite the general increase in final exports in the periphery, the gain in market share of the periphery was concentrated in those subsystems where the core region had the worst performance: electronics and optical products (17ICTEQ), metal products (16METPRDS), electrical machinery (18ELECEQ), vehicles (20VEHIC) and furniture manufacturing (22OMAN). In these types of subsystems, nominal growth was not enough to keep core’s market share afloat. Paradoxically, textile products (06TEXT) subsystems, where the periphery showed a certain specialisation and weight in the European final export base, were the only ones to lose weight in total European exports during the analysed period.
Lastly, the chapter provides preliminary evidence of the effects of offshoring in the core region and the risk of falling into the middle-income trap for the peripheral region addressed in Chapter 5. The strategy of supplying the increase in foreign demand, expanding the amount of required labour instead of increasing productivity in the core countries, seems to respond to a cost-reduction strategy by offshoring labour to lower-wage peripheral regions (objective 2). This strategy may be successful in the short term, but it may affect competitiveness in the long term, as we will study in Chapter 6 (objective 3).
Chapter 5: Structural change, wage cutting and employment distribution in EU GVCs

5.1 Introduction

Chapter 4 has highlighted the two opposite dynamics followed by core and peripheral regions. In core-country subsystems, the labour productivity performance was very low, and the increases in foreign demand were supplied with increases in the quantity of labour, which encourages looking into the inward GVCs dynamic. On the other hand, peripheral-country subsystems experienced an exporter boom, with increases in both labour productivity and foreign demand’s induced labour, making them gain market share in general terms.

The findings from Chapter 4 provide a backdrop to research objective 2 of this dissertation, i.e., to address the structural changes linked to the labour organisation in EU value chains in the period of 2000-2014. Starting from the focal point of Braun’s model of unequal exchange, where there is an inverse relationship between core and peripheral wages, this chapter shows an inward view of the GVCs. It focuses on the labour distribution across GVCs and how it affects the structure of labour costs and vertically integrated labour productivity. The analysis is developed around the following research questions: What is the structure of employment distribution in the EU core and peripheral subsystems? Has this structure changed across the period? Has the distribution of labour affected the average labour costs across the GVCs? Has this effect been different in core and peripheral subsystems? Has the cost reduction strategy impacted on labour productivity in core and peripheral GVCs? Have changes in labour distribution followed similar patterns in all the product types? Have these changes affected the cost structure differently according to product type?

The publication of MRIO tables has helped facilitate the study of GVCs from a macroeconomic perspective. There is abundant literature about the tendency of GVCs to be either global or regional (Los, Timmer, and De Vries 2015; Bo et al. 2019), upgrading in GVCs (Bontadini et al. 2021), structural change (Stöllinger 2016), sectoral analysis (Chen 2016; Grodzicki and Skrzypek 2020) and countries’ specialisation patterns (Johnson and Noguera 2012; Borin and Mancini 2017; Dell’Agostino and Nenci 2018). Nevertheless, a common characteristic of most studies is the use of value added as a proxy variable of production fragmentation in GVCs. The higher the share of foreign value added in the total value added embodied in the final product, the greater the fragmentation. However, as detailed in Section 3.3 of Chapter 3, the value added as an indicator of internationalisation masks certain methodological issues. Value added is calculated as the residual difference between total production minus intermediate products in the national accounts. This implies that its final volume is
conditioned by political and institutional factors unrelated to the production structure, defining the international income distribution.

As an alternative, this work proposes to use vertically integrated labour through GVCs as a proxy for fragmentation in production. This indicator is based on physical labour units per product, avoiding distortions generated by income distribution. Moreover, it starts from final production values to avoid double counting problems\(^{37}\), considers all the production stages, and decomposes the labour required by the global production chain by geographical origin of labour.

The empirical analysis of the effects of labour offshoring on GVCs’ labour cost structure is conducted from an original decomposition of the vertically integrated wage rate per worker by geographical origin. A more detailed reasoning of the theoretical implications of these two measures is provided in Section 3.5 of Chapter 3. Finally, domestic and imported wage changes per product are decomposed into changes in wage per worker and changes in required labour per product. This allows determining whether labour cost reduction strategies are driven by changes in the distribution of labour or by adopting technical changes in the production chain.

The empirical analysis is carried out based on the preliminary study of the data detailed in Section 4.3 of Chapter 4. It focuses on the subsystems of the 24 EU member economies over 2000-2014, excluding Cyprus, Malta and Luxembourg and the 14 industries with the highest relevance in EU final exports. The subsystems of each country were grouped into two regions, i.e., core and periphery, based on their domestic wage level, as set out in Figure 4.2\(^{38}\).

The chapter is organised as follows. Section 5.2 shows the theoretical core of Braun’s unequal exchange model and the usefulness of input-output techniques for its empirical development. Section 5.3 provides the main general results of the analysis for core and peripheral regions. Then, in Section 5.4., the analysis focuses on the subsystems according to product type and the effects of changes on the distribution of labour and the labour cost structure. Finally, Section 5.5 presents the main conclusions of the chapter.

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\(^{37}\) See Section 3.3 of Chapter 3.

\(^{38}\) Section 4.3 of Chapter 4.
5.2 Braun’s Model of Unequal Exchange and its Empirical Application

Braun (1973) starts from point is a Sraffian production system with a surplus. That is, ‘the economy produces more than the minimum necessary for replacement’ (Sraffa 1960, 6), and this surplus is distributed between wages and profits. For the sake of simplicity, let us assume a closed economy in which two goods are produced (Braun 1973, 35; Sraffa 1960, 9):

\[
\begin{align*}
\{(\bar{z}_{11}p_1 + \bar{z}_{21}p_2)(1 + r) + l_1w &= \bar{q}_1p_1 \\
\{(\bar{z}_{12}p_1 + \bar{z}_{22}p_2)(1 + r) + l_2w &= \bar{q}_2p_2
\end{align*}
\]

(5.01)

Each equation represents the total production of a commodity. Each commodity is produced using other commodities as inputs and a certain amount of labour. The term \( \bar{z}_{ij} \) represents the quantities of inputs needed for the total production of each commodity, \( p_i \) the price of each commodity, \( r \) the profit rate, \( l_i \) the amount of direct labour required for the total production of each commodity, \( w \) the wage per unit of labour, and \( \bar{q}_i \) the quantity of total physical output of each commodity. The profit rate \((r)\) and the wage per hour worked \((w)\) are uniform across the economic system.

Let us assume that all intermediate inputs are entirely consumed during the production period. As a result, the physical ratios of intermediate inputs to labour indicate the level of technology. At the end of each period, the total output of the system is used for two purposes: firstly, to replace the intermediate inputs needed to start the production process again and, secondly, with the remainder (the final net output or net income), the factors capital and labour are remunerated.

Therefore, given the technical conditions and considering that the net income is distributed between wages and profits, the equation system 5.01 can be rewritten in price terms (Pasinetti 1978, 45:73):

\[
\begin{align*}
\{(p_1a_{11} + p_2a_{21})(1 + r) + a_{11}w &= p_1 \\
\{(p_1a_{12} + p_2a_{22})(1 + r) + a_{12}w &= p_2
\end{align*}
\]

(5.02)

As is detailed in Section 3.4 of Chapter 3, each element \( a_{ij} \) denotes the coefficients of production, and \( a_{ii} \) the direct labour requirements per unit of total output. The set of \( a_{ij} \) and \( a_{ii} \) elements describe the economic system’s technique. The literature has further discussed the relationship between income distribution and changes in relative prices (Sraffa 1960; Pasinetti 1978). For a given technique, the relationship between the profit and wage rate
becomes negative. This clear-cut inverse relationship between distributive variables remains a key point in Braun’s model.

Following the main assumptions and insights of the Sraffian model, Braun (1973) describes a global economic system composed of two countries and two goods. The core country produces commodity 1, and the peripheral country produces commodity 2:

\[
\begin{align*}
(p_1 a_{11} + p_2 a_{21})(1 + r) + a_{11} w_c &= p_1 \\
(p_1 a_{12} + p_2 a_{22})(1 + r) + a_{12} w_p &= p_2
\end{align*}
\] (5.03),

where \(w_c\) represents the core country's unit labour wage, and the peripheral country's unit labour wage is represented by \(w_p\). Converting one of the commodity prices into a unit price arbitrarily, for example, \(p_1 = 1\), the number of unknown variables is reduced to 4, i.e. \(p_2, r, w_c\) and \(w_p\), where \(p_2\) becomes a relative price with respect to \(p_1\). Assuming that profit rate depends on international competition and core wages are ruled by institutional factors exogenous to the system, both wage and profit rates can be considered as given (\(r = r_0\) and \(w_c = w_{0c}\)) in order to obtain the equilibrium point:

\[
\begin{align*}
(\bar{a}_{11} + p_2 \bar{a}_{21})(1 + r_0) + a_{11} w_{0c} &= 1 \\
(\bar{a}_{12} + p_2 \bar{a}_{22})(1 + r_0) + a_{12} w_p &= p_2
\end{align*}
\] (5.04)

Nevertheless, any equilibrium point between \(p_1, p_2, r, w_c\) and \(w_p\) illustrates a feasible situation of prices, wages and profit rate for two countries that trade internationally with each other and whose technical conditions of production do not change when the relationships between the levels of prices, wages and profit rates change (Braun 1973, 42–43). Operating algebraically, the Equation system 5.04 can be rewritten as\(^\text{39}\):

\[
\begin{align*}
p_2 &= \frac{1 - a_{11} w_c - \bar{a}_{11}(1 + r_0)}{\bar{a}_{21}(1 + r_0)} \\
\frac{1 - a_{22}(1 + r_0)}{a_{12}} - \frac{\bar{a}_{12}(1 + r_0)}{a_{12}}
\end{align*}
\] (5.05)

\(^{39}\) See Appendix D for more detail.
Substituting equation 1 into 2 in the Equation system 5.05, we obtain:

\[
w_p = \frac{1 - \bar{a}_{11}(1 + r_0) - \bar{a}_{22}(1 + r_0) + \bar{a}_{11}\bar{a}_{22}(1 + r_0)^2 - \bar{a}_{21}\bar{a}_{12}(1 + r_0)^2}{\bar{a}_{21}\bar{a}_{12}(1 + r_0)}
- \frac{\bar{a}_{11}(1 - \bar{a}_{22}(1 + r_0))w_{0c}}{\bar{a}_{21}\bar{a}_{12}(1 + r_0)}
\]

(5.06)

Dividing both sides by \(\frac{1}{1 + r_0}\) we can express the peripheral wage rate as a straight line with the core wage rate as an independent variable:

\[
w_p = \frac{(1 + r_0)^{-1} + (1 + r_0)(\bar{a}_{11}\bar{a}_{22} - \bar{a}_{21}\bar{a}_{12}) - (\bar{a}_{11} - \bar{a}_{22})}{\bar{a}_{21}\bar{a}_{12}} - \frac{\bar{a}_{11}}{\bar{a}_{21}(1 + r_0)}\left(1 - \bar{a}_{22}(1 + r_0)\right)w_{0c}
\]

(5.07)

Where \(1 - \bar{a}_{22}(1 + r_0) > 0\), i.e. the profit rate is lower than the maximum profit rate, a necessary condition since the maximum profit rate reduces the wage rates to zero (Braun 1973, 44). Therefore, the inverse relationship between peripheral and core wage rates depends on the relative labour productivity between the peripheral and core economy \(\left(\frac{a_{11}}{a_{12}}\right)\) and on the technical coefficients produced in the peripheral country \(\left(\frac{1 - \bar{a}_{22}(1 + r_0)}{\bar{a}_{21}(1 + r_0)}\right)\). Following the numeric example presented by Braun (1973, 41):

\[
\begin{align*}
\left\{ \begin{array}{l}
\left(\frac{13}{27} + p_2\frac{2}{27}\right)(1 + r_0) + \frac{10}{27}w_{0c} = 1 \\
\left(\frac{5}{6} + p_2\frac{1}{3}\right)(1 + r_0) + \frac{5}{6}w_p = p_2
\end{array} \right.
\end{align*}
\]

(5.08)

Figure 5.1 shows the linear relationship (Equation 5.07) between core and peripheral wage rates with a given profit rate, using the empirical relationship of the system of Equation 5.08. This yields several relevant highlights. Firstly, each combination of values for \(r_0, w_{0c}, w_p\) will define a given price vector. Assuming a given profit rate, an increase of \(w_{0c}\) translates into a fall of \(w_p\), the price of industries 1 will increase\(^{40}\). This deterioration in the trade terms for the peripheral commodity shows the possibilities of the core region obtaining advantages over the periphery through international trade. It is the dynamics of international trade

\(^{40}\) In the case of an economic system in which both core and periphery regions produce more than one industry, as core wages increase, the prices of the core industries will increase on average, although the scale will be different, as it depends on the technical conditions of each industry.
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which reproduce the unequal conditions among participants. Moreover, there is an inverse relationship between profit rate and the total wage rate available in the economy, \( \frac{dr}{d_w} < 0 \) and \( \frac{dr}{d_{wp}} < 0 \). In this example, the profit rate makes the wage rate 0, i.e., the maximum rate of profit is 0.5%. As the profit rate starts to decrease, the total wage rate increases, that is, the straight line that links core and peripheral wages goes further from the origin, up to the point in which the profit rate is 0% and all the net income is shared between core and peripheral wages (dark purple straight line). Secondly, there is a trade-off between core and peripheral wage rates, \( \frac{dw_p}{dw_{0c}} < 0 \). Given the profit rate and the global economy’s technical conditions, the total wage rate is shared between core and peripheral wages. Since it is assumed that the core wage rate is an exogenous variable, due to the workers’ power bargaining, peripheral wages will negatively depend on it.

**Figure 5.1. The trade-off between core and peripheral wage rates with a given profit rate**

As is shown in Equation 5.07, the relative labour productivity determines the slope of the negative relationship between core and peripheral wage rates. Figure 5.2 represents what happens when starting from a specific equilibrium situation, showing a change in the relative labour productivity between core and peripheral regions. The red line describes all the possible combinations for core and peripheral wage rates for a particular profit rate. The red point represents the initial equilibrium situation (\( w_c', w_p' \)).

Sources: developed by author based on Braun’s unequal exchange model (Braun 1973, 41)
Figure 5.2. Changes in the relative labour productivity of core and peripheral regions

Say the technical conditions improve in the periphery and the required labour per product \( (a_{l2}) \) drops. Consequently, the relative physical labour productivity \( \left( \frac{a_{l1}}{a_{l2}} \right) \) between both countries decreases, with an increase in the redistributive capacity of peripheral regions (as represented by the blue line). Supposing that the profit rate does not change; there are four possibilities: 1) if the core wage rate is also maintained, the improvement in peripheral labour productivity will translate into a rise in the peripheral wage rate (equilibrium point: \( w_c', w_p'' \)); 2) if the core wage rate rises, although to a lesser extent than the rise in peripheral labour productivity, the redistributive capacity improves in both countries (equilibrium point: \( w_c'', w_p''' \)); 3) if the core wage rate increases in the same proportion as peripheral labour productivity, the peripheral wage rate does not change (equilibrium point: \( w_c''', w_p''' \)); 4) if the increase of the wage rate is greater than peripheral labour productivity, the peripheral wage rate decreases to levels below the starting point (equilibrium point: \( w_c''''', w_p''''' \)).

Braun’s unequal exchange model also has a number of limitations. Firstly, it assumes the complete specialization of core and peripheral regions. In other words, the core region cannot produce peripheral goods and vice versa. Thus, both regions are forced to trade between them. This framework could represent international trade during the first unbundling of globalisation (Baldwin 2006), in which peripheral countries specialised in exporting agriculture and raw materials and core economies specialised in manufacturing products. Nevertheless, the emergence of GVCs has changed the nature of international trade. Nowadays, there is a continuous flow of intermediate manufacturing and service inputs from peripheral to core and core to peripheral economies. This fact is a motivation to
continue exploring Braun’s unequal exchange model in the future, for instance, converting it into a vertically integrated model. Furthermore, empirical testing of Braun’s unequal exchange model is challenging. The main problems lie in the lack of data on relative prices and the rate of profit for a given period.

Despite these limitations, the principal argument to be drawn from Braun’s model remains valid. There is an inverse relationship between core and peripheral wages, and labour offshoring reduces the core subsystems’ cost structure. International production fragmentation continues reproducing the unequal exchange between core and peripheral regions, i.e., the unequal exchange conditions between the countries that participate in international trade have contributed to the reorganisation of the world’s physical production toward peripheral regions, but not of the net income in the same proportion. The empirical work of this chapter aims to measure the consequences of labour offshoring in the GVCs’ labour costs via an accounting system based on a MRIO model in which Braun’s theory of unequal exchange plays a fundamental role. Nonetheless, this goal does not imply to empirically test Braun’s model, which is not contemplated as a research objective of this thesis.

As is described in Section 3.5 of Chapter 3, using an MRIO model, it is possible to identify the geographical origin of the vertically integrated unit wage rate, that is, of the total wage per worker paid in order to produce one unit of output across the subsystem as shown in Equation 3.32:

\[
\hat{w}_i^r = \left[ \frac{w_i^{rT} \frac{v_i^{rT}}{v_i}}{v_i} \right] + \left[ \frac{w_i^{rsr} \frac{v_i^{rsr}}{v_i}}{v_i} \right] + \left[ \frac{w_i^{sr} \frac{v_i^{sr}}{v_i}}{v_i} \right],
\]

where the vertically integrated unit wage rate of country \( r \), \( w_i^r \), is decomposed into vertically integrated traditional domestic unit wage \( w_i^{rT} \frac{v_i^{rT}}{v_i} \), internationalised unit wage \( w_i^{rsr} \frac{v_i^{rsr}}{v_i} \) and foreign unit wage \( w_i^{sr} \frac{v_i^{sr}}{v_i} \). Each element, in turn, can be decomposed into the unit wage rate and the distribution of labour along the global value chain:

\[
w_i^{rT} = \left( \frac{a_i^r} {a_i} \right)^T \frac{b_i^{rT}} {b_i}, \quad w_i^{rsr} = \left( \frac{a_i^r} {a_i} \right)^T \frac{b_i^{rsr}} {b_i}, \quad \text{and} \quad w_i^{sr} = \left( \frac{a_i^r} {a_i} \right)^T \frac{b_i^{sr}} {b_i}.
\]

and the labour distribution across the GVCs, i.e., the shares of traditional domestic labour, and internationalised domestic labour and imported labour over the total required labour by the GVCs \( \left( \frac{v_i^{rT}} {v_i}, \frac{v_i^{rsr}} {v_i}, \frac{v_i^{sr}} {v_i} \right) \).
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Through a counterfactual exercise, we can estimate the changes in the cost structure of GVCs associated with changes in the labour distribution over a current year \( t \), using Equation 3.34:\(^{41}\)

\[
\frac{\Delta w^r_t}{w^r_t} = \frac{(w^r_t - w^r_0)}{w^r_0}
\]

In addition, from Equation 3.29, we can define the vertically integrated traditional domestic nominal wage per product for years 0 and \( t \) as \( v^{rr}_{wi(t_0)} = w^r_{i(t_0)} \times v^r_{i(t_0)} \) and \( v^r_{wi} = w^r_t \times v^r_t \), respectively. This equals the vertically integrated traditional domestic nominal wage per worker times the vertically integrated traditional domestic labour per product for each year.

Therefore, as is detailed in Section 3.5 of Chapter 3 (Equations 3.36 and Equation 3.38), the change for the traditional domestic wage per vertically integrated product between periods \( t \) and \( t_0 \) can be structurally decomposed as:

\[
\frac{\Delta v^r_{wi}}{v^r_{wi(t_0)}} = \frac{\Delta w^r_{i(t_0)}}{w^r_{i(t_0)}} \cdot \frac{v^r_{i(t_0)}}{v^r_{i(t_0)}} + \frac{\Delta v^r_{i(t_0)}}{v^r_{i(t_0)}} \cdot \frac{w^r_{i(t_0)}}{w^r_{i(t_0)}}
\]

As a result, we express \( \frac{v^r_{wi(t_0)} - v^r_{wi(t)}}}{v^r_{wi(t_0)}} \) as the average of both definitions (Equation 3.39):

\[
\frac{\Delta v^r_{wi}}{v^r_{wi(t_0)}} = \frac{\left( \frac{\Delta w^r_{i(t_0)}}{w^r_{i(t_0)}} \cdot \frac{v^r_{i(t_0)}}{v^r_{i(t_0)}} \right) + \frac{\Delta v^r_{i(t_0)}}{v^r_{i(t_0)}} + \frac{\left( \frac{\Delta w^r_{i(t_0)}}{w^r_{i(t_0)}} \cdot \frac{v^r_{i(t_0)}}{v^r_{i(t_0)}} \right)}{2}}{2}
\]

wage per worker component + labour per output component

The same reasoning is used to estimate changes in the structural decomposition of the vertically integrated internationalised domestic nominal wage per product and the vertically integrated imported nominal wages per product across the period.

In conclusion, the vertically integrated unit wage rate (\( w^r_t \)) has two fundamental analytical advantages. On the one hand, \( w^r_t \) makes it possible to trace the evolution of each subsystem’s nominal wages per worker by geographical origin. On the other hand, it allows

\[41W^r_t = \left[w^r_{i(t_0)} \frac{v^r_{i(t_0)}}{v^r_{i(t_0)}}\right] + \left[w^r_{i(t_0)} \frac{v^r_{i(t_0)}}{v^r_{i(t_0)}}\right] + \left[w^r_{i(t_0)} \frac{v^r_{i(t_0)}}{v^r_{i(t_0)}}\right], \text{ where } t_0 \text{ represents the distribution of employment in the first period analysed (Equation 3.33).}
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us to trace technical changes through changes in the quantity and distribution of vertically integrated labour. These two dimensions allow us to quantify the consequences of the inverse relationship between wages rates in the EU GVCs’ cost structure which is needed to address the research objective 2. For this purpose, in the following sections of this chapter, we will decompose the imported component of each subsystem $\left( w_{i}^{sr}, v_{i}^{sr}, v_{i}^{r} \right)$ into four regions.

The first two regions will encompass the EU countries divided according to their core and peripheral wage level – Core-EU and Pral-EU, respectively –, as discussed in Section 4.3 of Chapter 4. Region 3 – Core-noEU – will consist of the high-income countries that do not belong to the EU (Australia, Canada, Switzerland, Japan, Korea, Norway and USA). And region 4 – Pral-noEU – will comprise the middle- and low-income non-EU countries (Brazil, China, Croatia, Indonesia, India, Mexico, Russia, Taiwan, Turkey and the rest of the world). Finally, within the extra-EU periphery, a distinction is made between peripheral labour collected in WIOD excluding China (Brazil, Croatia, Indonesia, India, Mexico, Russia, Taiwan and Turkey), China and the rest of the world\(^{42}\). This classification will be used throughout the chapter.

5.3 Trends in the international division of labour and their effect on the cost structure of GVCs in the EU

This section aims to measure changes in the international division of labour and, consequently, in the labour cost structure of European global value chains from 2000 to 2014. The results are shown for an average subsystem\(^{43}\) of each region under a core-periphery perspective. The analysis is structured in two sub-periods: 1) before the financial crisis (from 2000 to 2008) and 2) after the financial crisis (from 2008 to 2014).

Despite all the EU economies count on the minimum development of productive forces to be integrated into different stages of the GVCs (Grodzicki and Geodecki 2016). The inequalities within the EU are remarkable, particularly in terms of wages. Figure 5.3 shows the evolution of the cost structure during the period of 2000-2014, and the role played by each of the regions. The data for the year 2014 shows a very different configuration between core and peripheral wage rates. In the EU core chains, the wage per domestic worker is much higher than that associated with imported labour, which reduces the average wage rate of the GVCs. The average domestic wage rate was approximately 1.73 times the average wage of the core

\(^{42}\) The rest of the world is a residual variable whose calculation method is detailed in the Appendix C.

\(^{43}\) In other words, the mean of all the subsystems in each region.
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chain in 2014\textsuperscript{44}. By contrast, domestic and imported wage rates move in similar patterns in the peripheral chains.

\textit{Figure 5.3. Evolution of the wage rate per worker of an average core and peripheral chain by geographical origin. Results for an average subsystem in each EU region}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure53.png}
\caption{Evolution of the wage rate per worker of an average core and peripheral chain by geographical origin. Results for an average subsystem in each EU region.}
\end{figure}

Consequently, it could be said that, while for the EU peripheral chains the import of labour does not lead to a decrease in the average labour costs of their GVCs, in the case of the core chains it acts as a cost-cutting variable. An example of this is the gap in average and domestic labour costs between both regions (core and periphery). The average vertically integrated wage rate per worker is approximately twice as high in the core GVCs as in the peripheral GVCs in 2014, while domestic wages paid in core chains are almost 3.5 times higher than in the peripheral ones. In short, labour from peripheral countries is more cost-competitive than labour from core countries, which has an important impact on the cost structure of GVCs.

Despite the inequality at the end of the period, the evolution of the wage rate by geographical origin suggests that integration into the world economy through production fragmentation entailed a process of wage convergence in the pre-crisis stage. Figure 5.4 shows the evolution of the average wage rate per worker by geographical origin relative to the average wage rate per worker throughout the chain. In those regions whose values are above 1, the wage has grown more than the average, while in those regions below 1 they earn less. In core GVCs, the gap between core and peripheral wages concerning the average wage rate per product have been held over time. As a result, the stronger convergence, in EU core subsystems, is that between core wages in the pre-crisis period.

\textsuperscript{44} Moreover, the gap between the two magnitudes widened during this period.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure54.png}
\caption{Evolution of the average wage rate per worker by geographical origin relative to the average wage rate per worker throughout the chain.}
\end{figure}
From 2000 to 2008, there was a catch-up effect between core and peripheral countries’ wages in the peripheral chains. The wage advantage of the core countries dropped sharply during this pre-crisis period, while the ratio between the average wage rate of the chain and peripheral wages, especially those of the EU, remained constant. This process stagnated and even reversed in the post-crisis stage, where the difference between core and peripheral countries’ wages increased again.

The stagnation wage convergence in peripheral GVCs may support the literature that points out the risk of the EU periphery coming to a standstill in the middle income trap (Bieńkowski 2016; Staehr 2015; Stöllinger 2019a). A growth of wages in middle-income countries, such as the periphery of the EU, can lead to a premature offshoring of these countries, which have not developed the production forces necessary to specialise in those stages of knowledge-intensive production and whose wages are no longer competitive to carry out those tasks that are more labour-intensive and those oriented to manufacturing.

The vertically integrated wage rate analysis yielded the inequalities between the EU core and peripheral GVCs in terms of average labour costs. In order to delve into these issues, Table 5.1 presents the evolution of the average distribution of vertically integrated labour in the subsystems belonging to the core and peripheral countries of the EU between 2000 and 2014, divided into two time periods. Its analysis reveals several important contributions.
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Table 5.1. Distribution of vertically integrated labour in the EU GVCs (%)

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Dom-Trad.</td>
<td>52.96</td>
<td>46.36</td>
<td>42.18</td>
<td>77.60</td>
<td>66.48</td>
<td>63.31</td>
</tr>
<tr>
<td>Dom-inter.</td>
<td>0.19</td>
<td>0.20</td>
<td>0.22</td>
<td>0.04</td>
<td>0.09</td>
<td>0.10</td>
</tr>
<tr>
<td>Imported,</td>
<td>46.85</td>
<td>53.44</td>
<td>57.60</td>
<td>22.35</td>
<td>33.43</td>
<td>36.59</td>
</tr>
<tr>
<td>of which</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core-EU</td>
<td>9.54</td>
<td>9.10</td>
<td>9.21</td>
<td>3.94</td>
<td>5.40</td>
<td>5.74</td>
</tr>
<tr>
<td>Pral-EU</td>
<td>2.63</td>
<td>3.20</td>
<td>3.77</td>
<td>2.17</td>
<td>3.72</td>
<td>4.27</td>
</tr>
<tr>
<td>Core-noEU</td>
<td>3.64</td>
<td>3.50</td>
<td>3.29</td>
<td>0.69</td>
<td>1.16</td>
<td>1.16</td>
</tr>
<tr>
<td>Pral-noEU,</td>
<td>31.05</td>
<td>37.65</td>
<td>41.33</td>
<td>15.55</td>
<td>23.15</td>
<td>25.42</td>
</tr>
<tr>
<td>of which</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ex-China&amp;RoW</td>
<td>8.98</td>
<td>8.1</td>
<td>9.44</td>
<td>6.78</td>
<td>5.99</td>
<td>6.35</td>
</tr>
<tr>
<td>China</td>
<td>5.06</td>
<td>10.2</td>
<td>8.89</td>
<td>1.39</td>
<td>5.38</td>
<td>5.17</td>
</tr>
<tr>
<td>RoW</td>
<td>17.01</td>
<td>19.38</td>
<td>23.00</td>
<td>7.37</td>
<td>11.78</td>
<td>13.89</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

Firstly, domestic internationalised labour is close to nil in both EU core and peripheral GVCs. Therefore, the analysis will focus on the dynamics of traditional domestic and imported labour and, consequently, wages\(^{45}\). Secondly, the fragmentation of production is more established in the core chains than in the peripheral ones. Although the difference between the two is mainly due to the offshoring of core GVCs, it began in earlier periods. Thirdly, during 2000-2014, both core and peripheral countries followed a similar strategy of labour offshoring outside national borders. This process was, in general terms, more intense in the peripheral chains (14.24p.p. versus 10.75 p.p., on average, in the core subsystems). In both types of regions, the change in the international division of labour was more intense in the pre-crisis stage, particularly in the case of the peripheral chains, where the offshoring of domestic labour exceeded 11p.p. between 2000 and 2008, decreasing dramatically during the second period. This labour offshoring strategy coincides with the stagnation wage convergence shown in Figure 5.4.

Fourthly, the labour offshoring in the EU GVCs confirms the new international division of labour in global production. In both regions, although more markedly in core GVCs, the loss

\(^{45}\) It has become popular in the input-output literature about GVCs distinguishing between traditional domestic and internationalised value added as a proxy of the complexity of GVCs (Wang et al. 2017). However, our results reveal that, in terms of labour, the quantity of domestic labour that is exported and reimported as it becomes embodied in intermediate inputs is insignificant in both core and peripheral GVCs.
of weight of domestic labour was replaced with labour from the peripheries. The peripheral labour came mainly from the extra-European periphery, whose average wage rate was the lowest of the four regions (Figure 5.5).

Figure 5.5. Evolution of the wage rate per worker imported according to geographical origin in thousands of dollars. Results for an average subsystem in each EU region

In particular, it is striking that Chinese labour demand's relative boom stopped after the crisis, where the share of required labour even dropped, particularly in core-country subsystems, which may be explained by the strong increases in Chinese domestic wage during the post-crisis period. Figure 5.6 shows the evolution of wages in the non-EU periphery during the period. While wages in the rest of the extra-EU peripheral countries stagnated or even decreased at the end of the period, Chinese domestic wages soared in the post-crisis stage, which gave rise to a brake on the relocation of work to this region. The RoW supplied a greater proportion of non-domestic work and became most relevant during the period (2000-2014). Labour from other peripheral countries (excluding China and RoW)\(^{46}\), the dark blue line, have had a similar trend in both chains, although it is more expensive for the peripheral chains than for the core chains, which indicates that the technical requirements from these economies might differ between EU core and peripheral GVCs\(^ {47}\).

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\(^{46}\) (Brazil, Croatia, Indonesia, India, Mexico, Russia, Taiwan and Turkey).

\(^{47}\) At this point, it should be noted that RoW is calculated as a residual that captures the employment of all countries not directly accounted for in WIOD. The specific methodology can be found in Appendix C.
It seems that the gradual labour offshoring undergone by core GVCs (Table 5.1) through the lowest wage regions (Figure 5.6) reduced the average labour costs across GVCs (Figure 5.3), but also deepened in the wage-cutting deindustrialisation, which may explain the lack of structural change, as is shown in the physical labour productivity performance analysed in Chapter 4.

In the peripheral chains, changes in the distribution of labour (Table 5.1) reflect a certain stagnation in the upgrading process. The relative weight of imported labour from core countries, which is usually characterised by its intensity in knowledge and capital, grew slightly before the crisis (1.93 p.p.), particularly in the EU, but stagnated in the subsequent stage. Moreover, the integration between middle-wage peripheral and low-wage peripheral regions, notorious up to the crisis, sharply decelerated afterwards, which may have been a brake on development and a symptom of being immersed in the middle-income trap, as has been also suggested by other authors (Soreg 2018; Bieńkowski 2016). Although domestic productive forces were developed within the peripheral GVCs (Grodzicki and Geodecki 2016), the wage rises may have led to the labour relocation to other regions with lower wage levels (Bevan and Estrin 2004; Caraveli 2017), which may have withheld the positive effects of upgrading on the socio-economic development motivated by the exporter boom analysed in Chapter 4. As in the case of the core countries, the China effect, although relevant, particularly in the first period, falls short of accounting for geographical labour relocation across peripheral GVCs. It is imported employment from the RoW region, providing raw
materials and low skill labour, which accounts for the most relevant increase in imported labour after the crisis in the EU periphery.

The results of GVCs’ integration and the labour offshoring to peripheral countries outside the EU differ markedly between the EU core and peripheral GVCs. Table 5.2 presents the changes in the cost structure of GVCs associated with changes in the labour distribution for an average core and peripheral GVC. It shows great asymmetry between the EU core and peripheral GVCs. While in an average EU core GVC the reduction of imported labour was around 15.85%, in peripheral economies, offshoring barely reduced the labour costs by 0.64%, which shows the different nature of GVCs in each EU region.

Table 5.2. Percentage of net reductions in the labour cost structure (%). Results for an average GVC in each EU region

<table>
<thead>
<tr>
<th></th>
<th>2000-08</th>
<th>2008-14</th>
<th>2000-14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>8.35</td>
<td>7.11</td>
<td>15.85</td>
</tr>
<tr>
<td>Periphery</td>
<td>0.83</td>
<td>0.01</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

In the case of EU core-country subsystems, the average imported labour shares (Table 5.1) increased by 6.59p.p. and 4.16p.p. in 2000-2008 and 2008-2014, respectively. As a result, the reductions in the labour cost structure were 8.56% in the first period and 7.11% in the second period (Table 5.2). These results support the focal point of Braun’s theory of unequal exchange, i.e., the inverse relationship between core and peripheral wage rates (Braun 1973). It seems that the labour offshoring from core to peripheral countries responded to a wage-cutting strategy that allowed high wages in core economies to embody cheap labour from peripheral regions. In contrast with the Marxist unequal exchange analysis (Tsaliki, Paraskevopoulou, and Tsoulfidis 2018b; Ricci 2019), Table 5.2 provides an alternative way of measuring the disequilibria in the new international division of labour, compatible with the National Accounts, based on vertically integrated wage rates and labour distribution. That is, it quantifies the consequences of the labour offshoring in the GVCs’ cost structure without falling into value transfer problems.

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48 The numerator is an estimation of the net difference between the average wage rate per vertically integrated worker in the final year and the average wage rate per vertically integrated worker for that same year calculated with the initial year’s wage distribution. The denominator is the average wage rate per vertically integrated worker for the final year of the period. See Equation 3.34 in Section 3.5 of Chapter 3.
Nevertheless, the wage-cutting strategy via labour offshoring to peripheral regions may have successfully reduced labour costs, but it also may have compromised the evolution of the EU core final export in the long run. Table 5.3 presents the structural decomposition of the change in the vertically integrated domestic and imported wages per output for an average core GVC. In other words, wage changes per output are decomposed into changes in the wage per worker and changes in the labour per output or nominal labour productivity.\(^{49}\)

**Table 5.3. Changes in the wage per output decomposed into wage per worker and required labour per output. Results for an average GVC in the EU core region**

<table>
<thead>
<tr>
<th>Core</th>
<th>Growth of wage per output</th>
<th>Wage per worker component</th>
<th>Labour per output component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td>-0.04</td>
<td>-0.04</td>
<td>-0.08</td>
</tr>
<tr>
<td>Imported</td>
<td>0.07</td>
<td>0.20</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

Even though the core domestic wage per worker increased, in general terms, over the wage per imported worker, the domestic labour reductions per output compensated the gap between both. That is to say, the improvement in the technical conditions of domestic production compared to imported production facilitated a more significant drop in the domestic wage per output than in the imported one, even though the wage per worker in the former increased more rapidly. This result points out the labour offshoring as the cause of the low physical labour productivity of the EU core GVCs, due to the fact that production was moved to peripheral regions, where labour productivity growth was lower. This wage-cutting strategy may work in the short term, since the average labour costs across the GVCs decrease. However, on the one hand, they continued to be higher than in the EU peripheral GVCs, and, on the other hand, this slowed down potential structural changes generated in core economies with higher innovation levels, which may compromise real competitiveness in the long term, as will be analysed in chapter 6.

\(^{49}\) The changes in nominal labour productivities provided as labour per product component in Table 5.3 cannot be used to compare the evolution of the technical conditions between core and periphery subsystems since they depend on different price dynamics. Nevertheless, they are valid to compare the domestic and imported technical conditions inside the GVCs. The physical labour productivity for each subsystem is estimated by deflating the price that defines the final product (see Equation 3.15 from Section 3.4 of Chapter 3), since the rest of components are given in labour terms. Consequently, both domestic and imported labour per product affect the same prices, which allows comparing them in nominal labour productivity terms.
In the EU peripheral region, the bulk of the reductions of the peripheral-country subsystems occurred in the pre-crisis period (Table 5.2), which was the most active period in terms of offshoring; however, the benefits of this are not striking, with the reductions of an average peripheral chain being less than 1%. Therefore, although the offshoring of peripheral subsystems was mainly to countries with lower wage costs, on a general level, these have not had a significant impact on the cost structure. This fact cannot be understood without considering the risk of the foreign-led export model in middle-income economies as the EU periphery (Kharas and Kohli 2011).

Export-led growth may improve domestic labour productivity. But it does not associate improvements in technical conditions with a domestic market's development that helps these economies exceed middle-income levels. The EU peripheral final export subsystems are based on FDI that respond to strategies and objectives determined by foreign parent companies (Gal and Schmidt 2017; Hunya 2015; Bieńkowski 2016). These companies separate their final market from their production locations, so their incomes do not depend on the socio-economic development of the producing country, but on global dynamics that are exogenous to this (Kottaridi 2005). As a consequence, the potential socio-economic upgrading, encouraged by the final export boom in the EU periphery, is limited by the containment of domestic effective demand (Soreg 2018; Völlmecke, Jindra, and Marek 2016; Stöllinger 2019b), whilst it is precisely the dynamics of domestic consumption a primary driver to escape the middle-income trap (Gal and Schmidt 2017; Bartlett and Prica 2017).

The acceleration of the relocation of production from the EU peripheral-country subsystems to other economies with cheaper labour may pose a brake on the growth of the wage bill in the long term and, therefore, on the process of wage catching-up within the EU, which has two direct consequences. On the one hand, it reproduces the socio-productive inequalities within the EU, and, on the other hand, it slows down the consolidation of a strong domestic market driven by the development of domestic productive forces and the labour income generated by export-oriented subsystems (Bartlett and Prica 2017).
The risk of falling into the middle-income trap seems to be reinforced by the decomposition of the changes in the average wage per unit of output in the EU peripheral GVCs presented in Table 5.4. Although in the pre-crisis period (2000-2008), the domestic wage per worker increased at a faster rate than the imported wage, the domestic wage per unit of output paid in the EU peripheral GVCs dropped steadily due to the fast-paced evolution of nominal domestic productivity with respect to the imported one. Nevertheless, this pace of growth came to a halt after the crisis. Despite the fact that the domestic wage per unit of output continued to fall between 2008 and 2014, both the upgrading and wage catching up processes slowed down. The slow-paced decrease in the domestic labour content of output was accompanied by a stagnant domestic nominal wage. In addition, in the post-crisis period, imported labour per unit of output increased, reducing imported labour productivity while the imported wage per worker was still slightly increasing, which may be related to the EU peripheral market share stagnation in the post-crisis period, described in Chapter 4.

Finally, the changes in the geographical composition of the EU GVCs (reflected in Table 5.1) also reveal the loss of relative importance of European production integration, also known as “factory Europe” (Baldwin 2006; Baldwin and Lopez-Gonzalez 2015). As Los et al. (2015) pointed out for the EU core economies, the trend toward regional fragmentation may have been dominant in the 1980s and early 1990s, but from the 2000s onward, fragmentation, at least of the EU GVCs, tends to be global. Our empirical analysis, based on the labour distribution rather than the value-added distribution, indicates that the same trend is found in the subsystems from the EU periphery. In both types of chains, labour from non-EU peripheral countries was increasingly relevant, which also questions the role of EU integration as a source of economic and production development.

Table 5.4. Changes in the wage per output decomposed into wage per worker and required labour per output. Results for an average GVC in the EU peripheral region

<table>
<thead>
<tr>
<th>Periphery</th>
<th>Growth of wage per output</th>
<th>Wage per worker component</th>
<th>Labour per output component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td>-0.07</td>
<td>-0.07</td>
<td>-0.14</td>
</tr>
<tr>
<td>Imported</td>
<td>0.09</td>
<td>0.12</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

Table 5.4 presents the same structural decomposition as Table 5.3 but for an average peripheral GVC.
To sum up, the analysis of the international labour division and the labour remuneration in core GVCs seems to be in line with the main arguments suggested by Braun (1973) in his theory of unequal exchange. Labour offshoring, in the EU GVCs, allows reducing the labour cost structure through the use of cheap labour from peripheral economies, while maintaining high domestic wage levels in core countries. Although this has also been shown, it cannot be understood as the panacea for core competitiveness problems. In the case of peripheral GVCs, the empirical analysis suggests that the foreign-led model has driven an upgrading process accompanied by a wage catching-up, but this phenomenon stopped after the crisis. This stagnation can cause these economies to fall into the middle-income trap.

5.4 Trends in the international labour division and their effect on the cost structure of GVCs in the EU by product types

In the previous section, we have analysed, in a general manner, the new international division of labour’s impact on the cost structure of the core and peripheral subsystems. In both the EU core and peripheral GVCs, a labour-offshoring strategy to non-EU peripheries seemed to dominate, although each region’s final impact on the cost structure was uneven. However, the international division of labour may adopt different patterns depending on the type of product, which may be more or less focused or have a greater or lesser effect on cost reduction. Therefore, this section will investigate trends in labour distribution and their impact on the cost structure by type of product.

Figure 5.7. Share of imported labour in final export country subsystems. Years 2000 to 2014

Source: Author’s calculations based on WIOD and ILOSTAT
Following the method of analysis carried out by Los et al. (2015) for the share of foreign value added, the scatter plots shown in Figure 5.7 capture the changes in the shares of imported labour in the leading export chains in each region for the period of 2000-2014 as a whole. Each point represents a country subsystem. There are 14 subsystems from 12 different economies in each region. The red line with slope 1 describes the particular situation in which the share of imported labour is the same at the beginning and the end of the period. Consequently, when the level of production fragmentation in a GVC does not vary during the period, the observations of each subsystem will be clustered around the red line. The green line is an ordinary least squares (OLS) regression through the origin.

Overall, almost all observations are above the red line for the period, reflecting a general increase in production fragmentation. As can be observed, the changes were more dramatic in peripheral subsystems that are further away from the red line. The estimated slope of the OLS regression in each region points in the same direction. The share of imported labour grew around 1.49 times in the EU peripheral subsystems versus 1.21 times in the EU core subsystems over the 15 years considered. Nonetheless, there are certain satellite subsystems in which the growth of imported labour was sharper or, in contrast, maintained.

Table 5.5. Changes in the share of imported labour between 2000 and 2014 (percentual points) and share in the year 2014 (%). Results for an average GVC in each product type

<table>
<thead>
<tr>
<th></th>
<th>Core</th>
<th></th>
<th>Periphery</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01AGRIC</td>
<td>5.59</td>
<td>3.26</td>
<td>46.05</td>
<td>9.04</td>
</tr>
<tr>
<td>05FOOD</td>
<td>4.53</td>
<td>2.45</td>
<td>64.72</td>
<td>11.33</td>
</tr>
<tr>
<td>06TEXT</td>
<td>7.97</td>
<td>7.72</td>
<td>68.75</td>
<td>11.34</td>
</tr>
<tr>
<td>11CHEM</td>
<td>6.84</td>
<td>6.33</td>
<td>72.77</td>
<td>14.49</td>
</tr>
<tr>
<td>12PHARMA</td>
<td>5.63</td>
<td>8.57</td>
<td>62.83</td>
<td>10.60</td>
</tr>
<tr>
<td>16METPRDS</td>
<td>7.20</td>
<td>1.02</td>
<td>49.84</td>
<td>10.31</td>
</tr>
<tr>
<td>17ICTEQ</td>
<td>4.19</td>
<td>4.46</td>
<td>66.55</td>
<td>19.62</td>
</tr>
<tr>
<td>18ELECQ</td>
<td>6.80</td>
<td>4.56</td>
<td>63.40</td>
<td>11.64</td>
</tr>
<tr>
<td>19MACH_EQ</td>
<td>8.82</td>
<td>3.60</td>
<td>58.90</td>
<td>12.76</td>
</tr>
<tr>
<td>20VENC_EQ</td>
<td>7.55</td>
<td>5.39</td>
<td>68.22</td>
<td>13.35</td>
</tr>
<tr>
<td>21TREQ</td>
<td>7.91</td>
<td>0.79</td>
<td>60.54</td>
<td>11.54</td>
</tr>
<tr>
<td>22OMAN</td>
<td>5.50</td>
<td>2.57</td>
<td>52.24</td>
<td>10.31</td>
</tr>
<tr>
<td>40ICTPROG</td>
<td>6.57</td>
<td>4.12</td>
<td>39.67</td>
<td>3.76</td>
</tr>
<tr>
<td>41FINANCE</td>
<td>7.12</td>
<td>3.40</td>
<td>31.93</td>
<td>4.97</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

This section delves into the differences between subsystems according to their product type. Table 5.5 shows the changes in the share of imported labour given, in an average final export
GVC, for each product type in the UE core and periphery regions. The change in the total share is divided into the pre-crisis sub-period (2000-2008) and the post-crisis sub-period (2008-2014). The last column for each region shows the share of imported labour at the end of 2014.

Although the trend toward labour offshoring in the final European chains is generalised, there are notable differences according to the product type. The two service types of subsystems, i.e., programming and consulting activities (40ICTPROG) and financial services (41FINANCE), show much lower shares of imported labour than the manufacturing subsystems in both regions, that is, they appear to be less fragmented subsystems. It seems that this trend changed rapidly in the core-country subsystems, which underwent a substantial increase in the weight of imported labour during the period, but not in the peripheral service subsystems, where the increase in the weight of imported labour is noticeable lower.

In the manufacturing subsystems, the process of production fragmentation was more intense in peripheral-country subsystems than in core-country subsystems, which makes sense, considering that core final exports started from a higher degree of internationalisation. Except in agriculture (01AGRIC), the imported labour was around or above 50% over the total labour required for core-country manufacturing subsystems. In the case of the peripheral-country subsystems, only the electronics (17ICTEQ), chemicals (11CHEM), and vehicles (20VEHIC) types of subsystems required more imported labour than domestic labour. It seems that these types of products were particularly prone to being integrated into GVCs and participating in the international division of labour. Consequently, both regions present high levels of production fragmentation and a strong increase in labour offshoring during the period.

It appears that the integration of final exports in GVCs was transversal in all types of manufacturing, not differentiating between those that were more labour-intensive, such as processed food (05FOOD) or textiles (06TEXT), from those with a high technological content, such as electronic and optical products (17ICTEQ), chemicals (11CHEM) and vehicles (20VEHIC), although not all internationalisation patterns were homogeneous between the two regions. In the case of core-country subsystems, the results across product types show that the production internationalisation responded to a long-term strategy in which progress was made progressively without being conditioned by the economic cycle. On the other hand, integrating final peripheral exports into GVCs seems to be more sensitive to cyclical changes. In the years before the crisis, these peripheral-country subsystems experienced an
intense process of productive fragmentation, which has slowed down notably in the current stage.

The increase in the weight of imported labour with respect to domestic labour may be explained by two reasons: the incorporation of more advanced technology from abroad, or reductions in labour costs. Table 5.6 shows the changes in imported labour distribution by geographical origin in an average GVC for each product type. There are certain patterns at a general level. Firstly, imported labour from countries outside the EU gained the most weight in the core GVCs. For example, in the core textile subsystems (06TEXT), the weight of non-peripheral imported labour grew by more than 18p.p. during the period. In addition to low-tech subsystems such as textile (06TEXT), in core-country subsystems, the labour offshoring from core to non-EU peripheries also stands out in most technology-intensive subsystems, being particularly important in the cases of pharmaceuticals (12PHARMA), chemicals (11CHEM) and vehicles (20VEHIC).

Table 5.6. Changes in the distribution of imported labour by geographical origin. Results for an average GVC in each product type. Period of 2000-2014 (percentual points)

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Core-EU</th>
<th>Pral-EU</th>
<th>Core-noEU</th>
<th>Pral-noEU</th>
<th>Core-EU</th>
<th>Pral-EU</th>
<th>Core-noEU</th>
<th>Pral-noEU</th>
</tr>
</thead>
<tbody>
<tr>
<td>01AGRIC</td>
<td>1.18</td>
<td>1.42</td>
<td>0.42</td>
<td>5.82</td>
<td>1.21</td>
<td>1.78</td>
<td>0.20</td>
<td>6.16</td>
</tr>
<tr>
<td>05FOOD</td>
<td>1.66</td>
<td>2.22</td>
<td>0.02</td>
<td>3.08</td>
<td>1.44</td>
<td>2.59</td>
<td>0.19</td>
<td>7.22</td>
</tr>
<tr>
<td>06TEXT</td>
<td>-2.65</td>
<td>0.15</td>
<td>-0.58</td>
<td>18.77</td>
<td>0.69</td>
<td>1.16</td>
<td>0.14</td>
<td>14.67</td>
</tr>
<tr>
<td>11CHEM</td>
<td>0.11</td>
<td>1.36</td>
<td>-0.76</td>
<td>12.46</td>
<td>2.99</td>
<td>2.60</td>
<td>0.59</td>
<td>10.75</td>
</tr>
<tr>
<td>12PHARMA</td>
<td>0.65</td>
<td>1.31</td>
<td>-0.94</td>
<td>13.17</td>
<td>2.05</td>
<td>1.97</td>
<td>0.36</td>
<td>10.20</td>
</tr>
<tr>
<td>16METPRDS</td>
<td>0.16</td>
<td>1.06</td>
<td>0.37</td>
<td>6.63</td>
<td>2.45</td>
<td>2.12</td>
<td>0.45</td>
<td>6.60</td>
</tr>
<tr>
<td>17ICTEQ</td>
<td>-2.72</td>
<td>0.73</td>
<td>-1.22</td>
<td>11.87</td>
<td>0.67</td>
<td>2.01</td>
<td>1.05</td>
<td>21.49</td>
</tr>
<tr>
<td>18ELECEQ</td>
<td>-0.89</td>
<td>1.51</td>
<td>-0.52</td>
<td>11.27</td>
<td>3.02</td>
<td>2.75</td>
<td>0.69</td>
<td>11.83</td>
</tr>
<tr>
<td>19MMACHEQ</td>
<td>0.12</td>
<td>1.39</td>
<td>-0.09</td>
<td>11.00</td>
<td>3.28</td>
<td>2.68</td>
<td>0.68</td>
<td>10.62</td>
</tr>
<tr>
<td>20VEHIC</td>
<td>-1.46</td>
<td>1.86</td>
<td>-0.10</td>
<td>12.65</td>
<td>1.78</td>
<td>3.04</td>
<td>0.81</td>
<td>13.24</td>
</tr>
<tr>
<td>21TREQ</td>
<td>-2.61</td>
<td>0.68</td>
<td>-0.23</td>
<td>10.86</td>
<td>2.45</td>
<td>2.72</td>
<td>0.85</td>
<td>10.22</td>
</tr>
<tr>
<td>22OMAN</td>
<td>0.22</td>
<td>1.01</td>
<td>-0.78</td>
<td>7.62</td>
<td>1.55</td>
<td>2.01</td>
<td>0.21</td>
<td>9.03</td>
</tr>
<tr>
<td>40ICTPROG</td>
<td>0.75</td>
<td>0.65</td>
<td>-0.75</td>
<td>10.03</td>
<td>0.77</td>
<td>0.97</td>
<td>0.10</td>
<td>3.21</td>
</tr>
<tr>
<td>41FINANCE</td>
<td>0.91</td>
<td>0.67</td>
<td>0.28</td>
<td>8.67</td>
<td>0.86</td>
<td>0.98</td>
<td>0.19</td>
<td>2.98</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

Except in the peripheral electronic and optical products (17ICTEQ) GVCs, where the imported core labour increased to a lesser extent, imported labour from core economies increased in all capital-intensive manufacturing GVCs between 2.4 and 4p.p. Despite this, the peripheral countries, particularly those outside the EU, increased their share the most, being the main source of imported labour in the periphery as well. The rise of peripheral labour from outside
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the EU stands out in electronic and optical products, where it increased its weight by 21.49p.p. during the 15 years studied.

The offshoring of domestic labour to peripheral non-EU countries suggests a strategy entirely based on cost-cutting in the EU core region and an upgrading process in the case of EU peripheral GVCs. Table 5.7 illustrates the percentage of net reductions associated with labour offshoring for each average subsystem by product type\(^{51}\). The table distinguishes between both regions and the pre- and post-crisis sub-periods. If offshoring increased labour costs, the reductions ratio will be negative.

**Table 5.7. Percentage of net reductions in the cost structure of an average GVC by product type (%).**

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Core 2008-00</th>
<th>Core 2014-08</th>
<th>Core 2014-00</th>
<th>Periphery 2008-00</th>
<th>Periphery 2014-08</th>
<th>Periphery 2014-00</th>
</tr>
</thead>
<tbody>
<tr>
<td>01AGRIC</td>
<td>6.45</td>
<td>4.04</td>
<td>11.29</td>
<td>1.72</td>
<td>0.01</td>
<td>0.25</td>
</tr>
<tr>
<td>05FOOD</td>
<td>8.82</td>
<td>5.03</td>
<td>14.61</td>
<td>6.03</td>
<td>-0.54</td>
<td>4.12</td>
</tr>
<tr>
<td>06TEXT</td>
<td>12.84</td>
<td>15.84</td>
<td>30.02</td>
<td>0.08</td>
<td>0.15</td>
<td>1.06</td>
</tr>
<tr>
<td>11CHEM</td>
<td>9.85</td>
<td>11.46</td>
<td>23.86</td>
<td>3.63</td>
<td>0.18</td>
<td>2.72</td>
</tr>
<tr>
<td>12PHARMA</td>
<td>6.31</td>
<td>12.79</td>
<td>20.08</td>
<td>3.69</td>
<td>1.58</td>
<td>5.74</td>
</tr>
<tr>
<td>16METPRDS</td>
<td>6.50</td>
<td>1.22</td>
<td>7.99</td>
<td>-2.06</td>
<td>-0.28</td>
<td>-3.05</td>
</tr>
<tr>
<td>17ICTEQ</td>
<td>6.56</td>
<td>11.86</td>
<td>18.04</td>
<td>2.71</td>
<td>0.65</td>
<td>3.82</td>
</tr>
<tr>
<td>18ELECEQ</td>
<td>9.75</td>
<td>6.08</td>
<td>15.05</td>
<td>-2.82</td>
<td>-0.50</td>
<td>-1.58</td>
</tr>
<tr>
<td>19MMACHEQ</td>
<td>8.91</td>
<td>5.23</td>
<td>14.14</td>
<td>-0.81</td>
<td>-0.87</td>
<td>-1.79</td>
</tr>
<tr>
<td>20VEHIC</td>
<td>7.75</td>
<td>6.88</td>
<td>15.44</td>
<td>-2.38</td>
<td>-0.89</td>
<td>-2.94</td>
</tr>
<tr>
<td>21TREQ</td>
<td>11.73</td>
<td>4.60</td>
<td>12.42</td>
<td>0.43</td>
<td>0.08</td>
<td>-1.08</td>
</tr>
<tr>
<td>22OMAN</td>
<td>6.89</td>
<td>5.31</td>
<td>14.20</td>
<td>-1.10</td>
<td>0.15</td>
<td>-1.42</td>
</tr>
<tr>
<td>40ICTPROG</td>
<td>7.59</td>
<td>5.36</td>
<td>13.37</td>
<td>0.94</td>
<td>0.30</td>
<td>1.57</td>
</tr>
<tr>
<td>41FINANCE</td>
<td>6.97</td>
<td>3.81</td>
<td>11.38</td>
<td>1.57</td>
<td>0.10</td>
<td>1.54</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

Incorporating the new international labour division into final production resulted in notable reductions in the cost structure in all core-country subsystems. As expected, due to their low technological intensity, the textile core GVCs are the ones that offshored the most labour, mainly to the extra-European periphery, and offshoring led to the most significant reduction in the cost structure. The production fragmentation in textile core subsystems is expected to affect the cost structure, since they are low-technological-intensity manufacture with a short margin for increases in labour productivity.

---

\(^{51}\) As in Table 5.2, the estimation was made using Equation 3.34 in Section 3.5 of Chapter 3.
However, the analysis of the labour distribution in GVCs and its impact on the cost structure reveals another essential result. The technology- or knowledge-intensive manufacturing subsystems also maintained a strategy of labour-cost reduction during the period, prioritising labour from less capital-intensive peripheral countries. The labour cost reductions triggered by the labour redistribution in core GVCs were significant in the chemicals (11CHEM), pharmaceuticals (12PHARMA) and electronic and optical products (17ICTEQ) industries, where the reductions over the period were approximately 23.86%, 20.08% and 18.04%, respectively. These results are in line with the main contributions of the theory of unequal exchange. The labour offshoring peripheral economies allow keeping wages high in core economies, while keeping costs in the production process, positively affecting final prices. Moreover, the cost reductions of the core subsystems maintained a stable trend for most types of products, which indicates that the wage-cutting strategy is little influenced by the economic cycle.

**Table 5.8. Changes in the wage per output decomposed into wage per worker and required labour per output by product type. Results for an average GVC in the EU core region. Period 2000-2024**

<table>
<thead>
<tr>
<th>Core</th>
<th>Domestic</th>
<th>Imported</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Growth of wage per output</td>
<td>Wage per worker component</td>
</tr>
<tr>
<td>01AGRIC</td>
<td>-0.06</td>
<td>0.75</td>
</tr>
<tr>
<td>05FOOD</td>
<td>-0.13</td>
<td>0.75</td>
</tr>
<tr>
<td>06TEXT</td>
<td>-0.10</td>
<td>0.73</td>
</tr>
<tr>
<td>11CHEM</td>
<td>-0.17</td>
<td>0.93</td>
</tr>
<tr>
<td>12PHARMA</td>
<td>-0.11</td>
<td>0.80</td>
</tr>
<tr>
<td>16METPRDS</td>
<td>-0.04</td>
<td>0.81</td>
</tr>
<tr>
<td>17ICTEQ</td>
<td>0.01</td>
<td>0.87</td>
</tr>
<tr>
<td>18ELECEQ</td>
<td>-0.04</td>
<td>0.81</td>
</tr>
<tr>
<td>19MMACHEQ</td>
<td>-0.12</td>
<td>0.77</td>
</tr>
<tr>
<td>20VEHIC</td>
<td>-0.09</td>
<td>0.84</td>
</tr>
<tr>
<td>21TREQ</td>
<td>-0.09</td>
<td>0.65</td>
</tr>
<tr>
<td>22OMAN</td>
<td>-0.04</td>
<td>0.83</td>
</tr>
<tr>
<td>40ICTPROG</td>
<td>-0.06</td>
<td>0.74</td>
</tr>
<tr>
<td>41FINANCE</td>
<td>-0.07</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based on WIOD and ILOSTAT

The cost-reduction strategy followed by the EU core GVCs affected labour productivity across the GVCs. Table 5.8 shows the structural decomposition of the changes in wages per product for the core subsystems categorised by product types. As is explained in Table 5.3, these can
be defined as the changes in the wage per worker plus the changes in the nominal labour productivity across GVCs\(^{52}\). The results shown are the average for each type of subsystem.

The domestic wage per product dropped over the period, while the imported wage per product rose. Although domestic wages per worker grew faster than imported wages per worker in all types of technology-intensive subsystems, domestic labour per product dropped more rapidly than imported labour. In other words, cost reduction, across product types in the core-country subsystems, based on labour offshoring to peripheral regions, affected the technical production conditions, as production was offshored to regions where the nominal labour productivity evolved at a slower pace. Therefore, as will be tackled in chapter 6, the priority of a strategy based on wage-cutting rather than on the improvement of technical production conditions affects the competitiveness of these industries, particularly in the long term. The difference between domestic and peripheral nominal labour productivity is particularly striking in the textile subsystems (06TEXT), but also in intensive subsystems such as chemicals (11CHEM), pharmaceuticals (12PHARMA) and electronic and optical products (17ICETQ), where the wage-cutting strategy was particularly relevant.

The impact on the core cost structure caused by production fragmentation differs for the periphery-country subsystems according to product types. Table 5.7 shows that labour offshoring seems to have had a slight positive effect on cost reduction in labour-intensive industries such as processed food (05FOOD) and textiles (06TEXT), as well as in IT services (40ICTPROG) and financial services (41FINANCE).

In peripheral technology-intensive capital subsystems, those requiring a larger production scale and most subject to foreign direct investment, labour offshoring has provoked an increase in labour costs (Table 5.7). The only three exceptions are the subsystems of chemicals (11CHEM), pharmaceuticals (12PHARMA) and electronic and optical products (17ICETQ), where production fragmentation went hand in hand with decreasing labour costs. As was seen above, these three types of subsystems are also where labour offshoring was more successful in core-country subsystems. These results support the idea that cost competitiveness may also exert pressures on capital-intensive sectors and, even middle-income economies, may need to moderate their wages in order to be competitive in certain industries. Products such as chemicals and pharmaceuticals show a generalised tendency to

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\(^{52}\) As is explained in footnote 49, since both domestic and imported nominal labour productivity affect the final product prices. The dynamic of each of them can be compared in each region.
reduce labour costs via labour relocation, which motivates research objective 3 (analysed in Chapter 6).

Returning to the general trend in capital-intensive final export industries in the EU peripheral GVCs, the failure to reduce labour costs via labour offshoring is related to domestic and imported nominal labour productivity. Table 5.9 shows the structural decomposition of wage changes by-product for subsystem groups summarised in the average GVC for each group\textsuperscript{53}.

\begin{table}[h]
\centering
\caption{Changes in the wage per output decomposed into wage per worker and required labour per output by product type. Results for an average GVC in the EU peripheral region. Period 2000-2024}
\begin{tabular}{lccccc}
\hline
Product & Domestic & & & \multicolumn{2}{c}{Imported} \\
 & Growth of & Wage per & Labour per & Growth of & Wage per \\
 & wage per & worker & output & wage per & worker & output \\
 & output & component & component & output & component & component \\
\hline
01AGRIC & -0.05 & 1.84 & -1.89 & 0.40 & 1.37 & -0.97 \\
05FOOD & -0.14 & 1.60 & -1.74 & 0.22 & 1.25 & -1.02 \\
06TEXT & -0.15 & 1.33 & -1.48 & 0.12 & 0.43 & -0.31 \\
11CHEM & -0.28 & 1.35 & -1.63 & 0.25 & 1.18 & -0.93 \\
12PHARMA & -0.05 & 2.03 & -2.08 & 0.22 & 0.93 & -0.71 \\
16METPRDS & -0.15 & 1.53 & -1.68 & 0.17 & 1.01 & -0.84 \\
17ICTEQ & -0.23 & 1.67 & -1.89 & 0.21 & 0.65 & -0.44 \\
18ELECEQ & -0.24 & 1.42 & -1.66 & 0.24 & 0.95 & -0.70 \\
19MMACHEQ & -0.25 & 1.67 & -1.92 & 0.19 & 0.99 & -0.80 \\
20VEHIC & -0.20 & 1.52 & -1.72 & 0.24 & 0.86 & -0.62 \\
21TREQ & -0.25 & 1.46 & -1.70 & 0.20 & 0.91 & -0.71 \\
22OMAN & -0.14 & 1.43 & -1.58 & 0.16 & 0.81 & -0.65 \\
40ICTPROG & 0.19 & 1.83 & -1.64 & 0.19 & 0.92 & -0.73 \\
41FINANCE & -0.08 & 1.38 & -1.46 & 0.15 & 0.88 & -0.73 \\
\hline
\end{tabular}
\end{table}

Source: Author’s calculations based on WIOD and ILOSTAT

The noticeable labour offshoring of the EU peripheral GVCs does not seem to fully respond to changes in their internal dynamics, even when, for all product types, the domestic wage per worker grew more than the imported wage per worker. The wage per product decreased faster domestically due to sharp rises in domestic nominal labour productivity compared to imported labour productivity.

\textsuperscript{53} The detailed structural decomposition can be found in the explanation of Table 5.3 and in footnote 49.

\textit{Maria Gomez Benitez}
The improvement in the domestic technical conditions in the EU periphery indicates that the region underwent an upgrading process accompanied by a relocation of labour to more labour-intensive regions which has not had a particularly positive effect on the cost structure of the peripheral GVCs. In most groups of capital-intensive subsystems, the data show a trade-off between improving the technical conditions of production and reducing labour costs.

To sum up, the changes in labour distribution allowed core GVCs to reduce labour costs without decreasing domestic wages. Moreover, it allowed these subsystems to make use of the international division of labour. Nevertheless, labour productivity grew more domestically than externally, which may generate structural problems in the long term. The marked increase in domestic labour productivity with respect to imported labour productivity in the EU peripheral final export GVCs shows that the region underwent a reversal in the process of technological upgrading. However, this improvement in technical conditions is linked to an increase in wages per worker, which triggered a premature labour offshoring to other peripheral regions with lower wage levels and lower technological development.

5.5 Summary

This chapter provides a reworked specification of Braun’s model of unequal exchange (Braun 1973), which has inspired the measurement of the changes in the cost structure of GVCs associated with changes in the labour distribution developed in Section 3.5, Chapter 3, and tested empirically in this chapter. The goal of the measurement was to estimate how much labour offshoring is entailed in terms of cost reductions. The chapter also analysed the impact of labour offshoring in the technical conditions of the final export GVCs. The main results are as follows.

Firstly, major GVCs in the EU gradually increased their international fragmentation. The share of imported labour grew for both regions, core and periphery. In general, the degree of labour offshoring was higher in the core region, but it was in the peripheral region, particularly in the pre-crisis phase, where it underwent a more significant increase in production fragmentation. Labour offshoring seemed to respond to a long-term process in the core region, without significant changes marked by economic cycles. In this sense, a relevant contribution has been to reassess the extent of international fragmentation in terms of labour content rather than value added contributions, highlighting the relative importance of peripheral regions, overlooked when measure in terms of value added.
Secondly, the production fragmentation of EU final exports had an extra-regional, global – rather than regional – trend. Moreover, in both regions, non-EU periphery, characterised by labour-intensive and low-wage regions, increased their share the most. In both types of chains, labour from the non-EU periphery gained the most weight during the period.

Thirdly, the inverse relationship between core and peripheral wages claimed by Braun’s model of unequal exchange seems to be valid in core final export subsystems. The greater weight of imported labour from the periphery had a notable cost-cutting effect on core-country subsystems, allowing them to maintain high (though not dynamic) core domestic wages at the same time.

Fourthly, labour offshoring does not seem to have significantly affected the cost structure in the peripheral region, but it did affect the process of wage catching-up with the core region. During the pre-crisis phase, domestic wages in the peripheral GVCs grew significantly compared to those in the core regions.

However, this process was paralleled by intensifying the offshoring of labour to other countries. Although the labour imported from core economies slightly increased its intensity in peripheral subsystems, most of labour offshoring was directed toward extra EU peripheral regions characterised by low-wage and relatively backward technical conditions. This has two implications: it denotes, on the one hand, a slow leap in domestic tasks toward activities that require a higher level of technology and knowledge, and, on the other hand, a tendency for this region to be caught in the middle-income trap. Without a change from an export-oriented strategy (very vulnerable to exogenous shocks) to an inward-oriented strategy (driven by domestic effective demand), the replication of a cost competitiveness logic within its own peripheral GVCs, slows down the catching-up process to overcome the middle-income threshold.

The cost reduction strategy through offshoring has also affected labour productivity across the GVCs. In both regions, the nominal domestic labour productivity grew more than the imported one. Therefore, there is a trade-off between improving technical conditions and cost reductions. The inclination to implement wage-cutting strategies instead of improving labour productivity may have a positive effect on reducing labour cost, particularly in core subsystems, but it may also have negative consequences on the final export performance, as will be studied in Chapter 6.

Please note that domestic productivity increases at a faster pace than imported productivity. Hence, by increasing the quantity of imported labour (for a given final output), overall GVC
productivity will be negatively affected. This does not mean that overall productivity is not increasing, but that it increases at a slower pace.

By product types, there are differences in the impact of labour offshoring. In general terms, the production fragmentation level was higher in manufacturing chains than in service chains, although the latter are gradually increasing their offshoring. Finally, as expected, the degree of production fragmentation was high in labour-intensive sectors, such as textile, and provided a relevant reduction in the cost structure. However, our analysis reveals that strong cost reduction strategies may also guide technology-intensive industries. In this sense, the chemical (11CHEM), pharmaceutical (12PHARMA) and electronic and optical products (17ICETQ) subsystems stand out. For these three subsystems, their cost competitiveness logic will be further explored in Chapter 6.
Chapter 6: Final export’s performance of EU subsystems: a cost competitiveness’ vertically integrated analysis

6.1 Introduction

Measuring international competitiveness has been challenged in recent decades. Globalised production has brought to light the limits of traditional export-based measures and the need to develop new techniques to enable a fresh look at the role of GVCs in trade. The EU is very much part of such changes across the global economy. Moreover, the integration of its members into GVCs has grown globally and at regional levels over the past decades. In this latter aspect, the European Single Market (ESM), the European Monetary Union (EMU) and the entry of the Eastern European economies have reinforced the integration process (Foster, Stehrer, and Timmer 2013; Bruszt and Langbein 2017).

In Chapter 4, we analysed the determinants of final export growth in the EU, and we concluded that there is a concerning lack of productivity increases in the core region, whilst real variables have led the growth of final exports in the EU periphery. As has been shown in Chapter 5, the weak productivity performance of core-countries’ GVCs seems to be related to a wage-cutting strategy based on labour offshoring to peripheral regions. Despite the impressive real growth of final exports in the EU periphery, subsystems from these countries have also accelerated their integration to global GVCs by deepening productive ties with non-EU peripheral areas with relatively backward technical conditions, which may slow down – in the long-period – the domestic upgrading of productive forces, if predominantly based on an export-led strategy.

This chapter contributes to the literature on GVCs and international competitiveness by providing a theoretical disaggregated framework based on a vertically integrated approach that singles out key mechanisms boosting cost competitiveness in the EU, considering the comprehensive set of inter-country, inter-industry relations linking production processes of final exported products. The chapter poses a number of research questions: in a globalised context, what is the role of relative vertically integrated unitary labour costs (rviulc) when accounting for the relative dynamism of final export subsystems in the EU? If rviulc are able to explain final export performance in real terms, is this dynamic path determined via changes in nominal wages or (physical) labour productivity? Are those patterns similar in the short and long-run? Furthermore, do rviulc impact EU core and peripheral economies in the same way? Finally, is the role of rviulc and their components similar or different between product types?
The remainder of the chapter is organised and follows. The next session recaps main aspects of the rviulc indicator and its definition. Section 6.3 introduces the theoretical model to obtain the rviulc and their components – based on national accounts and a vertically integrated approach – as well as the characteristics of the econometric model for panel-data specified for the analysis. Section 6.4 presents and discusses the empirical results. Its objective is to identify the cost determinants that may influence final exports' market shares – in real terms – of EU subsystems. Finally, Section 6.5 outlines the main conclusions.

6.2 Turning the vertically integrated unitary labour costs in relative vertically integrated unitary labour costs

The scholarship has widely discussed the link between labour costs and technology (Carlin, Glyn, and Reenen 2001; Kapeller, Gräbner, and Heimberger 2019; Baccaro and Benassi 2017; Bournakis 2014; Wolfmayr 2012; Artto 1987). However, as we have seen in Section 3.6, Chapter 3, most of the literature considers that cost competitiveness depends only on domestic unit labour costs (ULC) and productivity, despite an increasing share of the value added to final exports being produced in GVCs, which divide production processes worldwide. This thesis contributes to this field by suggesting a new measurement framework compatible with international production fragmentation – developed in Section 3.6 – based on a vertically integrated approach (Pasinetti 1973). This framework is capable of singling out determinants of cost competitiveness in each GVC articulated within the EU, whilst considering all the productive ties across international production processes.

The main variables obtained in Section 3.6 are the vertically integrated unit labour costs (viulc) and its components, the ratio of the vertically integrated nominal wages and (w) to the vertically integrated labour productivity in volume terms (\( \hat{\rho}^* \)), as defined in Equation 3.44.

Since the vertically integrated unit labour productivity is built in constant local currency units, whereas several currencies are in operation within the EU, the analysis needs to focus on rates of change instead of levels. Hence, the vector of viulc is reformulated as an index (Idx_viunw), where each \( Idx_{viulc}^r(i,t) \) represents the viulc for subsystem \( i \) of country \( r \) in year \( t \), divided by the viulc for subsystem \( i \) of country \( r \) in year 0 \( (t_0) \) (as shown in Equation 3.45). The same reasoning applies to each component of the viulc: \( Idx_{viunw}^r(i,t) \) and \( Idx_{viulp}^r(i,t) \) (from Equations 3.46 and 3.47, respectively).
The purpose of this chapter is to identify general patterns across subsystems of different size. To control for this latter factor in our econometric estimation, indexes have been standardised to test subsystems’ dynamics. Due to \( \text{viulc} \) being expressed in local currencies, the average \( \text{viulc} \) across countries for a given product cannot be taken as a measuring rod. Consequently, following Carlin et al. (2001), each \( Idx_{\text{viulc}}^{R}_{i(t)} \) element is weighted by the average final export market share for the \( t^{th} \) subsystem in the base year:

\[
XMS^{R}_{i(t_b,t_b)} = \frac{f_{i(t_b,t_b)}^{USD}}{\sum_{r=1}^{m} f_{i(t_b,t_b)}^{USD}}
\]

(6.01)

namely, the final exports in subsystem \( i \) of country \( r \) \( f_{i(t_b,t_b)}^{USD} \) divided by the sum of final exports across \( i^{th} \) subsystems \( \sum_{r=1}^{m} f_{i(t_b,t_b)}^{USD} \) in the base year, 2010. As a result, the \( \text{viulc} \) of each subsystem becomes a measure of relative vertically integrated unit labour costs:

\[
rv_i^{\text{viulc}}^{R}_{(t)} = \frac{Idx_{\text{viulc}}^{R}_{i(t)}}{XMS^{R}_{i(t_b,t_b)}}
\]

(6.02)

The relative vertically integrated unit nominal wages \( rviunw \) and unit labour productivity in volume terms \( rviulp \) have been calculated following the same method:

\[
rv_i^{\text{viunw}}^{R}_{(t)} = \frac{Idx_{\text{viunw}}^{R}_{i(t)}}{XMS^{R}_{i(t_b,t_b)}}
\]

(6.03)

\[
rv_i^{\text{viulp}}^{R}_{(t)} = \frac{Idx_{\text{viulp}}^{R}_{i(t)}}{XMS^{R}_{i(t_b,t_b)}}
\]

(6.04)

In short, this section suggests a new notion of \( \text{rviulc} \) based on \( \text{viulc} \) that includes production fragmentation across countries. Starting from an accounting scheme rooted in an MRIO model, it pays special attention to distinguish between changes in nominal labour costs across the GVC and changes in the comprehensive, GVC-wide output per unit of (total) labour inputs, reflecting technical change.

**6.3 Econometric model**

The econometric modelling strategy to study the relationship between real export performance and vertically integrated unit labour costs closely follows the work of Carlin, Glyn and van Reenen (2001). However, in that contribution total export market shares were measured in nominal terms and relative unit labour costs were limited to the industry of completion of the exported product, rather than across its GVC.
I set out a simple model which measures the relationship between a subsystem’s final export market share in real terms (RXMS) and the relative vertically integrated unit labour costs (rviulc) as proxies of export performance and cost competitiveness, respectively.

Crucially, the model embeds the new international labour division brought about by GVCs, since the international position of each subsystem, its RXMS, is determined by operating costs across the comprehensive, inter-country inter-industry network required to produce a unit of final exports.

Based on the above logic, the following baseline econometric specification synthesises the relationship between the real export market shares (RXMS) and relative vertically integrated unit labour costs (rviulc):

\[
\ln(RXMS_{i(t,t_b)}^r) = \beta_0 + \beta_1 \ln(rviulc_{i(t)}) + \delta t + \left( \gamma^r + u_{i(t)}^r \right) \tag{6.05},
\]

where \(\beta_0\) is the model’s intercept and \(\beta_1\) measures the \(rviulc)\) elasticity of real export market shares. While \(\delta t\) represents a deterministic trend, \(\gamma^r\) captures country fixed effects such as its institutional framework, historical conditions or innovation environment that differ between countries-of-completion articulating each GVC. Finally, \(u_{i(t)}^r\) is a time-varying additive random term, including industrial concentration level, marketing strategies, risks of new competitors, trade unions’ bargaining power and/or final demand changes modifying the international industry structure. Both fixed and time-varying effects \((\gamma^r, u_{i(t)}^r)\) influence real export market shares.

The left-hand-side variable, \(RXMS_{i(t,t_b)}^r\) measures the real final export market share of country \(r\) for product type \(i\) in current USD\(^{54}\) prices during year \(t\). It is estimated by dividing the constant-USD value of final exports for a given country-product combination by the sum of the product’s final exports from the 24 EU economies in the sample\(^{55}\). We focus on the

\(^{54}\) Notice the reader that we differentiate between the year 0, \(t_0\), and the base year, \(t_b\). As we will explain above the year 0 is 2000 and the base year 2010.

\(^{55}\) \(RXMS_{i(t,t_b)}^r = \frac{\sum_{r=1}^{m} \frac{f_{i(t,t_b)}^{USD}}{P_{i(t)}^{USD}}}{\sum_{r=1}^{m} \frac{f_{i(t,t_b)}^{USD}}{P_{i(t)}^{USD}}},\) where the final exports of country \(r\) in industry \(i\) at prices of the base year in period \(t\) \((\bar{f}_{i(t,t_b)}^{USD})\) is defined as \(\bar{f}_{i(t,t_b)}^{USD} = \frac{\bar{f}_{i(t)}^{USD}}{\sum_{r=1}^{m} \frac{f_{i(t,t_b)}^{USD}}{P_{i(t)}^{USD}}},\) in which \(\sum_{r=1}^{m} \frac{f_{i(t,t_b)}^{USD}}{P_{i(t)}^{USD}}\) is the final export of country \(r\) in industry \(i\) at current prices, the price index is estimated as \(\bar{f}_{i(t,t_b)}^{USD} = \frac{\bar{f}_{i(t)}^{USD}}{\sum_{r=1}^{m} \frac{f_{i(t,t_b)}^{USD}}{P_{i(t)}^{USD}}},\) and the exchange rate index \(\bar{\phi}_{i(t,t_b)} = \frac{\bar{\phi}_{i(t)}}{\bar{\phi}_{i(t,b)}}\). This measure is also known as the export market share in volume. More details can be found in Eurostat: \(https://ec.europa.eu/eurostat/web/products-datasets/-/tispex13\).
EU-level rather than global market shares to avoid the interference of third countries from outside the EU\textsuperscript{56}. Finally, on the right-hand side, $r\text{viulc}_{i(t)}$ measures relative vertically integrated unit labour costs, as specified in Equation 6.02, Section 6.2.

Many factors that influence the real final export market share, other than $r\text{viulc}$, such as institutional framework, historical conditions or innovation environment, may also be related to $r\text{viulc}$ and bias estimated regression coefficients. However, if those effects are relatively invariant over time, a first difference estimation will eliminate all these fixed effects at the subsystem level and hence provide unbiased estimations of the $r\text{viulc}$ impact:

$$\Delta \ln(RXMS_{i(t,b)}) = \delta + \beta_1 \Delta \ln(r\text{viulc}_{i(t)}) + \lambda_{i(t)}^r$$ \hspace{1cm} (6.06),

where $\Delta$ is the first-difference operator. The new constant of the model – time-trend coefficient ($\delta$) – will capture the effect of the passage of time on average export performance, once country-specific factors have been accounted for. The first difference between time-varying errors ($u_{i(t)}^r - u_{i(t-1)}^r$) becomes the new disturbance term, $\lambda_{i(t)}^r$.

The impact of changes in $r\text{viulc}$ on RXMS can differ between the short and long run. As previously specified, producers can adopt diverse strategies. For instance, French automotive firms may face fixed prices in a given year, so increases in $r\text{viulc}$ may be absorbed by reducing the profit mark-up without affecting the export performance. On the other hand, it may also happen that increasing $r\text{viulc}$ induces an initial increase in French automotive prices, but the introduction of new production techniques allows French firms to sell at a price close to the international weighted average price in the long-term. Consequently, we estimate a second regression model allowing us to capture long-run effects of $r\text{viulc}$ on RXMS:

$$\Delta \ln(RXMS_{i(t,b)}^{r_{(t,b)}}) = \delta + \sum_{k=0}^{2} \beta_{k}^* \ln(r\text{viulc}_{i(t-k)}) + \lambda_{i(t)}^{r_{(t)}}$$ \hspace{1cm} (6.07),

where $k = 0, 1, 2$ represent time lags, and $T = 2$ is the highest lag length considered\textsuperscript{57}. Furthermore, we assume that there may be an adjustment period between a variation in $r\text{viulc}$ and the response of real export market shares. The cumulative effect ($\beta_{\text{cum}}^*$) of $r\text{viulc}$ on RXMS is the sum of the partial effects, $\beta_{\text{cum}}^* = \beta_0^* + \beta_1^* + \beta_2^*$. Then, $\beta_{\text{cum}}^*$ can be

\textsuperscript{56} If we considered the global market share as a measure of performance for each EU-based subsystem, without explicitly incorporating data points corresponding to big international players such as China, Japan or the USA, the dynamics of those economies would be reflected in our dependent variable but remained unexplained within the regression model.

\textsuperscript{57} Tests with lags of diverse length other than $T=2$ were made to confirm there was no obvious truncation bias in our estimations.
interpreted as the delayed impact of previous (and contemporary) changes in rviulc on current-period real export performance.

The estimation method is Ordinary Least Squares (OLS). If we estimated Model 6.05, this would amount to assuming that error terms \((y^r, u^r_{it})\) are uncorrelated with rviulc. Clearly, there may be several determinants of relative export performance in real terms besides rviulc. If these factors not explicitly included in 6.05 are correlated with rviulc, the OLS estimator will be biased. However, if country-specific factors are relatively fixed over time, by estimating a model in differences – as in Regression Equations 6.06 - 6.07 – we implicitly deal with those factors influencing real export performance – such as union power or the access to innovative techniques – which may also impact the dynamics of operating costs across the GVC.

Therefore, what remains crucial is that \(\lambda_{it}(t)\) and \(\Delta ln(rviulc^r_i)\) are uncorrelated. Nonetheless, this assumption is not as restrictive as might be initially thought. By estimating a model in differences, shocks to RXMS may have immediate feedback effects on rviulc (Carlin, Glyn and van Reenen, 2001, p. 138). Moreover, for all reported results, heteroskedasticity and autocorrelation consistent (HAC) standard errors are computed using the variance-covariance estimator proposed by Newey and West (1987).

An analogous procedure leading to Regression Equations 6.06 - 6.07 is followed to specify a regression model in which rviulc is decomposed into its two key components: relative vertically integrated unit nominal wages (rviunw) and the relative vertically integrated unit labour productivity (rviulp)\(^{58}\). The short and long-run baseline equations are:

\[
\Delta ln(RXMS^r_{(t,b)}) = \delta + \beta_{\omega}^{\omega} \Delta ln(rviunw^r_{i(t)}) + \beta_{\alpha}^{\alpha} \Delta ln(rviulp^r_{i(t)}) + \lambda_{i(t)}^r
\]  
(6.08)

\[
\Delta ln(RXMS^r_{(t,b)}) = \delta + \sum_{k=0}^{2} \beta_{\omega}^{\omega} \Delta ln(rviunw^r_{i(t-k)}) + \sum_{k=0}^{2} \beta_{\alpha}^{\alpha} \Delta ln(rviulp^r_{i(t-k)}) + \lambda_{i(t)}^r
\]  
(6.09)

where \(\beta_{\omega}^{\omega}\) and \(\beta_{\alpha}^{\alpha}\) are the (contemporaneous) regression coefficients capturing the short-run sensitivity of real export market shares to changes in rviunw and rviulp, respectively. Instead,

\(^{58}\) As was the case for rviulc\(^r_{i(t)}\), rviunw\(^r_{i(t)}\) and rviulp\(^r_{i(t)}\) are computed following Equations 6.03 and 6.04, respectively.
Global Value Chains in the European Union: An input-output approach

Chapter 6: Final export’s performance of EU subsystems: a cost competitiveness’ vertically integrated analysis

Maria Gomez Benitez

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**6.4 Results and Discussion**

In order to answer the chapter’s research questions, the linear regression models for panel data 6.06 - 6.09 were implemented using the World Input-Output Tables (WIOTs) and Socio-Economics Accounts (SEAs) supplied by the WIOD database. The econometric application considers a panel of 24 EU countries and the top 14 final export product types covering the 2000-2014 period. According to the exploratory data analysis carried out in Section 4.3, Chapter 4, we exclude Malta, Luxembourg and Cyprus because of specific problems in the specification of their productive structures and we also exclude industry 10REFPETR due to a lack of data for all countries. To summarise, the panel’s cross-section dimension is formed by 336 subsystems from 24 different countries across 14 product types. Appendix E reports descriptive statistics for variables in levels across subsystems and distinguishes by product type and region.

The first research goal of this chapter is to figure out the effect of changes in relative vertically integrated unit labour costs (rviulc) on final export dynamics across EU subsystems, as well as the role played by the relative vertically integrated unit nominal wages (rviunw) and labour productivity (rviulp) in the short and long run. Table 6.1 displays the results for the pooled sample across the whole 2000-2014 period. Columns (1) to (3) involve only rviulc variables, while columns (4) to (6) report results for rviunw and rviulp. Short-run effects are reported in columns (1) and (4), whereas long-run, cumulative effects in columns (3) and (6). The

---

\[ \beta_{\text{cum}}^{\omega^*} = \beta_0^{\omega^*} + \beta_1^{\omega^*} + \beta_2^{\omega^*} \quad \text{and} \quad \beta_{\text{cum}}^\alpha = \beta_0^\alpha + \beta_1^\alpha + \beta_2^\alpha. \]
intercepts are statistically significant and positive across specifications. Therefore, even without changes in rviulc (and their components), the average RXMS tends to grow.

Table 6.1. rviulc decomposed into rviunw and rviulp: Pooled Regression Results (Estimation method: OLS)

<table>
<thead>
<tr>
<th>Dependent variable: Δln(RXMS)</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.032 ***</td>
<td>0.031 ***</td>
<td>0.031 ***</td>
<td>0.028 ***</td>
<td>0.023 ***</td>
<td>0.023 ***</td>
</tr>
<tr>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Δln(rviulc)</td>
<td>-0.711 ***</td>
<td>-0.675 ***</td>
<td>(0.057)</td>
<td>(0.063)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δln(rviulc (β*1))</td>
<td>-0.002</td>
<td>0.020</td>
<td>(0.040)</td>
<td>(0.045)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR rviulc (β*cum)</td>
<td>-0.658 ***</td>
<td></td>
<td>(0.087)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δln(rviunw)</td>
<td>-0.322 ***</td>
<td>-0.290 ***</td>
<td>(0.072)</td>
<td>(0.073)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δln(rviunw (β*1))</td>
<td>0.121 *</td>
<td>0.101</td>
<td>(0.062)</td>
<td>(0.063)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δln(rviunw (β*2))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR rviunw (β*cum)</td>
<td>-0.068</td>
<td></td>
<td>(0.116)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δln(rviulp)</td>
<td>0.947 ***</td>
<td>0.935 ***</td>
<td>(0.056)</td>
<td>(0.057)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δln(rviulp (β*1))</td>
<td>0.076</td>
<td>0.015</td>
<td>(0.043)</td>
<td>(0.051)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δln(rviulp (β*2))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR rviulp (β*cum)</td>
<td>1.026 ***</td>
<td></td>
<td>(0.097)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observations: 4704 4032 4032 4704 4032 4032

Wooldridge FD-based test:

<table>
<thead>
<tr>
<th></th>
<th>4704</th>
<th>4032</th>
<th>4032</th>
<th>4704</th>
<th>4032</th>
<th>4032</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-stat</td>
<td>0.551</td>
<td>0.000</td>
<td>0.000</td>
<td>1.406</td>
<td>0.684</td>
<td>0.684</td>
</tr>
<tr>
<td>p-value</td>
<td>0.458</td>
<td>0.995</td>
<td>0.995</td>
<td>0.236</td>
<td>0.408</td>
<td>0.408</td>
</tr>
<tr>
<td>R Square</td>
<td>0.075</td>
<td>0.072</td>
<td>0.072</td>
<td>0.125</td>
<td>0.133</td>
<td>0.133</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.075</td>
<td>0.071</td>
<td>0.071</td>
<td>0.125</td>
<td>0.131</td>
<td>0.131</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05

Notes: Heteroskedasticity and Autocorrelation Consistent (HAC) standard errors in parenthesis computed using the variance-covariance estimator proposed by Newey and West (1987). Based on Wooldridge’s (2010, 319–20) first-difference (FD) test for serial correlation in panels, we do not reject the null hypothesis of no serial correlation in differenced errors.

Following Charlin et al. (2001, 151), my empirical strategy has been to maintain a simple estimation by OLS, which may generate potential endogeneity problems. The first two columns of Table E.4 of Appendix E report the results of estimating a model in levels with lagged regressors using country x sector, country x year and sector x year fixed effects. Estimated coefficients broadly confirm the sign and direction of estimates reported in Table 6.1. This reduces potential endogeneity issues in the model, but I am aware that further improvements in estimation method and econometric strategies are possible.

Source: Author’s calculations based on WIOD and ILOSTAT

It is expected that the R Square of a model whose dependent variable and regressors are specified in differences is lower than when working with variables in levels. See, for example, Békés and Kézdi (2021, 629–37).
First and foremost, the effect of rviulc on RXMS is negative and statistically significant both in the short and long run. The adjustment dynamics of real final exports as rviulc changes shows that an increase in rviulc has a strong negative contemporary effect on RXMS, however, its intensity decreases over time. This phenomenon is known as the J-curve effect in the literature (Carlin, Glyn and van Reenen, 2001; Bahmani-Oskooee and Kutan, 2009; Gürtler, 2019)\(^61\). Furthermore, due to an upsurge in the costs, an increase in price causes a slowdown in final export demand. Although these adverse effects persist, they become blurred in the long run.

As was developed in Section 6.2., the rviulc can be decomposed into relative vertically integrated unit nominal wages (rviunw) and unit labour productivity (rviulp) within each GVC. Naturally, given its theoretical specification in Equation 3.44, rviulc will be directly related to rviunw and inversely related to rviulp. Therefore, it is expected that an increase in rviunw will cause an increase in rviulc, affecting the real market share negatively. By contrast, an increase in physical labour productivity will lead to a decrease in rviulc, improving the export performance in real terms.

Both rviunw and rviulp take the expected signs (and are statistically significant) in the short run, column (4). Nonetheless, the sensitivity of RXMS to fluctuations in rviunw and rviulp diverge considerably. The positive impact of labour productivity on the real export performance is almost three times larger than the negative effect due to an increase in nominal wages. The role of the technical change as a relatively more relevant driver of unit labour costs, and therefore, of international competitiveness is more evident in the long run, as reported in column (6). In this case, rviunw becomes statistically insignificant, whereas the positive impact of the rviulp intensifies.

Differently from other contributions (Fagerberg 1988; Amendola, Dosi, and Papagni 1993), we find a statistically significant, negative effect of rviulc on export performance (in real terms). At the same time, though, the fact that it is productivity dynamics the main driver of rviulc in the long run, suggests that our results are compatible with Kaldor-Verdoorn’s law

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\(^{61}\) The J-curve phenomenon is commonly used in the international trade literature to describe the initial deterioration that a particular phenomenon may have in the trade balance or export performance in short, but that it is followed by an improvement in the long-term. For example, Carlin et al (2001) find a J-curve effect between relative unit labour costs and nominal (total export) market shares. Bahmani-Oskooee and Kutan (2009) analyse the J-curve relationship between the trade balance and exchange rate in emerging Eastern European economies. This phenomenon has also been studied at the country level. For instance, Gürtler (2019) evinces that the depreciation of the Czech Koruna to the Euro has had a J-curve effect on the Czech trade balance.
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(Kaldor 1966; Verdoorn 1993). It is labour productivity dynamics which translate – for given nominal wages – into lower production costs across a GVC and correlates positively with a faster expansion of real final exports, making it sustainable over time (Thirlwall 1983; Romero 2017).

Interestingly, for Carlin, Glyn and van Reenen (2001), the long-run effects of wages are stronger than labour productivity effects, whereas my results suggest that the effect of rviuwu on RXMS is only statistically significant in the short run, whilst the effect of rviiulp remains statistically significant also in the long run and intensifies. Several factors may explain these differences. For example, we consider market share dynamics for final exports in real terms, rather than market share for total exports in nominal terms. Moreover, we consider wages and productivity across a GVC, rather than focusing only on the industry of completion. Also, the time period and set of countries considered are markedly different.

The second goal of this chapter is to assess whether the impacts of rviiulc and their components on RXMS follow similar patterns in core and peripheral economies. Table 6.2 reports estimation results splitting data into two sub-samples: core and peripheral subsystems.

The opposite sign of core and peripheral time trends (i.e., the intercept for each model) suggests a catching-up dynamics between the core and periphery. In core subsystems, for given (and constant) rviiulc (and its components), the evolution of the market share in real terms is negative. By contrast, in peripheral countries, relative export performance tends to improve. Nevertheless, the catching-up process between core and peripheral subsystems is considerably slow. In the 14 years considered, trade imbalances amongst EU members have only slightly reduced, and core countries still keep the lion’s share of final exports in real terms.

The effect of rviiulc on RXMS is negative and statistically significant in both sub-samples, although the elasticity coefficient is higher (in absolute terms) for core subsystems. The stronger negative sensitivity of core subsystems to increases in rviiulc suggests their cost-reduction strategy is more aggressive than in peripheral subsystems. This may be related to higher labour costs per worker in core GVCs, as a result of higher domestic nominal wages.
## Table 6.2. Variable rviulc decomposed into rviunw and rviulp: Core and peripheral sub-samples (Estimation method: OLS)

<table>
<thead>
<tr>
<th></th>
<th>Core</th>
<th>Periphery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.014</td>
<td>-0.015</td>
</tr>
<tr>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Δln(rviulc)</td>
<td>-0.823</td>
<td>-0.862</td>
</tr>
<tr>
<td>(0.074)</td>
<td>(0.082)</td>
<td>(0.067)</td>
</tr>
<tr>
<td>Δln(rviulcp(1))</td>
<td>-0.071</td>
<td>0.082</td>
</tr>
<tr>
<td>(0.067)</td>
<td>(0.067)</td>
<td>(0.055)</td>
</tr>
<tr>
<td>Δln(rviulcp(2))</td>
<td>0.026</td>
<td>0.062</td>
</tr>
<tr>
<td>(0.072)</td>
<td>(0.072)</td>
<td>(0.055)</td>
</tr>
<tr>
<td>LR rviulcp(βcum)</td>
<td>-0.959</td>
<td>-0.959</td>
</tr>
<tr>
<td>(0.129)</td>
<td>(0.129)</td>
<td>(0.129)</td>
</tr>
</tbody>
</table>
| Notes: Heteroskedasticity and Autocorrelation Consistent (HAC) standard errors in parenthesis computed using the variance-covariance estimator proposed by Newey and West (1987). Based on Wooldridge’s (2010, 319–20) first-difference (FD) test for serial correlation in panels, we do not reject the null hypothesis of no serial correlation in differenced errors. Following Charlin et al. (2001, 151), my empirical strategy has been to maintain a simple estimation by OLS, which may generate potential endogeneity problems. The last four columns of Table E. 4 of Appendix E report the results of estimating a model in levels with lagged regressors using country x sector, country x year and sector x year fixed effects. Estimated coefficients broadly confirm the sign and direction of estimates reported in Table 6.2. This reduces potential endogeneity issues in the model, but I am aware that further improvements in estimation method and econometric strategies are possible.
| Source: Author’s calculations based on WIOD and ILOSTAT |
Moreover, results also suggest that the EU periphery has experienced a process of economic upgrading during the period analysed. It has been involved in an export-led industrialisation process fuelled by foreign direct investment and the access to a large EU market for final goods (Grodzicki and Geodecki 2016). These factors have tamed – with respect to the core – the adverse impact of rviulc increases on RXMS dynamics, especially in the long term.

The influence of nominal wages and physical labour productivity in real export performance also differs. The signs of rviunw and rviulp are as expected in both cases, but the elasticities between core and peripheral subsystems vary considerably. The strategy of core-country subsystems (captured by models 4 and 6) is grounded in wage-cutting, as evinced by the statistically significant, negative (and notoriously larger in absolute terms with respect to peripheral subsystems) relationship between nominal wages and changes in real competitiveness. Although the increases in physical labour productivity help boost final export performance, it is more than fully offset by the negative effect of increasing nominal wages in the long run. For core subsystems, the lack of sustained labour productivity increases as a driver of international competitiveness – analysed in Chapter 4 – may explain the downward tendency in final export market shares in real terms.

The sensitivity of peripheral subsystems to changes in nominal wages across the GVC is relatively low in the short-run, and statistically insignificant in the longer term, being technology the main driver of real export performance (captured by models 10 and 12). However, the relatively low elasticity coefficient for rviunw in peripheral subsystems does not mean that their low domestic wages have not influenced their international integration. As was discussed in Chapter 5, the gap between core and peripheral average wages per worker across their GVCs has allowed peripheral subsystems to increase their average labour costs and keep their cost advantages as final exporters. Nonetheless, the gap between within-EU and extra-EU peripheral wages, Chapter 5, went hand in hand with sharp labour offshoring outside the EU, despite the low labour productivity of such imported extra-EU labour, highlighting an important limitation of dependent development within the EU periphery.

In short, results suggest a form of upgrading in the EU periphery which has boosted its final export performance. Market shares in real terms seem to have especially benefited from labour productivity increases across GVCs articulated by peripheral EU countries. Nevertheless, despite the fact that peripheral competitiveness is not strongly linked to increases in nominal wages, especially in the longer term, these subsystems have experienced labour offshoring directed to extra-EU economies with relatively lower labour productivity. As a result, the reproduction of a cost-competitiveness logic exerted
by the EU periphery on extra-EU peripheral countries may lead to a halt in their process of upgrading, risking them to become stuck in a middle-income trap in the long-run (Bruszt and Greskovits 2009; Bruszt and Vukov 2015).

Finally, we have estimated Regression Equations 6.06 - 6.09 separately for each of the top 14 final export product types in the EU, to analyse the effect of cost competitiveness by subsystem. Table 6.3 summarises the estimated effects of rviulc (and its components, rviunw and rviulp) on RXMS for each product type.

Starting from general to specific results, the rviulc has a statistically significant, negative short-run effect on RXMS across subsystems, except ICT services (40ICTPROG), which persist in the longer term. Moreover, while the negative effect of increases in nominal wages on RXMS is limited to a few product types in the short run, rises in labour productivity are immediately translated into RXMS increases, and its impact remains statistically significant in the long run across most subsystems.

Interestingly, we may distinguish different patterns between manufacturing and service subsystems: rviulc changes seem more relevant as a determinant of final export performance for manufacturing subsystems. The role of services as final products in international markets is relatively new (though in expansion), and competitive dynamics may have not yet fully developed. In fact, the relevance of service activities is more linked to their use as intermediate inputs than as final products (Low 2013; Miroudot and Cadestin 2017). Service activities are concentrated in certain pre-and post-production stages of the production process, such as R&D, design or marketing, which tend to be knowledge-intensive and, therefore, international dynamics are less associated with their cost structure (Runi and Del Prete 2018; Stöllinger 2021). The EU final export subsystems of computer programming, consultancy, and information service activities (40ICTPROG) consist mainly in investment products requiring specific technical capabilities for their production. Also, in view of the increasing digitalisation of outputs by service industries, their measurement is ongoing continuous development within the System of National Accounts (OCDE 2019) and, hence, this might not be fully captured by the way in which rviulc, rviunw and rviulp are currently built.
When it comes to subsystem-specific results, the statistically significant adverse impact of changes in $r_{vpu}$ on $RXMS$ is found for 05FOOD, 17ICTEQ, 12PHARMA, 21TREQ, 06TEXT, 18ELECEQ, 11CHEM and 01AGRIC. In labour-intensive subsystems with a low-technological content such as food processing (05FOOD) and textile manufacturing (06TEXT), the improvements in the technical conditions are more restricted, making real export performance more vulnerable to changes in the nominal wages. In 05FOOD subsystems, the short and long-run elasticities for nominal wages are quantitatively greater than those for changes in labour productivity. In the case of 06TEXT, it is the only manufacturing subsystem for which the long-run labour productivity effect is statistically insignificant.

Agricultural markets are characterised by being very competitive internationally. The large number of competitors is reflected in the sensitivity of 01AGRIC subsystems in the EU to changes in $r_{vunw}$. However, the EU final export 01AGRIC subsystems are also known for being vastly mechanised and with high levels of labour productivity. In fact, the greater quantitative effect of changes in GVC productivity ($r_{vulp}$) over that of nominal wages ($r_{vunw}$) on $RXMS$ confirms the prevalence of technological determinants for market shares in agricultural final exports, particularly in the long run.

To avoid overloading the presentation of subsystem-specific results, only point estimates and their statistical significance is reported in each case. Full regression output tables for each individual cell are available upon request.

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**Table 6.3. Regression coefficients by each of the 14 groups of subsystems (Estimation method: OLS)**

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Δln($r_{vulp}$)</th>
<th>Δln($r_{vunw}$)</th>
<th>Δln($r_{vui}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01AGRIC</td>
<td>-0.6555 ***</td>
<td>-0.8974 **</td>
<td>-0.6271 **</td>
</tr>
<tr>
<td>05FOOD</td>
<td>-0.9765 ***</td>
<td>-1.0566 *</td>
<td>-1.0438 **</td>
</tr>
<tr>
<td>06TEXT</td>
<td>-0.865 ***</td>
<td>-1.0438 **</td>
<td>-0.8579 ***</td>
</tr>
<tr>
<td>11CHEM</td>
<td>-0.9493 ***</td>
<td>-0.8091 *</td>
<td>-1.338 **</td>
</tr>
<tr>
<td>12PHARMA</td>
<td>-0.668 ***</td>
<td>-0.6221 **</td>
<td>-0.5789 ***</td>
</tr>
<tr>
<td>16METPRDS</td>
<td>-0.5893 **</td>
<td>-0.622 **</td>
<td>-0.0455</td>
</tr>
<tr>
<td>17ICTEQ</td>
<td>-1.1454 ***</td>
<td>-1.2247 ***</td>
<td>-0.4432 *</td>
</tr>
<tr>
<td>18ELECEQ</td>
<td>-1.0246 ***</td>
<td>-1.1553 ***</td>
<td>-0.5597 *</td>
</tr>
<tr>
<td>19MMACHEQ</td>
<td>-0.8039 ***</td>
<td>-1.1066 ***</td>
<td>-0.2443</td>
</tr>
<tr>
<td>20VEHIC</td>
<td>-1.0259 ***</td>
<td>-0.5477 *</td>
<td>-0.4559</td>
</tr>
<tr>
<td>21TREQ</td>
<td>-1.0481 ***</td>
<td>-1.5697 ***</td>
<td>-0.3925 *</td>
</tr>
<tr>
<td>22OMAN</td>
<td>-0.6554 ***</td>
<td>-0.5897 *</td>
<td>-0.4168</td>
</tr>
<tr>
<td>40ICTPROG</td>
<td>-0.0599</td>
<td>0.4004</td>
<td>0.016</td>
</tr>
<tr>
<td>41FINANCE</td>
<td>-0.4522 *</td>
<td>-0.573 *</td>
<td>-0.115</td>
</tr>
</tbody>
</table>

Dependent variables: $\Delta \ln(RXMS)$

Source: Author’s calculations based on WIOD and ILOSTAT
More challenging to interpret are the results for high and medium-high technology product types – such as 17ICETEQ, 21TREQ 12PHARMA, 21TREQ, 18ELECEQ and 11CHEM – where nominal wages are not expected to play a prominent role. Nevertheless, excluding chemical subsystems in the short run, the effect of changes in labour productivity on RXMS are larger and more persistent over time than variations in nominal wages.

The EU subsystems of computer, electronic and optical products (17ICETEQ) evince a strong degree of GVC integration which accelerated during the period considered, particularly in the EU periphery, as shown in Chapters 4 and 5. China’s influence has changed the international market for 17ICETEQ products\(^63\). Even though in some EU peripheral economies – such as the Czech Republic, Poland and Slovakia – there is a sizeable 17ICETEQ international industry associated to Chinese FDI (Cieślik 2020),\(^64\) EU’s global market share in 17ICETEQ has decreased by 4p.p. throughout the period considered. Despite an apparently positive impact of wage-cutting strategies, 17ICETEQ subsystems are characterised by a high technological content which explains that the effect of rviunw on RXMS becomes statistically insignificant in the long term. In fact, an increment of 1% in rviulp not only surpasses the negative effect of an equivalent increase in rviunw in the short run, but it is also associated with a proportionally higher increase in final export performance in real terms (with elasticity coefficients of 1.22% and 1.38% in the short and long run, respectively).

The international dynamics of electrical equipment (18ELECEQ) has been similar to 17ICETEQ. China has gained 29.42p.p. over the period, representing approximately 39.33% of the world final exports. Although the EU has maintained its international position, the Chinese upgrading has pushed prices down, leading to a reconsideration of nominal wages as a determinant of market shares. As in 17ICETEQ subsystems, the success of wage-cutting strategies is restricted to the short run, and it is less effective than the introduction of novel production techniques or the development of scale economies associated to productivity increases (the short and long run elasticity coefficients for rviulp are statistically significant, positive and greater than 1, being 1.16% and 1.36% respectively).

The results for other transport equipment (21TREQ), pharmaceuticals (12PHARMA) and chemical products (11CHEM) refute the idea that GVCs articulated by industries with a relatively medium/high

\(^63\) China has become the largest world exporter between 2000 and 2014. Its 17ICETEQ market share has expanded 32.37p.p. over the period considered, representing roughly 39.54% of the global final exports of 17ICETEQ products.

\(^64\) On average, Chinese imported labour for 17ICETEQ subsystems in the EU periphery amounted to (approx.) 16% of total subsystem employment in 2014. Throughout the period considered, the Chinese share of subsystem employment increased by almost 12 p.p.
technological content automatically generate competitive advantages. Outsourcing strategies, based on wage-cutting, can also be successful in high-tech subsystems, at least in the short run. Products included in other transport equipment (21TREQ) involve fixed capital goods with lengthy production process, such as boats, trains, or planes. Although offshoring strategies have no immediate consequences for market share dynamics, the positive effect of reducing nominal wages are observed in the long run. Nonetheless, product characteristics of 21TREQ goods and wage-cutting strategies cannot, on their own, explain the long-lasting negative effect of rviulc on RXMS. This is crucially explained by the statistically significant and highly positive impact of labour productivity changes, particularly in the longer term. An improvement of 1% in labour productivity across the GVC is associated with a market share increase of 1.7% in the long run. This figure represents the highest elasticity of Table 6.3.

The importance of cost competitiveness in high tech manufacturing is evinced by pharmaceuticals (12PHARMA) and chemical products (11CHEM). As illustrated in Table 5.06 from Chapter 5, in both core and peripheral regions, changes in the distribution of labour have been labour-saving throughout the period considered. The adverse effects of rviulc are very similar in the short and long run, and in both, an increase in rviunw has immediate negative consequences for market shares. Although the impact of rviunw becomes statistically insignificant in the long run, the sensitivity of those subsystems to improvements in labour productivity is less remarkable than expected.

Hence, a short-sighted, wage-cutting strategy can be successful in high-tech subsystems in the short run, although it does not seem to work from a longer term perspective. This fact is particularly relevant in chemical subsystems. In the short term, market shares are relatively more sensitive to changes in nominal wages than to those in labour productivity. A rise of 1% in rviunw is associated to an initial market share decline of 1.34%, while a proportional increase in rviulp is associated to an improvement in real export performance by only 0.92%. However, in the long run, it is only by means of labour productivity increases that final export performance in real terms may improve.

Finally, the case of motor vehicles (20VEHIC) subsystems should be highlighted. Estimated coefficients for rviulc suggest a J-curve pattern. The sizeable short-run impact of changes in vertically integrated unit labour costs is tamed over time. That is, in the long run, factors beyond cost competitiveness seem to be the main drivers of market share dynamics in motor vehicle GVCs. Market structure (highly concentrated production by a small number of prominent international players) may contribute to explain this result.

The analysis of rviulc components for 20VEHIC also reveals interesting information. Only changes in labour productivity have a statistically significant effect on the path of RXMS. This is in line with the geographical
distribution of motor vehicle GVCs across EU countries. Emerging EU economies -- such as the Czech Republic, Hungary, Slovakia -- became relevant international players that have dramatically increased their labour productivity across the GVC, while experiencing a sustained growth of their vertically integrated nominal wages.

To sum up, the statistically significant long-run effects of changes in rviulc on final export market shares in real terms crucially depend on labour productivity dynamics. A strategy based on wage-cutting may boost international performance in the short run, but it is not effective in the longer term. Although there are different patterns across product types, the role of labour productivity as the main component of real cost competitiveness is evident and conclusive.

6.5 Summary

This chapter investigates the impact of cost competitiveness and its determinants on the evolution of final export market shares across EU countries and product types within a globalised framework. Although global production fragmentation has been widely studied, indicators explicitly measuring unit labour costs (ULC) across an entire GVC and its effect on market shares (in real terms) were lacking.

The analysis starts from the analytical framework developed in Section 3.6, advancing an indicator to measure and decompose unit labour costs across GVCs. Considering the global economy as closed economic system, we suggest a novel measure of relative vertically integrated labour costs (rviulc) based on Sraffa’s (1960) notion of subsystem and Pasinetti’s (1973) vertically integrated approach. Equally important, we decompose rviulc into a relation between relative average vertically integrated nominal wages per worker (rviunw) and vertically integrated labour productivity (rviulp). Advancing with respect to previous contributions, the former (rviunw) measures average nominal labour compensation across a GVC, whereas the latter (rviulp) synthesises given technical conditions of production across a GVC. Hence, wages and productivity become inter-country, global magnitudes, anchored to the production of a specific final product type within a given country of completion.

Empirical results have been obtained by means of a regression model for panel data estimated in first differences. Alternative model specifications allowed us to distinguish between short run and longer term effects. Moreover, besides obtaining results for the full sample, we estimated regression models for different sub-samples, in order to facilitate the identification of patterns specific to core and peripheral EU subsystems, as well as those specific to certain product types.
In general terms, the effect of changes in rviulc on final export market shares in real terms (RXMS) can be described as a J-curve phenomenon. It initially has a strong negative impact, which is tamed over time. Nonetheless, the positive impact of labour productivity on RXMS is almost three times larger than the negative effect of an increase in nominal wages on real export competitiveness. In addition, the effect of increases in nominal wages across a GVC tend to become statistically insignificant in the longer term. Therefore, in line with Kaldor-Verdoorn’s law, it is (physical) labour productivity dynamics the primary driver of EU international competitiveness over time.

Results suggest a slow catching-up process between core and peripheral subsystems related to their internationalisation strategies. Core subsystems seem to have adopted an internationalisation strategy based on wage-cutting, resulting in a negative time trend for real export competitiveness: a natural tendency to lose market share. In peripheral subsystems, labour productivity increases are the main driver of real export performance, which has boosted their final export market shares in real terms. Even so, this process of economic upgrading has been partial. Peripheral labour productivity has grown thanks to imported technology, and core-country subsystems have kept their leading position internationally. As a result, the EU peripheral economies seem to be involved in a process of dependent development, which does not guarantee a socio-economic convergence with EU core economies.

Finally, the effect of vertically integrated unit labour costs (rviulc) on final export performance in real terms seems more prominent for manufacturing product types rather than final services. Labour-intensive subsystems, such as food processing (05FOOD) and textile (06TEXT) products, seem more vulnerable to changes in nominal wages, while the impact of labour productivity changes are more limited. Nevertheless, as shown in the results for pharmaceuticals (12PHARMA) and chemicals (11CHEM), a short-sighted, wage-cutting strategy can appear successful even for medium/high-tech subsystems. However, this holds only in the short run. In fact, for most product types, it is only by increasing labour productivity across the GVC that international competitiveness improves over the longer term.
Chapter 7: Conclusions

7.1 Introduction

This chapter summarises the main contributions of this thesis and its main results. Section 7.2 summarises how the thesis has addressed the three objectives and their related research questions that have motivated this work, highlighting the main results of the research. In section 7.3 some limitations of the research are considered. Finally, section 7.4 suggests areas of future research based on the results obtained in this work.

7.2 Contributions to the knowledge

To highlight the main research findings concerning the three research objectives outlined in this thesis, it is relevant to summarise the origin and motivation behind this research. The fragmentation of production into different processes worldwide has disrupted traditional international trade patterns. The emergence of Global Value Chains has altered national production structures, the international division of labour and the international income distribution. Specifically, the new international division of labour has affected the relationship between industrialisation and socio-economic development. While industrialisation remains a necessary condition for socio-economic development, the fragmentation of production and the new fragmentation of labour has meant that industrialisation alone is not enough as a basis for development (Ricci 2019; Bosmans, Decancq, and Decoster 2014; Selwyn 2015).

Despite the increased attention on the role of global value chains in the world economy, the literature has a certain bias towards the value added analysis (Timmer, Los, and De Vries 2015; Stöllinger 2019a; Foster-McGregor and Stehrer 2013). Consequently, there are relevant gaps on the consequences of production fragmentation on the final export dynamics, wage distribution and international competitiveness in core and peripheral economies. Moreover, the research space is even wider in the EU context, where there is no consensus on the impact of political-economic integration on its members' convergence and socio-economic development, as is discussed in Chapter 2.

The main motivation of this thesis is to shed light on the role of GVCs in EU export performance. The analysis has a double implication. On the one hand, it points out the different dynamics and strategies followed by the main exporting industries at the sectoral level, since the internationalisation of production has not affected all industries in the same way. On the other hand, a distinction is made between the effects of GVCs on EU economies, depending on their labour income levels.
Methodologically, this thesis is based on the vertical integration approach proposed by Pasinetti (1973). This approach has two fundamental advantages for the analysis of global value chains. First, theoretically, it is based on Sraffa’s subsystem notion, rooted in the circular flow of production principle stemming from classical economists (Kurz and Salvadori 2000). Following Sraffa (1960), the world economy can be defined as a closed economic system that contains the production processes of all commodities produced. Mathematically, this economic system can be formalised as a system of linear equations. Each equation of the set, a subsystem, represents a commodity production process equal to the intermediate products and the amount of labour needed to produce it. Thus, the world economy is composed of a set of subsystems interrelated to each other through the intermediate input-labour relationships within each subsystem (Scorzieri 1990). Since for Sraffa all intermediate inputs are commodities, and all commodities are made up of inputs and labour, inputs can be defined as ‘a series of labour, each with its appropriate date’ (Sraffa 1960, 34); the net output of each subsystem can be defined as the past and current amount of labour required for the production of one unit of output.

Second, Pasinetti’s notion of vertical integration associates Sraffa’s direct and indirect quantities of labour with the direct and indirect technical requirements arising from Leontief’s inverse matrix (Leontief 1986b). The link between the two approaches allows Pasinetti to develop an accounting framework compatible with national accounts, based on physical units of labour, capable of identifying each subsystem’s direct and indirect technological requirements from a disaggregated quantitative scheme. Third, the rise of global value chains and the fragmentation of production at the international level motivates us to understand the world economy as a global economic system. Each subsystem reflects the international division of labour along the global production chains given in each country-industry.

The empirical results from operationalizing this system are obtained from the analysis of data provided by the WIOD database (WIOD), the second release, WIOD-2016. WIOD is composed of World Input-Output Tables (WIOTs) and Socio-Economic Accounts (SEAs) for 56 industries and 43 countries plus the rest of the world (RoW). However, this database has one main limitation. SEAs do not provide information for RoW, which prevents the construction of an accounting framework based on an endogenous world economic system. Therefore, a dataset has been constructed for RoW compatible with SEAs through data provided by the SEAs themselves and ILOSTAT to solve this problem. The details of this construction and its compatibility with the WIOD database can be reviewed in Appendix C.

As is shown in Section 4.2 of Chapter 4, this thesis analyses the 14 main industries exported by the EU. Then, following the theory of unequal exchange (Braun, 1973; Emmanuel, 1972), this work differentiates
between those subsystems belonging to the EU core and peripheral regions according to average domestic nominal wage levels. The reasoning behind this is to understand the different implications of the rise of global value chains for different levels of European development.

Based on these premises, the thesis addresses three objectives synthesised in specific research questions:

- **Objective 1:** Identify the drivers of final export growth for EU subsystems in core and peripheral regions and by product type between 2000 and 2014.

The underlying questions to address this issue are: What are the determinants of final exports dynamics in the GVCs of core and peripheral countries? Which are the main differences between product types? Are the final export dynamics stable across the period? Do the final export dynamics impact the market share of each region? Has this impact been uniform between product types?

The first contribution of this objective is the development of an accounting framework, based on the vertical integration approach, that allows to distinguish prices and quantities as determinants of final export growth (Section 3.4 of Chapter 3). The nominal variables are the nominal exchange rate and the price index. The real variables are physical productivity and the amount of labour induced by final foreign demand. Both latter variables represent the change along the production chain. In the case of obtaining vertically integrated physical labour productivity, it should be noted that it represents the technological conditions along the production process, i.e., the physical interrelationships between industries without being contaminated by income distribution variables such as value added. Therefore, it does not change when economies are affected by institutional changes unrelated to the technical conditions of production (Brondino 2019; De Juan and Febrero 2000).

The findings reveal several relevant considerations to understand the export dynamics in the EU. The most important aspect that arises is the decline in the core’s market share favouring the peripheral region, which is caused by the underperformance of real variables, particularly labour productivity, in core-country subsystems. In addition, in the peripheral region, productivity and the foreign demand’s induced labour have been the main drivers of growth even in the post-crisis period, 2008-2014. In the core region, the final export growth is explained by monetary variables, particularly the exchange rate, whereas the real variables led to the drop of final export between 2008 and 2014. Despite this finding, the gain in EU peripheral market share has been concentrated in the pre-crisis period (2000-2008), as has the growth in nominal final exports. The gap in absolute volume between
the two regions is still persistent, as shown by the fact that the peripheral region needs very high growth rates, particularly real growth, to increase its market share.

The data also shows another important result about the performance of monetary variables. The hegemony of real variables in peripheral subsystems does not mean that monetary variables have played an insignificant role; in fact, the behaviour of the exchange rate and the relative prices have been more unstable in peripheral than in core-country subsystems. The export boom in the EU periphery has provoked increases in relative prices associated with income increments, and the greater financial vulnerability of peripheral economies make exchange rates more volatile in this region.

The findings by product types provide a new map of the changes in the final performance of the main final exporter subsystems according to the degree of development of the region in which they are located. Trends appear to have been less homogeneous in the core than in the peripheral economies. On the one hand, only the EU core-country subsystems of agriculture (01AGRIC), pharmaceuticals (12PHARMA), and programming services (40ICTPROG) have, on average, seen higher growth in real variables than in monetary variables, mainly the scale of labour. In the core types of subsystems of chemicals (11CHEM), food processing (05FOOD), finance (41FINANCE) and machinery and equipment (19MMACHEQ), the role of real variables have also been relevant. On the other hand, the core-country subsystems of textiles (06TEXT), electronic and optical products (17ICTEQ), metal products (16METPRDS), electrical machinery (18ELECEQ), other transport equipment (21TREQ), and furniture manufacturing (22OMAN) have experienced, on average, a fall in the physical volume of final exports. In the particular cases of furniture manufacturing (22OMAN), electronic products (18ELECEQ), and most markedly in textile products (06TEXT) subsystems, both real variables, labour productivity and induced employment, has fallen, showing the fragility and decline of these subsystems in the core economies.

The EU peripheral-country subsystems have generally shown high growth rates led by real variables, except in textile subsystem groups (06TEXT), where the volume of physical sales has fallen, leading to a reduction in required labour which productivity gains have not compensated.

The increase in periphery market share by product type varies considerably across industries. Electronics and optical products (17ICTEQ), metal products (16METPRDS), electrical machinery (18ELECEQ), vehicles (20VEHIC) and furniture manufacturing (22OMAN) are the product types in which peripheral economies have gained the most market share. These same types of subsystems
are the worst-performing core-country subsystems in terms of real variables. In other product types, such as other transport equipment (21TREQ) and finance (41FINANCE), the periphery’s share has remained stable. Finally, the only product type in which the peripheral region lost market share was textile products (06TEXT). Paradoxically, this is the only industry in which the peripheral economies had a significant export share at the beginning of the period. The results for peripheral textile subsystems (06TEXT) are very revealing and encourage to study the limits of the export-led growth.

Finally, the results obtained in Chapter 4 are also a link between EU GVCs and the EU core-peripheral literature. They provide new results about the determinants of final exports that can be considered as preliminary evidence of the offshoring impact in core production structure and the risk of falling into the middle-income trap in the EU periphery which has motivated the objectives 2 and 3, addressed primary in Chapter 5 and 6 respectively.

- **Objective 2:** quantify the structural changes linked to the reorganisation of labour across space in EU GVCs, adopting a core-periphery perspective (over the period 2000-2014).

The empirical analysis of objective 1 offered in chapter 4 highlights the low labour productivity growth of the exporting GVCs in the core region and, therefore, their low contribution to export dynamics, mainly driven by monetary variables. In contrast, the EU periphery shows strong growth in final exports, mainly driven by real variables, productivity growth and labour activated by external demand.

Objective 2 aims to go deeper into these questions by studying the structural differences within the European exporting GVCs; that is, studying the asymmetries between the distribution of labour associated with the new international division of labour and the remuneration of workers according to their geographical origin in each exporting subsystem. The questions associated with this objective are: What is the structure of employment distribution in the EU core and peripheral subsystems? Has this structure changed across the period? Has the distribution of labour affected the average labour costs across the GVCs? Has this effect been different in core and peripheral subsystems? Has the cost reduction strategy impacted on labour productivity in core and peripheral GVCs? Have changes in labour distribution followed similar patterns in all the product types? Have these changes affected the cost structure differently according to product type?

This thesis makes several contributions to the literature under objective 2. Firstly, it provides a reworked specification of Braun’s unequal exchange model (Braun 1973), which has had little
attention in the literature\textsuperscript{65}, providing an upgraded mathematical reformulation based on Pasinetti’s work (Pasinetti 1978). The focal point of the model is the inverse relationship between core and peripheral wages, which has not been tested empirically in the literature. With a given profit rate and considering the core wage rate as exogenous, and, consequently given, the inverse relationship between the core and peripheral region can be represented as a straight line whose negative slope depends on the relative labour productivity and the technical coefficients of the commodities produced in the peripheral region. Consequently, changes in peripheral wages depend on the changes in core wages. For instance, if core wage increases and the relative labour productivity does not change, this will translate into a low peripheral wage rate. On the other hand, improving peripheral labour productivity will increase the line slope. If core wages are held constant, the increase in peripheral labour productivity will increase peripheral wage rate, but if core wage rate increases, it will absorb the periphery’s improvement of labour productivity which will restrain or decrease core wages.

Secondly, inspired by the key insight of Braun’s unequal exchange model: the negative, monotonic relationship between core and peripheral wages – whose slope depends on relative labour productivities – I propose a novel labour cost-saving indicator to measure the effect of offshoring on the cost structure of GVCs, reflecting the new international division of labour. This is based on the counterfactual analysis of the vertically integrated nominal wage rate and vertically integrated labour distribution across GVCs: a phenomenon that has been little explored in the literature (see Section 3.5, Chapter 3).

The construction of this new measure has four main analytical advantages, over and above the existing literature, for the study of GVCs from a development perspective. First, the degree of fragmentation is based on the distribution of labour across GVCs, pointing out the relative relevance of the peripheral regions in GVCs, underestimated by income distribution problems such as value added. Second, it allows a disaggregation of the average wage per worker across the whole GVC by geographical origin, identifying which workers earn a higher wage per unit of labour. Furthermore, it allows for the identification of domestic labour into traditional labour, which never leaves the country before being incorporated into final demand. Domestic labour is linked to intermediate processes in global value chains, which are embedded in intermediate products that return to the country in

\textsuperscript{65} I am only aware of Evans’s critique (Evans 1984).
imported intermediate inputs. Third, the decomposition allows us to analyse the technical changes in the subsystem. For this purpose, the analysis has been complemented with the decomposition of vertically integrated nominal wage per product into two components, nominal wage per worker and labour per product, distinguishing by geographical origin. Finally, the cost-saving indicator allows us to measure changes in the structure of labour costs associated with the fragmentation of production during the period, contributing to the debate on the role of GVCs in economic development.

The results presented in Chapter 5 indicate a large asymmetry between domestic nominal wages per worker between core and peripheral regions in favour of core regions. In contrast to peripheral chains where average domestic and imported nominal wages move at similar levels, imported wages have a depressing effect on average labour costs in core exporting GVCs. This is because the EU core exporting subsystems are intensively integrated into GVCs, with, on average, the amount of imported labour incorporated into the chains being higher than the domestic one. The imported labour has allowed the EU core final exporting subsystems to take advantage of the unequal exchange between core and peripheral regions, i.e., it allows to hold labour costs and keep high domestic wages in core GVCs.

The GVC Literature has tended to focus cost-cutting strategies as one of the main drivers of labour offshoring (Ricci 2019; Goto 2011). Nevertheless, I am unaware of a previous empirical study that estimates the GVCs’ cost-saving caused by labour offshoring using a vertically integrated approach, as is done in Chapter 5. The increase in imported labour has resulted in an average saving of about 15.85% in the core subsystems' labour cost structure. In line with Braun unequal exchange theory, the new international division of labour allows the EU core subsystems to maintain high wages in the core economies by increasing the share of labour from peripheral countries to reduce their labour costs. Although the domestic wage per worker in the core countries has grown more than the imported ones, the gap between domestic and imported labour productivity has caused the wage per domestic product to fall more than the imported ones. Therefore, the strategy based on cost reductions through the offshoring of labour to less technically efficient peripheral regions is resulting in a drop in the average labour costs, but also in stagnation or fall in the average physical labour productivity of the core GVCs, which has relevant consequences on the competitiveness of the EU core-country subsystems, particularly in the long run, as developed in objective 3.

In the peripheral GVCs, there was an upgrading process accompanied by a wage catching-up in the pre-crisis period (2000-2008), which slowed down after the financial crisis. However, wage growth in
the periphery has been accompanied by a process of offshoring of domestic labour even more intense than in the core countries. Although imported labour from more knowledge and capital-intensive core countries has grown very slightly, offshoring has mainly taken place to other peripheries with lower wages and inferior technical production conditions.

In contrast to the core EU GVCs, the offshoring process in the periphery has not had a generalised positive effect on their cost structure. This may be explained by the uneven differentials in domestic vis-à-vis imported productivity growth as opposed to nominal wage growth. In other words, the strong physical labour productivity gains of EU peripheral GVCs analysed in the objective 1 seem to be more related to improvements in domestic technical conditions rather than technical improvements in imported inputs. Although there has been, on average, higher growth in domestic wages per worker in peripheral exporting subsystems, the increase in labour productivity has been even higher, causing domestic nominal wages to fall in contrast to imported ones.

Therefore, it may seem puzzling how the EU periphery engaged in process of labour offshoring when its domestic nominal wage per unit of output expanded at a slower pace than the imported GVC component. Our empirical findings lend some support to arguments about the limits of an export-oriented strategy – very vulnerable to exogenous shocks – in middle-income economies such as the EU periphery. In fact, the imitation of a cost competitiveness logic – prevalent in core EU subsystems – may have actually slowed down the catching-up process to overcome a middle-income threshold.

Hence, EU peripheral economies may face a trade-off between improving technical conditions of production and cost reductions which may lead to premature deindustrialisation, instead of adopting a strategy driven by domestic effective demand, which is plausibly a pre-requisite to reach average socio-economic levels of core EU countries (Cieślik, Biegańska, and Środa-Murawska 2016; Soreg 2018; Bieńkowski 2016).

Finally, the analysis by product types shows that labour-intensive sectors such as textiles (06TEXT) or processed food (05FOOD), characterised by being very labour-intensive. In both regions, although much more intensively in the core, the offshoring of labour to the periphery has had a positive impact on cost reductions in the subsystems of chemical products (11CHEM), pharmaceutical products (12PHARMA) and electronic and optical products (17ICETQ). This shows that the cost-cutting strategy based on the fragmentation of production is not inherent to those industries at a lower technological level but is relevant to the manufacturing sector as a whole.
Objective 3: Analyse the role of relative vertically integrated unit labour costs (rviulc), and their components, as determinants of final export performance in EU subsystems.

The results of research objectives 1 and 2 show that both types of exporting subsystems, core and peripheral, are integrated into GVCs. On the one hand, in the core region, integration in GVCs allows them to take advantage of the unequal terms of trade with peripheral countries by lowering average labour costs in their final exports. Nevertheless, this wage-cutting strategy harms the labour productivity, whose increases have been low or non-existent during the period analysed. On the other hand, there has been spectacular growth in real exports in the peripheral region accompanied by large productivity gains, which is associated with an upgrading process in the region. However, between 2000 and 2014, the offshoring of labour, particularly to other peripheries with lower improvements in labour productivity, has been even higher in percentage terms than in the core countries. This may slow down the upgrading process, cause these economies to remain stuck in the middle-income trap, and eventually affect their international performance.

Objective 3 measures the effect of unit labour costs via the GVCs on the actual export performance of the EU final exporting subsystems, distinguishing between the wage-cutting effect and the effect of changes in labour productivity. For this purpose, Section 3.6 of Chapter 3 provides a new measure of unit labour costs based on the vertical integration approach, which is based on physical units of production and not on income distribution variables with value added. That is, the vertically integrated unit labour cost indicator can be decomposed into the vertically integrated unit wage rate in current dollars and the vertically integrated labour productivity in physical volume, expressed in constant local currency, of each exporting subsystem. As there are different local currencies in the EU, the viulc and its components are expressed as year 0 indices to measure the dynamics. Furthermore, in order to facilitate the comparison between subsystems of countries of different sizes, following Carlin et al. (2001) in Chapter 6, the variables are standardised by weighting them by the market share of each subsystem within each industry in the base year, in this case, 2010. As a result, we obtain the relative vertically integrated unitary labour costs (rviulc).

In order to understand what are the main determinants of cost-competitiveness in EU export subsystems, Chapter 6 focuses on answering the following research questions: what is the role of relative vertically integrated unitary labour costs (rviulc) when accounting for the relative dynamism of final export subsystems in the EU? If rviulc are able to explain final export performance in real terms, is this dynamic path determined via changes in nominal wages or (physical) labour productivity? Are those patterns similar in the short and long-run? Furthermore, do rviulc impact EU
core and peripheral economies in the same way? Finally, is the role of rviulc and their components similar or different between product types? In order to answer these questions, the chapter tests the relationship between the rviulc and its components with the actual market share of each EU exporting subsystem through a dynamic panel-data econometric model.

In general, there is a negative relationship between rviulc and market share in both the short and the long run, but this loses intensity in the long run. By components, the relationship between real market share and rviunw is direct and inverse with rviulp. It means that an increase in nominal wages in GVCs causes a loss of the real market share of each exported subsystem, while increases in labour productivity result in a gain of real market share. However, the sensitivity of the market share to changes in labour productivity is much higher and long-lasting in the long run, making it the main driver of real competitiveness.

Results suggest a slow catching-up process between the EU core and peripheral regions in relation to their internationalisation strategies. The core region is more vulnerable to increases in rviulc, both in the short and long term, and increases in rviunw have a strong negative impact. This may explain why the wage-cutting strategy highlighted in the analysis of objective 2 appears to be effective in the short term but unsustainable in the long term. The lack of increases in physical labour productivity seems to explain the loss of real market share. In EU peripheral subsystems, the growth of labour productivity is the main driver of real export performance, which has accompanied the expansion of peripheral final export market shares in real terms. Nevertheless, this process of economic upgrading has been limited. Peripheral labour productivity gains remained dependent on imported technology incorporated through inward FDI (Grodzicki and Geodecki 2016), and core-country subsystems have kept a leading role in final export markets. As a result, the EU peripheral economies may be immersed in a process of dependent development, which complicates the socio-economic convergence with EU core economies.

By subsystem groups, it appears that the rviulc are less relevant in the services subsystems than in the manufacturing subsystems. As expected, in the labour-intensive manufacturing exporting subsystems’ nominal wage increases negatively affect export performance. However, the results also reveal that in high-tech manufacturing, such as pharma (12PHARMA) and chemicals (11CHEM), the wage-cutting strategy also positively affects the real market share in the short run. These findings contradict the mainstream idea of wage-cutting only work with low-tech. Nevertheless, in the long
run, the data point out that 12PHARMA and 11CHEM still need to increase their labour productivity to remain competitive.

7.3 Implications for EU policy and institutions

The above divergence between EU core and periphery regions reflects the need for more effective common economic policies in the EU. As has been argued, both the EU core and periphery seem to face long-term challenges related to globalisation. The EU core economies have to face a decrease in their export competitiveness derived from the productivity fall associated with labour offshoring to lower-wage economies. While the EU peripheral economies have experienced an improvement in their export capacity thanks to productivity gains generated by foreign capital, the lower labour cost of non-EU peripheries may lead to early deindustrialisation of this region – the catching-up process slowed down since the financial crisis and it has been a strong labour offshoring process through non-EU peripheries – and the deterioration of inter-industrial relations between member states (see Section 5.3 of Chapter 5). These divergences in their development paths and their different insertion in the world economy mean that the long-term recipes for each region may be required from dissimilar, even incompatible, measures if common goals based on the solidarity between members are not defined.

As a result, I argue that the gap between the core and the periphery in Europe can only be reduced by abandoning the neoliberal postulates of the Maastricht Treaty and opting for greater economic and social integration between member states. Accordingly, I propose a new coordinated policy strategy based on the following fundamental pillars.

Firstly, the EU needs a new common industrial policy to address the lack of competitiveness of final core exports – see Section 4.4. of Chapter 4 – related to labour offshoring to peripheral regions with lower labour costs (Section 5.3., Chapter 5). Globalization has positively affected core GVCs’ labour costs but also damaged core productivity and the growth dynamic of core-country subsystems in the long term. Therefore, a new common industrial policy must focus on rebuilding ‘factory Europe’ again, promoting the sourcing of inputs intra-EU instead of the interdependences with third economies out of the EU; and taking advantage of the advances provided by the EU domestic market (Celi et al. 2018).

Secondly, in the analyses of the impact of relative labour costs on the real market share – shown in Section 6.4 of Chapter 6 – I show that the decrease of real wages has a short-run effect on export competitiveness, while the increase in productivity drives it in the long term. These results highlight the need for two
essential regulations, a solid pan-European R&D policy to ensure technical change in the long run, and a wage rate harmonization to avoid unequal exchange between state members.

On the one hand, the continuous upgrading of the EU production structure requires a solid R&D policy at the EU level led by public investment to socialise both the risks — basic investment — and rewards — taxes to profitable innovations — of technological change (Mazzucato 2015). Following this approach, the European Union has implemented policies to stimulate knowledge and innovation projects, such as the Europe 2020 strategy (European Commission 2010) and the European Industrial Renaissance (European Commission 2014). Nevertheless, both EU initiatives promote competitiveness between member states instead of complementarities and coordination (Ambroziak 2014), which does not help reduce core-periphery disparities in the technological capacity presented in this work. Therefore, the European institutions could, it might be argued, be braver in designing an effective industrial policy from a pan-European perspective that reduces polarisation and technological dependency between regions. This will imply public and solidary financial support from the EU project to, first, modernise and diversify current production structures through capital accumulation and improvements of domestic demand in EU peripheral economies; and second, to create new niches that lift productivity in the core countries from stagnation, as shown in chapter 4.

On the other hand, Chapter 6 demonstrates that a wage rate harmonization at the EU level does not need to go against cost-competitiveness since the main long-term driver is physical labour productivity and not the nominal wage per worker. This measure might boost the social catching-up between member states, but also expand the domestic market and improve the impact of the EU industrial policy detailed above.

Finally, I advocate for a common fiscal policy and the re-regulation of the financial sector. This would complement my recommendations for industrial policy as vital part of a complete EU norm framework. An effective industrial policy can reorganise EU production in different regional hubs, but it will not prevent the emergence of conglomerates and industrial clusters inherent to the spillovers of industrial activity. Therefore, a common industrial policy must be complemented by a common fiscal policy that distributes profits and balances living standards throughout the member states. In addition, the re-regulation of the financial sector is also necessary to avoid financial speculation, tax evasion and the relocation of assets (Kapeller, Gräbner, and Heimberger 2019).
7.4 General limitations of the research

It is necessary to consider certain limitations of this research. First, empirical analyses based on MRIO models, such as the ones presented in this thesis, allow capturing direct and indirect exchanges between countries and industries, i.e., they allow disaggregating content generated abroad and domestically, as well as by each industry. It endows input-output indicators a greater explanatory capacity for GVCs rather than indicators based on conventional trade data. Moreover, by adopting a final demand-based approach, the analytical framework used in this thesis also avoids double counting. However, input-output databases such as WIOD also have certain limitations (Timmer et al. 2012). The construction of robust and compatible input-output tables across regions and industries is a data-intensive process that presents numerous challenges due to heterogeneity in data quality. In particular, the construction of the MRIO model is very complex due to data restrictions and inconsistencies between countries due to the accuracy problems associated with bilateral links66 (Ahmad et al. 2017; Dietzenbacher, Los, et al. 2013).

The allocation of trade flows between the origin and destination country industry is rooted in several statistical assumptions. Thanks to the International Standard Industrial Classification, identifying the origin country-sector is simple. However, the destination sector is based on the import SUT coefficients built under the proportionality principle. For instance, if the vehicle industry consumes 20% of Spain’s metal imports, 20% of the bilateral import flows of metal products will be allocated to the vehicle industry. This does not allow for the quality of metal products differing according to their origin, and the product quality required by domestic industries also vary between sectors (Escaith 2014; Timmer et al. 2012). The difficulties are even higher in the case of services since the database on bilateral service trade is more limited (Ahmad et al. 2017). Because of this, in this thesis, the six industries (29WTRADE, 30RTRADE, 31LANDTR, 32WATERTR, 33AIRTR and 42INSUR) have excluded trade and transport margins as final export subsystems; nevertheless, they have been accounted as intermediate inputs for the rest of the industries. These subsystems provide services that other subsystems need to export, but because of the way that bilateral service flows are calculated, WIOD tends to oversize their international performance.

There is an important heterogeneity of firms and the levels of specialisation of each country’s industry that is not captured by input-output tables. Input-output tables are built under a high degree of industrial aggregation. It is assumed that all the grouped firms in an industry operate under the same technical conditions, produce the same product and sell to the same markets. Nevertheless, the reality is more

66 The export accounting of one country do not always match with the accounting of buying industries or final demand consumers.
complicated. Firms oriented to the domestic market can make use of different technical conditions from firms oriented to international markets, which may also cause analytical disturbances (Ahmad 2015; Amador and Cabral 2016).

Finally, by definition, the global economy is a close economic system. However, the lack of data about the rest of the world (RoW) in WIOD’s Social-Economic Accounts (SEAs) allows studying the global wage and labour relationships. Therefore, it has been necessary to complement it with the data obtained from ILOSTAT. The RoW is calculated as a residue, i.e., using for SEAs the exact proportionality that the RoW has over the total labour in ILOSTAT. This rule may introduce some noise into the estimations. The full details of the estimation of RoW’s socioeconomic variables are found in Appendix C.

7.5 Further research
This research has attempted to shed light on the impact of GVCs on the dynamics of the EU final exports. The thesis distinguishes between core and peripheral economies, and it provides a descriptive analysis of the growth factors in the EU final exports, a contrafactual exercise to measure the impact of the production fragmentation in the cost structure, and econometric analysis to measure the effects of the GVCs on the EU subsystems’ international competitiveness.

However, this thesis’s contributions do not exhaust the possibilities for future research in this field. In addition to the considered factors in this work, other variables related to GVCs also affect final export performance and economic development. This dissertation, in particular, focuses on wages and labour distribution across GVCs and the disequilibria between core and peripheral economies. Nevertheless, it does not analyse how the GVCs impact on the gross operating surplus distribution, which adds to the wage bill representing the whole value added generated in an industry. The EU peripheral export-led model is driven by foreign direct demand, which means that part of the generated income is exported as profits and dividends toward core economies or other semi-peripheries. This fact may also limit the upgrading of the EU periphery linked to foreign-led development.

Based on the Sraffan price model, Braun's unequal exchange theory can be a potential tool to understand the main benefits of globalisation. This thesis explores this via empirically testing the inverse relationship between core and peripheral wages under the new division of labour. Nevertheless, there are opportunities to continue research in this area: exploring new theoretical frameworks based on unequal
exchange theory with empirical application that allows mapping GVCs complexity implications for economic development.
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Global Value Chains in the European Union: An input-output approach
Appendix A: Hypothetical extraction technique

Appendix A: Hypothetical extraction technique

Using the hypothetical extraction method, we can obtain the physical labour contribution by geographical origin for each subsystem. For instance, in the case of country $r$, we can create a hypothetical system in which country $r$ does not supply physical labour to its own production, while the rest of the global economic structure is not altered (Los, Timmer, and De Vries 2016):

$$[v_r^r v_s^v]^T = [a_i^r a_i^s]^T \begin{bmatrix} 0 & B_{rs}^T \ b_{sr}^r \\ B_{ss} & a_i^s B_{rs} + a_i^s B_{ss}^T \end{bmatrix}^T$$

Now $v_i^r = (a_i^s)^T b_{sr}^r$ represents the vertically integrated foreign labour required subsystems $i$ in country $r$ to produce a unit of final product.

The logical hypothetical extraction can be applied to multiple-region systems since region $s$ can be disaggregated in as many regions as country as the MRIO tables. For instance, consider the three-region case where region $s$ is now split into region $s$ and $t$. We could estimate the labour from region $t$ allocated to country $r$'s per unit final products:

$$[v_r^r v_s^s v_t^t]^T = [a_i^r a_i^s a_i^t]^T \begin{bmatrix} 0 & B_{rs}^T & B_{rt}^T \\ 0 & B_{ss} & B_{st}^T \\ B_{tr}^T & B_{ts} & a_i^t B_{rs} + a_i^t B_{ss}^T \end{bmatrix}^T$$
Appendix B: WIOD and ILOSTAT databases

WIOD is a European project funded by the European Commission. The project has published two releases of the database. The first one, WIOD -2013 release, provides national and world input-output tables (WIOTs) and socio-economic accounts (SEAs) for 27 EU countries and 13 other major economies, for 35 industries during the period 1995-2011. The second, the WIOD-2016 release, covers the same information for 28 EU countries and 15 other major economies for 56 industries from 2000 to 2014. In the case of WIOTs, the database also provides an estimation for the Rest of the World (RoW), which is not complemented in the SEAs.

The construction of the world input-output tables (WIOTs) is explained in Dietzenbacher et al. (2013), which is based on the construction of ‘WIOD Data, 2013 Release’. We assume that the construction of ‘WIOD data, 2016 release’ follows the same methodology since it is the official reference given for the 2016 release. The methodology followed to build the Social Economic Accounts (SEAs) collected in Gouma et al. (2018).

The difficulty of tracking all the domestic and international transactions of goods and services is usually the main reason for discrepancies between databases. The different databases require assumptions to address the lack of data. These choices are made for groups of researchers in charge of the estimations according to the purpose of the database. As a result, the data shown by different databases vary, and they could be more appropriate or less depending on the research question of each work.

‘WIOD data, 2016 release’ combines detailed information from suppliers and use tables (SUTs) supplied by official national statistics consistent with National Accounts (NAS) with International Trade Statistics (ITS). Supply tables describe how much of each good or service is produced domestically and how much is imported. Use tables show the consumption of each product (without distinction between domestic or imported products) by each of the industries and components of final demand. SUTs are the primary resources to construct the input-output tables (IOTs) at national levels. SUTs are not usually square or symmetric and capture secondary production (which is more similar to the real world). In the construction of IOTs, it is assumed that each industry produces only one class of goods and services. Consequently, the division between industry and product disappears, and SUTs can be linked with ITS.

Relating national SUTs to international tables is made using bilateral trade databases that cover both goods and services. International trade flows were obtained in UN Comtrade databases (at the six-digit level in the Harmonized System (HS)). In cases where data is missing, this has been addressed using the
corresponding National Statistical Institutes (NSIs). Comtrade HS six-digit data supply information about the flows of around 5000 goods whose flows were grouped according to the HS six-digit product to distinguish between the categories of ‘intermediate consumption’, ‘final consumption’, and ‘capital goods’. These three categories match with the Broad Economic Categories (BEC revision 3) provided by the UN and the end-use categories used by the OCDE. This classification is also compatible with NACE rev. One and two-digit levels supplied by Eurostat to the CPA classification in the national SUTs (Dietzenbacher, Lenzen, et al. 2013, 84). To combine national SUTs with bilateral trade data it is necessary to express all the data in the same unit. Since most trade statistics are reported in US-$, WIOTs are given in current US-$. The exchange rates (year averages) are taken from the International Financial Statistics published by the International Monetary Fund (IMF) (Dietzenbacher, Los, et al. 2013). Besides, imports are described in cif prices while the flows of exports are given in “free on board” prices. To transform imports’ cif prices into fob prices, the bilateral international trade margins available in the UN Comtrade database has been used (Dietzenbacher, Los, et al. 2013).

The building of the bilateral data on service flows across countries presents additional problems caused by their intangibility or difficulty to be stored. As a result, WIOD only records the services provided from inside one country to inside other countries. It means that the services consumed by foreign people or companies inside the border of the ‘producer country’ or services provided for local people or companies established in foreign countries are not counted. The services flows are obtained from UN, Eurostat and OCDE. Despite the quality of service data not being comparable with the manufacturing data yet, WIOD makes a strong effort to offer a whole picture of the global trade in services.

The bilateral flows between RoW and the countries included in WIOD were obtained from the data set obtained from UN Comtrade, UN sources, EUROSTAT and OECD series, adding all countries in the trade database excluded in WIOD. The flows from each industry-economy to each industry-RoW (intermediate or final use) were well-adjust applying RAS procedure (Dietzenbacher, Los, et al. 2013; Erumban et al. 2013).

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67 UN Comtrade presents some problems, particularly with China and Taiwan. Taiwan does not appear in the UN Comtrade, and Hong Kong and Macao are registered separately. WIOD included Hong Kong and Macao with China as it is in the Chinese national SUTs. The bilateral flows of Taiwan have been estimate using ‘Other Asia, nes’ reported by the OECD.

68 The authors point out that working with several sources allow them to court the data and identify errors. In the case of UN data, the errors have been cleaned while they remain in EUROSTAT and OECD series. For this reason, the UN data was adopted as main.
Global Value Chains in the European Union: An input-output approach

Appendix B: WIOD and ILOSTAT databases

2012). WIOD opts to use the average export share of the final product from developed economies to the existing developing economies in WIOD (BRICIM: Brazil, Russia, India, China, Indonesia and Mexico). In the cases in which the exporting country is a BRICIM country, this country is excluded from the BRICIM average for these specific cells. The Row domestic data is calculated from the UN National Accounts. To estimate the domestic flows of RoW, the data has been collected from the UN National Accounts. Firstly, value-added data by economic activity and final demand category were added for all countries not contained within the WIOD to obtain the GDP by broad industries and final demand categories for RoW. Gross output levels were calculated by applying the industry-specific average ratios of gross output to value-added for developing economies in the WIOD (BRICIM). To divide the broad manufacturing sectors provided by the UN National Accounts at the same levels as the countries included in WIOD, it has been used the average shares by the industry from the UNIDO industrial statistics for all countries not included in the WIOD. Initial estimations of the domestic intermediate use block and the domestic final demand block have been calculated as weighted averages shares from the BRICIM countries. The RAS algorithm is applied to ensure that the column addition is equal to the row addition for RoW. The exports from RoW remained unchanged. The initial values fed into the algorithm were the input coefficients from the BRICIM countries, whereas the row and column totals were given by the externally provided data based on the UN National Accounts and UNIDO industrial statistics as described Dietzenbacher, Los, et al. (Dietzenbacher, Los, et al. 2013).

The Socio-economic Accounts (SEAs) provided by WIOD has created using Eurostat information for the European Union countries. In the case of missing data, the disaggregation is based on the economic activities suggested by ISIC rev. 4. This means, if there is no available data at the two-digit level, it is estimated by interpolating the information of one level of aggregation. SEAs are entirely consistent with WIOTs at the industry level. Therefore, changes have been introduced to guarantee the consistency of the data. For example, in the case of the employment data, the total employment (EMPE) is not directly adopted from Eurostat. However, instead, the proportion of value added per employee given by Eurostat (ratio of VA to EMP) is multiplied by VA taken from WIOD 2016 (which is calculating using national SUTs and NAS)\textsuperscript{69} and fully consistent with the WIOD 2016 output. The number of employees (EMPE) is estimated by multiplying the new value for EMP by the ratio of employees to total employment (EMPE/EMP) from Eurostat.

\textsuperscript{69} See Dietzenbacher et al. (2013).
The total labour compensation (LAB) brings together the compensation of employees and self-employed persons whose earnings are similar to the average wages of employees in the same industry. On some occasions, data on Mixed Income (MIXINC) is reflected on the uses table, then SEAs calculate the weight of MIXINC over VA and add it to the weight of COMP over VA to estimate an upper limit for LAB. This upper limit is extrapolated for years without data according to the growth of LAB. Finally, the minimum value of the upper limit is taken, such as the value for LAB.

In the cases of non-European countries, there is no common source of data. Therefore, the previous methods explained for EU countries have been used to harmonise the available data of Non-European countries with WIOD. The primary resource databases are National Accounts, OCDE, Eurostat, SEA-2013, KLEMS (Gouma et al. 2018).

ILOSTAT belong to the UN agency of the International Labour Organization (ILO). Since WIOD considered the UN databases the most reliable as primary sources (Dietzenbacher, Los, et al. 2013), we assume that WIOD and ILOSTAT are compatible databases. ILOSTAT provided the number of employees for 234 countries disaggregated in 14 economic activities according to the fourth version of the International Standard Industrial Classification of All Economic Activities (ISIC)\(^70\). Each economic activity refers to the characteristics of the economic sector; it does not refer to the tasks that a person developed in her/his job. The data is organised following the International Standard Industrial Classification of All Economic Activities (ISIC), in our case revision 4.

The main data source for employment by economic activity is provided by labour force surveys. This survey usually allows covering, in a coherent framework, the whole labour markets in a country, including the self-employed, number of family’s workers, the informality of the employment, unemployment, workers’ age, workers’ sex etc. This information can be complemented with household surveys, population censuses and other official sources, although these latter are less reliable than labour force surveys. In the case that any of these databases are available, their information can be obtained from establishment surveys or administrative records, although they often excluded the informal economy\(^71\).

ILO Department of Statistics, in collaboration with the Research Department, works to compile the different labour statistics and ensure the accuracy, reliability, timeliness and comparability of ILOSTAT. It

\(^70\) NACE is based on ISIC as well.

Acceded 20\(^{th}\) February 2020.
elaborates its own econometric models to estimate missing data and guarantees a single, internationally comparable database on the labour market based on the 19th International Conference of Labour Statisticians (ICLS) agreement. In the case of economic activity (sector), the share of each employment-related category in each country and the missing data is identified using a cross-country regression. Next, the evolution of the shares of each category is calculated according to the available data about the economic cycle, the economic structure and the demographics. Finally, the results are balanced to guarantee the consistency and robustness of the database (ILO 2019, 6–7).
### Table B.1. Subsystems’ coding

<table>
<thead>
<tr>
<th>Code</th>
<th>Long description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01AGRIC</td>
<td>Crop and animal production, hunting and related service activities</td>
</tr>
<tr>
<td>02FOREST</td>
<td>Forestry and logging</td>
</tr>
<tr>
<td>03FISHING</td>
<td>Fishing and aquaculture</td>
</tr>
<tr>
<td>04MINING</td>
<td>Mining and quarrying</td>
</tr>
<tr>
<td>05FOOD</td>
<td>Manufacture of food products, beverages and tobacco products</td>
</tr>
<tr>
<td>06TEXT</td>
<td>Manufacture of textiles, wearing apparel and leather products</td>
</tr>
<tr>
<td>07WOOD</td>
<td>Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials</td>
</tr>
<tr>
<td>08PAPER</td>
<td>Manufacture of paper and paper products</td>
</tr>
<tr>
<td>09PRINT</td>
<td>Printing and reproduction of recorded media</td>
</tr>
<tr>
<td>10REFPETR</td>
<td>Manufacture of coke and refined petroleum products</td>
</tr>
<tr>
<td>11CHEM</td>
<td>Manufacture of chemicals and chemical products</td>
</tr>
<tr>
<td>12PHARMA</td>
<td>Manufacture of basic pharmaceutical products and pharmaceutical preparations</td>
</tr>
<tr>
<td>13RUBPLAS</td>
<td>Manufacture of rubber and plastic products</td>
</tr>
<tr>
<td>14NMETMIN</td>
<td>Manufacture of other non-metallic mineral products</td>
</tr>
<tr>
<td>15METALS</td>
<td>Manufacture of basic metals</td>
</tr>
<tr>
<td>16METPRDS</td>
<td>Manufacture of fabricated metal products, except machinery and equipment</td>
</tr>
<tr>
<td>17ICTEQ</td>
<td>Manufacture of computer, electronic and optical products</td>
</tr>
<tr>
<td>18ELECEQ</td>
<td>Manufacture of electrical equipment</td>
</tr>
<tr>
<td>19MMACHEQ</td>
<td>Manufacture of machinery and equipment n.e.c.</td>
</tr>
<tr>
<td>20VEHIC</td>
<td>Manufacture of motor vehicles, trailers and semi-trailers</td>
</tr>
<tr>
<td>21TREQ</td>
<td>Manufacture of other transport equipment</td>
</tr>
<tr>
<td>22OMAN</td>
<td>Manufacture of furniture; other manufacturing</td>
</tr>
<tr>
<td>23REPAIR</td>
<td>Repair and installation of machinery and equipment</td>
</tr>
<tr>
<td>24ELECGAS</td>
<td>Electricity, gas, steam and air conditioning supply</td>
</tr>
<tr>
<td>25WATER</td>
<td>Water collection, treatment and supply</td>
</tr>
<tr>
<td>26WASTE</td>
<td>Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services</td>
</tr>
<tr>
<td>27CONST</td>
<td>Construction</td>
</tr>
<tr>
<td>28REPVHEIC</td>
<td>Wholesale and retail trade and repair of motor vehicles and motorcycles</td>
</tr>
<tr>
<td>29WTRADE</td>
<td>Wholesale trade, except of motor vehicles and motorcycles</td>
</tr>
<tr>
<td>30RTTRADE</td>
<td>Retail trade, except of motor vehicles and motorcycles</td>
</tr>
<tr>
<td>31LANDTR</td>
<td>Land transport and transport via pipelines</td>
</tr>
<tr>
<td>32WATERTR</td>
<td>Water transport</td>
</tr>
<tr>
<td>33AIRTR</td>
<td>Air transport</td>
</tr>
<tr>
<td>34SUPPTR</td>
<td>Warehousing and support activities for transportation</td>
</tr>
<tr>
<td>35POST</td>
<td>Postal and courier activities</td>
</tr>
<tr>
<td>36ACCOMFOOD</td>
<td>Accommodation and food service activities</td>
</tr>
<tr>
<td>37PUBLISH</td>
<td>Publishing activities</td>
</tr>
</tbody>
</table>
Global Value Chains in the European Union: An input-output approach
Appendix B: WIOD and ILOSTAT databases

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>38MEDIA</td>
<td>Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities</td>
</tr>
<tr>
<td>39TELECOMM</td>
<td>Telecommunications</td>
</tr>
<tr>
<td>40ICTPROG</td>
<td>Computer programming, consultancy and related activities; information service activities</td>
</tr>
<tr>
<td>41FINANCE</td>
<td>Financial service activities, except insurance and pension funding</td>
</tr>
<tr>
<td>42INSUR</td>
<td>Insurance, reinsurance and pension funding, except compulsory social security</td>
</tr>
<tr>
<td>43AUXFIN</td>
<td>Activities auxiliary to financial services and insurance activities</td>
</tr>
<tr>
<td>44REALEST</td>
<td>Real estate activities</td>
</tr>
<tr>
<td>45LEGACCBS</td>
<td>Legal and accounting activities; activities of head offices; management consultancy activities</td>
</tr>
<tr>
<td>46ARCHENGBS</td>
<td>Architectural and engineering activities; technical testing and analysis</td>
</tr>
<tr>
<td>47SCIRD</td>
<td>Scientific research and development</td>
</tr>
<tr>
<td>48ADVMARKBS</td>
<td>Advertising and market research</td>
</tr>
<tr>
<td>49OPROFSERV</td>
<td>Other professional, scientific and technical activities; veterinary activities</td>
</tr>
<tr>
<td>50ADMINBS</td>
<td>Administrative and support service activities</td>
</tr>
<tr>
<td>51PUBLICADM</td>
<td>Public administration and defence; compulsory social security</td>
</tr>
<tr>
<td>52EDUC</td>
<td>Education</td>
</tr>
<tr>
<td>53HEALTH</td>
<td>Human health and social work activities</td>
</tr>
<tr>
<td>54OSERV</td>
<td>Other service activities</td>
</tr>
<tr>
<td>55HHSERV</td>
<td>Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use</td>
</tr>
<tr>
<td>56EXORG</td>
<td>Activities of extraterritorial organisations and bodies</td>
</tr>
</tbody>
</table>

Source: WIOD. Own elaboration
Appendix C: Estimations of the Number of Employees (EMPE), and the Labour Compensation (LAB), the vector of price index and exchange rate for RoW

In order to work with global subsystems, it is necessary to start from an accounting framework based on a closed economic system. WIOD provide a close economic system in terms of value added, but it does not provide data about the quantity of labour and labour compensation corresponding to the rest of the world (RoW). This thesis aims to contribute to the GVCs’ empirical analysis literature, providing RoW vectors of the quantity of labour and labour compensation compatible with WIOD. In line with WIOD methodology, the primary data is obtained from UN statistics, to which ILOSTAT belongs (Gouma et al. 2018; Dietzenbacher, Los, et al. 2013; Timmer et al. 2012). Further details about the compatibility of WIOD and ILOSTAT are provided in Appendix A.

The vector of the number of employees (EMPE) for RoW:

As described in Dietzenbacher, Los et al. (2013, 93–94), we first calculate the share of total labour supplied by the 43 economies collected in WIOD using the data provided by the ILO database, which contains the employee number of 234 economies disaggregated in 14 industries:

\[ \theta_{L(t)}^{ILO-43} = \frac{\sum_{r=1}^{43} \sum_{i=1}^{14} L_{t,i}^{ILO}}{\sum_{r=1}^{234} \sum_{i=1}^{14} L_{t,i}^{ILO}} = \frac{L_{ILO-43}^{ILO}}{L_{ILO}} \quad (A.01) \]

where \( L_{ILO-43}^{ILO} \) is the sum of the total employment of the 43 economies registered in WIOD according to ILO data, \( L_{ILO} \) is the total employment for the whole economic systems registered by the ILO database and \( \theta_{L(t)}^{ILO-43} \) is a scalar representing the share of the labour provided by these 43 countries regarding the total employment in the global in a \( t \) year.

There we can define the share of total labour provided by RoW as:

\[ \theta_{L(t)}^{ILO-RoW} = \frac{1}{\theta_{L(t)}^{ILO-43}} \quad (A.02) \]

We assume that the distribution of employment between the 43 countries and RoW is the same in both databases. Then, we can estimate the total global employment using SEAs as\textsuperscript{72}:

\textsuperscript{72} \( \sim \) indicates it is an estimation
Appendix C: Estimations of the Number of Employees (EMPE), and the Labour Compensation (LAB), the vector of price index and exchange rate for RoW

\[ \bar{L}_{t(\text{SEA})} = \frac{1}{\theta(t)} \sum l_{i=t}^{43} \sum l_{i=1}^{56} \bar{L}_{t(\text{SEA})} \]  \hspace{1cm} (A.03)

where \( \sum l_{i=t}^{43} \sum l_{i=1}^{56} \bar{L}_{t(\text{SEA})} \) is the summary of the total employment in the forty-three countries registered in SEAs. Thus, the total employment of RoW can be calculated such as:

\[ \bar{L}_{t(\text{RoW})} = \bar{L}_{t(\text{SEA})} - \sum l_{i=t}^{43} \sum l_{i=1}^{56} \bar{L}_{t(\text{SEA})} \]  \hspace{1cm} (A.04)

The disaggregation of the total employment in each one of the 56 industries of RoW has been done by using the weighted average shares from the developing countries in WIOD, i.e., BRICIM (Brazil, Russia, India, China, Indonesia, and Mexico):

\[ S_i(t) = \frac{\sum l_{i=t}^{43} \bar{L}_{t(\text{SEA})} - \beta_i(t)}{\sum l_{i=t}^{56} \bar{L}_{t(\text{SEA})} - \beta_i(t)} \]  \hspace{1cm} (A.05)

\( S \) is the 56×1 vector with the weighted average shares from BRICIM \( S_i(t) \). Therefore, the vector of the number of employees for RoW compatible with WIOD can be defined as:

\[ \bar{L}_{t(\text{RoW-SEA})} = S_i(t) \cdot \bar{L}_{t(\text{RoW})} \]  \hspace{1cm} (A.06)

Putting in row form, the vector of total employment of the 43 countries registered in SEAs \( L_{t(\text{SEA})}^{43-SEA} \) and the estimated vector for the RoW, \( \bar{L}_{t(\text{RoW-SEA})} \), we got the vector of total employees in the global economic system: \( L_{t} \).

The vector of labour compensation for RoW:

To calculate labour compensation, we follow the same method of Dietzenbacher, Los et al. (2013) to estimate the value-added for RoW. We build a weighted average labour compensation of the developing countries in SEAs, i.e., BRICIM (Brazil, Russia, India, China, Indonesia, and Mexico).

The labour compensation for each \( \Psi_{t(\text{RoW})} \) RoW industry is calculated as:

\[ \Psi_{t(\text{RoW})} = \frac{\sum l_{i=t}^{56} \bar{L}_{t(\text{SEA})} - \beta_i(t)}{\sum l_{i=t}^{56} \bar{L}_{t(\text{SEA})} - \beta_i(t)} \]  \hspace{1cm} (A.07),

where \( \Psi \) is the 56×1 vector with the weighted average labour compensation of BRICIM \( S_i(t) \). Merging the vector of labour compensation of the 43 countries registered in SEAs \( \Psi_{t(\text{SEA})}^{43-SEA} \) and the estimated vector
Global Value Chains in the European Union: An input-output approach

Appendix C: Estimations of the Number of Employees (EMPE), and the Labour Compensation (LAB), the vector of price index and exchange rate for RoW

for the RoW, \( \Psi_{i(t)}^{RoW} \) into a row, we derive the vector of labour compensation in the global economic system: \( \Psi_{(t)} \).

The vector of price index and exchange rate for RoW:

In the case of index price, the vector of a price index \( \tilde{\Phi}_{i(t_0)}^{RoW} \) will be estimated as a weighted price index by the share of gross output of each BRICIM geo-industry over the total BRICIM gross output. Firstly, we have calculated the share of gross output of each BRICIM geo-industry to the total BRICIM gross output:

\[
\theta_{q_i(t)}^{r-BRICIM} = \frac{q_i^r}{\sum_{r=1}^{BRICIM} q_r^r} \quad (A08)
\]

Secondly, we have weighted each \( \Phi_{i(t_0)}^{r-BRICIM} \) element by its share over the total BRICIM gross output:

\[
\tilde{\Phi}_{q_i(t_0)}^{r-BRICIM} = \Phi_{i(t_0)}^{r-BRICIM} \ast \theta_{q_i(t)}^{r-BRICIM} \quad (A.09)
\]

Lastly, we have aggregated the six \( \tilde{\Phi}_{q_i(t_0)}^{r-BRICIM} \) elements of each industry:

\[
\bar{\phi}_{BRICIM} = \sum_{r=1}^{BRICIM = 6} \tilde{\Phi}_{q_i(t_0)}^{r-BRICIM} \quad (A.10)
\]

Therefore, \( \bar{\phi}_{(t,t_0)}^{RoW} \) is a 56×1 vector of the weighted price index of BRICIM. Adding \( \bar{\phi}_{(t,t_0)}^{RoW} \) to the \( \phi_{(t,t_0)}^{43-SEA} \) vector, we have the price index vector \( \phi_{(t,t_0)} \) for the whole economic system.

The vector of exchange rate for the rest of the world is estimated following a similar procedure to the price index vector. We calculate the share of gross output of each BRICIM economy of the total gross output of the six BRICIM economies:

\[
\theta_{q_i(t)}^{r-BRICIM} = \frac{q_r^r}{\sum_{r=1}^{BRICIM = 6} q_r^r} \quad (A.11)
\]

We use the \( \theta_{q_i(t_0)}^{r-BRICIM} \) elements to weigh the exchange rate of each BRICIM economy \( \varepsilon_{q_i(t)}^{r-BRICIM} \):

\[
\tilde{\varepsilon}_{q_i(t)}^{r-BRICIM} = \varepsilon_{q_i(t)}^{r-BRICIM} \ast \theta_{q_i(t)}^{r-BRICIM} \quad (A.12)
\]

Consequently, \( \tilde{\varepsilon}_{(t)}^{RoW} \) is a 56×1 vector of the weighted exchange rate of BRICIM. Aggregating \( \tilde{\varepsilon}_{(t)}^{RoW} \) to the \( \varepsilon_{(t)}^{43-SEA} \) vector, we have the price index vector \( \varepsilon_{(t)} \) for the whole economic system.
Appendix D: The Braun unequal exchange model

Braun’s global economic system is defined as:

\[
\begin{align*}
(p_1 \bar{a}_{11} + p_2 \bar{a}_{21})(1 + r) + a_{11}w_c &= p_1 \\
(p_1 \bar{a}_{12} + p_2 \bar{a}_{22})(1 + r) + a_{12}w_p &= p_2
\end{align*}
\]

(5.03)

Assuming that \( p_1 = 1 \) and the wage and profit rates as given (\( r = r_0 \) and \( w_c = w_{0c} \)), the system can be redefined as:

\[
\begin{align*}
(\bar{a}_{11} + p_2 \bar{a}_{21})(1 + r_0) + a_{11}w_{0c} &= 1 \\
(\bar{a}_{12} + p_2 \bar{a}_{22})(1 + r_0) + a_{12}w_p &= p_2
\end{align*}
\]

(5.04)

Employing the systems of equation 5.04, both equations can be redefined as:

Equation D.01:

\[
\begin{align*}
(\bar{a}_{11} + p_2 \bar{a}_{21})(1 + r_0) + a_{11}w_{0c} &= 1 \rightarrow \bar{a}_{11}(1 + r_0) + p_2 \bar{a}_{21}(1 + r_0) = 1 - a_{11}w_{0c} \\
p_2 \bar{a}_{21}(1 + r_0) &= 1 - a_{11}w_{0c} - \bar{a}_{11}(1 + r_0) \rightarrow \\
p_2 &= \frac{1 - a_{11}w_{0c} - \bar{a}_{11}(1 + r_0)}{\bar{a}_{21}(1 + r_0)}
\end{align*}
\]

Equation D.02:

\[
\begin{align*}
(\bar{a}_{12} + p_2 \bar{a}_{22})(1 + r_0) + a_{12}w_p &= p_2 \rightarrow a_{12}w_p = p_2 - (p_1 \bar{a}_{12} + p_2 \bar{a}_{22})(1 + r_0) \rightarrow \\
w_p &= \frac{p_2 - (\bar{a}_{12} + p_2 \bar{a}_{22})(1 + r_0)}{a_{12}} = \frac{p_2(1 - \bar{a}_{22}(1 + r_0)) - \bar{a}_{12}(1 + r_0)}{a_{12}}
\end{align*}
\]

The system of equation is rewritten now as:

\[
\begin{align*}
p_2 &= \frac{1 - a_{11}w_{0c} - \bar{a}_{11}(1 + r_0)}{\bar{a}_{21}(1 + r_0)} \\
w_p &= \frac{p_2(1 - \bar{a}_{22}(1 + r_0)) - \bar{a}_{12}(1 + r_0)}{a_{12}}
\end{align*}
\]

(5.05)

Substituting equation D.01 and D.02 in the system of equation 5.05:
Global Value Chains in the European Union: An input-output approach

Appendix D: Braun unequal exchange model

\[ w_p = \frac{1 - a_{11}w_{0c} - \bar{a}_{11}(1 + r_0)}{\bar{a}_{21}(1 + r_0)} \ast \left( 1 - \bar{a}_{22}(1 + r_0) \right) - \frac{\bar{a}_{12}(1 + r_0)}{a_{l2}} \]

\[ w_p = \frac{1 - a_{11}w_{0c} - \bar{a}_{11}(1 + r_0)}{\bar{a}_{21}a_{l2}(1 + r_0)} \ast \left( 1 - \bar{a}_{22}(1 + r_0) \right) - \frac{\bar{a}_{12}(1 + r_0)}{a_{l2}} \]

\[ w_p = \left[ \frac{1 - a_{11}w_{0c} - \bar{a}_{11}(1 + r_0)}{\bar{a}_{21}a_{l2}(1 + r_0)} \ast \left( 1 - \bar{a}_{22}(1 + r_0) \right) \right] - \frac{\bar{a}_{12}(1 + r_0)}{a_{l2}} \]

\[ w_p = \frac{(1 - \bar{a}_{11}(1 + r_0))(1 - \bar{a}_{22}(1 + r_0))}{\bar{a}_{21}a_{l2}(1 + r_0)} - \frac{a_{11}(1 - \bar{a}_{22}(1 + r_0))w_{0c}}{\bar{a}_{21}a_{l2}(1 + r_0)} - \frac{\bar{a}_{12}(1 + r_0)}{a_{l2}} \]

\[ w_p = \frac{(1 - \bar{a}_{11}(1 + r_0))(1 - \bar{a}_{22}(1 + r_0)) - \bar{a}_{21}(1 + r_0)\bar{a}_{12}(1 + r_0)}{\bar{a}_{21}a_{l2}(1 + r_0)} - \frac{a_{11}(1 - \bar{a}_{22}(1 + r_0))w_{0c}}{\bar{a}_{21}a_{l2}(1 + r_0)} \]

We therefore obtain equation 5.06:

\[ w_p = \frac{1 - \bar{a}_{11}(1 + r_0) - \bar{a}_{22}(1 + r_0) + \bar{a}_{11}\bar{a}_{22}(1 + r_0) - \bar{a}_{21}\bar{a}_{12}(1 + r_0)^2}{\bar{a}_{21}a_{l2}(1 + r_0)} - \frac{a_{11}(1 - \bar{a}_{22}(1 + r_0))w_{0c}}{\bar{a}_{21}a_{l2}(1 + r_0)} \]

Dividing both sides by \( \frac{1}{(1+r_0)} \):

\[ w_p = \frac{(1 + r_0)^{-1} - \bar{a}_{11} - \bar{a}_{22} + \bar{a}_{11}\bar{a}_{22}(1 + r_0) - \bar{a}_{21}\bar{a}_{12}(1 + r_0)}{\bar{a}_{21}a_{l2}} - \frac{a_{11}(1 - \bar{a}_{22}(1 + r_0))w_{0c}}{\bar{a}_{21}a_{l2}(1 + r_0)} \]
Global Value Chains in the European Union: An input-output approach

Appendix D: Braun unequal exchange model

\[
wp = \frac{(1 + r_0)^{-1} + (1 + r_0)(\bar{a}_{11}\bar{a}_{22} - \bar{a}_{21}\bar{a}_{12}) - (\bar{a}_{11} - \bar{a}_{22})}{\bar{a}_{21}\bar{a}_{l2}} - \frac{a_{l1}(1 - \bar{a}_{22}(1 + r_0))w_{0c}}{\bar{a}_{21}\bar{a}_{l2}(1 + r_0)}
\]

Finally, the peripheral wage rate can be defined in 5.07:

\[
w_p = \frac{(1 + r_0)^{-1} + (1 + r_0)(\bar{a}_{11}\bar{a}_{22} - \bar{a}_{21}\bar{a}_{12}) - (\bar{a}_{11} - \bar{a}_{22})}{\bar{a}_{21}\bar{a}_{l2}} - \frac{a_{l1}}{\bar{a}_{l2}} \cdot \frac{(1 - \bar{a}_{22}(1 + r_0))}{\bar{a}_{21}(1 + r_0)} \cdot \bar{a}_{l2} \cdot w_{0c}
\]
### Appendix E: Summary statistics and endogeneity experiment

#### Table E.1. Summary statistics of the full sample

<table>
<thead>
<tr>
<th></th>
<th>RXMS</th>
<th>rviulc</th>
<th>rviunw</th>
<th>rviulp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>0.0000045</td>
<td>0.2704000</td>
<td>0.3925000</td>
<td>0.0734300</td>
</tr>
<tr>
<td>1st Qu</td>
<td>0.0027200</td>
<td>0.9313000</td>
<td>0.9643000</td>
<td>0.9348600</td>
</tr>
<tr>
<td>Median</td>
<td>0.0139063</td>
<td>1.0025000</td>
<td>1.0246000</td>
<td>1.0175100</td>
</tr>
<tr>
<td>Mean</td>
<td>0.0406530</td>
<td>1.0734000</td>
<td>1.2028000</td>
<td>1.1245400</td>
</tr>
<tr>
<td>3rd Qu</td>
<td>0.0465995</td>
<td>1.1300000</td>
<td>1.2626000</td>
<td>1.1933500</td>
</tr>
<tr>
<td>Max.</td>
<td>0.4754163</td>
<td>6.8850000</td>
<td>4.6881000</td>
<td>3.9731800</td>
</tr>
</tbody>
</table>

#### Table E.2. Summary statistics of the EU core and periphery sample

<table>
<thead>
<tr>
<th></th>
<th>Core</th>
<th>Periphery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RXMS</td>
<td>rviulc</td>
</tr>
<tr>
<td>Min.</td>
<td>0.0000204</td>
<td>0.3797000</td>
</tr>
<tr>
<td>1st Qu</td>
<td>0.0199718</td>
<td>0.9243000</td>
</tr>
<tr>
<td>Median</td>
<td>0.0444628</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Mean</td>
<td>0.0734207</td>
<td>1.0095000</td>
</tr>
<tr>
<td>3rd Qu</td>
<td>0.0923009</td>
<td>1.0663000</td>
</tr>
<tr>
<td>Max.</td>
<td>0.4754163</td>
<td>6.8850000</td>
</tr>
</tbody>
</table>
Table E.3. Variable rviulc decomposed into rviunw and rviulp: Full sample, core and peripheral sub-samples (Fixed Effects estimation; lagged regressors; log-level variables)

<table>
<thead>
<tr>
<th></th>
<th>All countries</th>
<th>Core</th>
<th>Periphery</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(rviulc)(t-1)</td>
<td>-0.590***</td>
<td>-0.761***</td>
<td>-0.552***</td>
</tr>
<tr>
<td></td>
<td>(0.0584)</td>
<td>(0.0715)</td>
<td>(0.0739)</td>
</tr>
<tr>
<td>ln(rviunw)(t-1)</td>
<td>-0.516***</td>
<td>-0.982***</td>
<td>-0.276*</td>
</tr>
<tr>
<td></td>
<td>(0.136)</td>
<td>(0.176)</td>
<td>(0.157)</td>
</tr>
<tr>
<td>ln(rviulp)(t-1)</td>
<td>0.603***</td>
<td>0.729***</td>
<td>0.601***</td>
</tr>
<tr>
<td></td>
<td>(0.0616)</td>
<td>(0.0685)</td>
<td>(0.0796)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-4.497***</td>
<td>-3.249***</td>
<td>-5.750***</td>
</tr>
<tr>
<td></td>
<td>(0.00520)</td>
<td>(0.00456)</td>
<td>(0.0101)</td>
</tr>
<tr>
<td>Observations</td>
<td>5,040</td>
<td>2,520</td>
<td>2,520</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.977</td>
<td>0.975</td>
<td>0.958</td>
</tr>
<tr>
<td>Country-Sector FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Country-Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sector-Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1