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Institute of Economics
Scuola Superiore Sant'Anna

Piazza Martiri della Libertà, 33 - 56127 Pisa, Italy
ph. +39 050 88.33.43
institute.economics@sssup.it

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Fabio Ascione [a]
Maria Enrica Virgillito [b]

[a] Department of Economics, Paris I Pantheon Sorbonne University, France.
[b] Institute of Economics, Scuola Superiore Sant'Anna, Pisa, Italy.

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Vertical integration and patterns of divergence in European industries: A long-term input–output analysis*

Fabio Ascione†[a] and Maria Enrica Virgillito[b]

[a]Department of Economics, Paris I Pantheon Sorbonne University

[b]Institute of Economics, Scuola Superiore Sant'Anna

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Abstract

Against a theoretical background which recognizes the gains from trade liberalization, this paper asks whether, and if so to what extent, economic integration as directly measured through vertically integrated value-added has increased or reduced convergence among European industries and related countries. To answer this question, we draw upon new input–output tables and sectoral divergence measures for 14 European countries and 19 sectors since 1970. Our novel database provides consistent long-run measures of international input–output linkages and sectoral dispersion in labor productivity and wages. We use these measures to study the timing and mechanisms that govern the relationship between economic integration and sectoral gaps, taking a European perspective and focusing on the role of international production fragmentation via input–output linkages. According to our findings, higher vertical integration has fostered divergence rather than convergence within industries. Lock-in effects in laggard positions coupled with positive feedback loops and increasing returns for leading positions are potential mechanisms to explain why the fruits of rising vertical integration are shared unequally between poor-performing industries and frontier industries.

Keywords: input–output analysis, divergence, economic integration, Europe, trade liberalization

JEL Classification: F6, F14, F15, D63, O47

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†Corresponding Author: Fabio Ascione. Address: 106–112 bd de l'Hôpital, 75642 Paris Cedex 13, France. Email: fabio.ascione@univ-paris1.fr.

1 Introduction

Since WWII the patterns of international trade have seen a rising trend, fostered by international institutions and trade agreements, such as the World Trade Organization, the World Bank, and the Bank for International Settlements. Considering that the root cause of World War II can be traced back, among other political factors, to the economic rivalry between Germany and France, the process of European integration has been considered a potential framework to steer cooperation and alliances between member states. While the aspiration of the initiators of the EU was primarily to achieve political integration with economic integration considered to be a secondary priority, the European project soon turned into the realization of economic integration through a series of legislative acts, firstly pursuing bilateral agreements, which then turned into multilateral agreements (Spolaore, 2013). Such agreements were meant to create favorable conditions for market exchanges, with the intention of enlarging the scope of market opportunities, in line with Balassa's theory of the benefits from economic integration, stemming from *trade*, *terms of trade*, and *factor movements* (Sapir, 2011).

Markets, however, were meant to favor the exchange not only of final products but also of intermediate goods. Indeed, the question of whether economic integration would have favored intra-industry versus inter-industry trade was discussed as early as Balassa (1966), providing evidence against the standard prediction of inter-industry specialization. In fact, economic integration at the European level has coincided with the so-called globalization second unbundling, that is, the rise of intermediate trade among actors, namely firms, operating in the same industry, or even among different industries. Trade of intermediate goods and firms' exchanges of intermediate parts and components have reached such importance as to give rise to the notion of Global Value Chains (GVCs), that is, production chains operating at the global level maintained by firms to make the production process more efficient. Similarly to the standard theory of international trade, GVCs are considered to be able to enlarge the opportunity of cost minimization, given the possibility of firms to specialize not in product production but rather in task production (R. E. Baldwin, 2006). The phenomenon of GVCs progressively taking up space previously occupied by firms, observed already by Pasinetti (1973), became quite widespread.

What has been defined as off-shoring, vertical specialization, or disintermediation, has mostly been considered to be a channel for the economic growth of countries, because

of static (price) as well as dynamic (quantity) effects, particularly concerning developing countries (Selwyn and Leyden, 2022). The process of European integration has served almost as a textbook case to study the benefits accruing due to regional economic integration (R. E. Baldwin and Venables, 1995). Empirical analyses so far have brought ambiguous results, with the majority of contributions developed in the 1990–2010 period, adopting new-trade-theory and endogenous growth models. In many instances, the actual variable of economic integration has not been measured, but rather identified with a dummy variable, treating the country's belonging to the EU as a proxy for economic integration (Spolaore, 2013). More recently, there has been greater interest in the construction of direct measures of economic integration, particularly with the use of Input–Output tables and GVC indicators as Trade-in-Value-Added. However, the GVC research streams are progressively more focused on international flows of trade, and the increasing role of China (Los et al., 2015; Timmer et al., 2014), giving less attention to regional integration. The post-pandemic phase has raised new concerns and interests regarding the future of GVCs (R. Baldwin and Freeman, 2022), rediscovering regional integration under the notion of Regional Value Chains or 'nearshoring' (Panwar et al., 2022).

From a theoretical perspective, the question of whether, and if so to what extent, GVCs and international trade spur mutual benefits among participating countries and sectors, or rather curb convergence, remains inconclusive. The neoclassical approach, starting with the standard theory of international trade, including that of GVCs, has always predicted convergence, both in performance and in factor prices, among countries involved in international exchanges. Indeed, price equalization remains the ultimate effect of any theory of comparative advantage, the latter being related to final or to intermediate goods exchange, or even tasks exchange. Another theoretical view, which takes account of the absolute advantages promoted by more complex production stages, as well as the presence of core–periphery structures due to self-reinforcement, lock-in, and specialization in low-value-added production activities (Kaldor, 1970, 1980; Krugman, 1991; Myrdal, 1957), considers the opening-up of market opportunities also as a source of divergences and amplifications of asymmetries (Amsden, 1991; Cimoli et al., 1990; Meier and Stiglitz, 2001), and thus predicts that production exchanges will lead to uneven development (Cresti and Virgillito, 2023; Dutt, 1989).

In this paper, against the theoretical and empirical background discussed so far, we ask whether, and if so to what extent, economic integration, hereby directly measured through

vertically integrated value-added, has increased or reduced convergence among European industries and related countries. To answer this question we draw upon new input–output tables and sectoral divergence measures for 14 European countries and 19 sectors since 1970. Our novel database provides consistent long-run measures of international input–output linkages and sectoral dispersion in labor productivity and wages. We use these measures to study the timing and the mechanisms that govern the relationship between economic integration and sectoral gaps, taking a European perspective and focusing on the role of international production fragmentation via input–output linkages.

First, we document that economic integration has passed through three eras since 1970, with rising integration until the mid 80s, relative stability until the late 1990s, and a remarkable increase since 2000. Second, the evolution of sectoral asymmetries in Europe has followed a U-shaped pattern, decreasing in the late 1970s until the late 1990s, and increasing since then. Although this general trend has evolved similarly in manufacturing and services, the period of divergence is more pronounced in manufacturing and to a lesser extent in services. Our results are robust to alternative measures of divergence. Third, using fixed-effects dynamic panel estimations, we assess the association between vertical integration and the sectoral divergence across sector-country, over time. We find that foreign indirect vertical integration, namely value-added captured abroad and outside the own sector, appears to be the main driver of the evolution of disparities among European industries, after controlling for a series of other covariates. The diverging effects deriving from vertical integration are at work in the first (1970–1984) and last (2000–2014) periods. On the contrary, vertical integration has a null or negative effect on divergence during the period of relative stability of vertical integration (1985–99). We test a series of different specifications, and our results are consistent and robust. Fourth, when distinguishing between manufacturing and services, we find that the overall increase in divergence in response to integration is entirely explained by international linkages in manufacturing. Relatively stronger-performing sectors benefit the most from vertical integration, while laggard sectors fall behind, implying a mechanism of polarization in response to vertical integration. Geographically, northern European countries benefited from integration, and southern ones fell behind, suggesting a fragmentation in productive capabilities along a "core–periphery" duality in Europe (Cresti et al., 2023).

The paper is structured as follows: in Section 2 we discuss the related literature, while

in Section 3 we present the data and methodology. Section 4 presents the evolution of vertical integration and patterns of divergence across industry-country. Our econometric specification is performed in Section 5, and our conclusions are laid out in Section 6.

2 Related literature

In this paper we investigate the nexus between economic integration, convergence, and divergence since 1970 from the perspective of European industries over time. The direction of these links depends considerably on whether there are mutual benefits from integration or whether some sectors are threatened due to lock-in effects and greater dependency. The discussion is preceded by a review of the literature concerning various perspectives on the relationship, namely theories and empirical evidence on convergence and divergence, respectively.

2.1 Globalization and convergence in the long run

The first strand of literature relates to economic globalization and convergence in productivity and income. The main reasons for expecting convergence in a more integrated global economy rest on two basic theoretical arguments. On the one hand, economic integration fosters market exchanges and removes barriers and limitations, such as access to capital and financial constraints in lagging countries. This proposition dates back to the ideas of Adam Smith (1776), who argued that lagging countries benefit more from the cheapening of imported consumption and capital goods while leading countries tend to benefit less due to marginal returns. However, from both a theoretical and an empirical perspective, the link between trade liberalization—in our setting: economic integration—and productivity growth is anything but unidirectional (Ocampo and Taylor, 1998). The second argument is based on heightened domestic competition due to international market integration, implying that market shares equalize across sectors and countries with positive effects on convergence (Sachs et al., 1995). In addition, winning firms, inside sectors, should become more similar, moving toward the frontier of technological upgrading, while low-performing firms should exit from the market due to the positive cleansing effects of international competition (Melitz and Trefler, 2012).

These arguments have led to a plethora of empirical studies examining whether countries

are converging or not. The bulk of this work examines convergence at the global level, sometimes finding compelling evidence of cross-country convergence in income and productivity (Barro, 2015; Johnson and Papageorgiou, 2020; Madsen and Timol, 2011; Patel et al., 2021; Rodrik, 2012; Williamson, 1996). Targetti and Foti (1997) find evidence for both hypotheses depending on the institutions in place. Studies looking at European integration often show contradictory results depending on the period. Milanovic (2006) shows that the deglobalization of the interwar period was characterized by increasing convergence, suggesting a weak relationship between economic integration and gaps between nations. Other works conclude that European countries converged during the major trade liberalizations of the postwar period, whether in the mid 1970s (Galli, 1997) or later (Ben-David, 1993; Kutan and Yigit, 2007), while more recent contributions find divergence, especially after the Great Recession (Bontadini et al., 2022; Cresti et al., 2023; Gräbner et al., 2019, 2020).

These mixed results illustrate that such findings are sensitive to the time horizon and the measure of economic integration. On the one hand, scholars infer convergence from one-off historical events such as EU integration and tariff liberalizations (Ben-David, 1993; Gräbner et al., 2019; Slaughter, 2001). The empirical challenge of this approach is the selection of trade events, whose ex-ante criteria are often somewhat ambiguous, leaving some room for discretion. On the other hand, the literature so far tends to focus on indicators of trade openness, neglecting alternative types of economic integration, notably the vertical integration of industries and countries into the world economy via participation in global value chains. As a result, it is unclear how these developments have affected the distribution of income and productivity among European industries over time.

We complement the literature by using long-run data that span 45 years and capture the main trends in integration since the 1970s. Using a series of structural break tests, we endogenously identify long-lasting shifts in the integration process that allow us to draw conclusions about the nexus between economic integration and convergence from historical periods. Additionally, we highlight the importance of sectoral interdependencies via input–output linkages in the divergence dynamics of European industries, extending prior work that focused on trade.

2.2 Input–output linkages, "lock-in," and patterns of divergence

Accordingly, the second debate relevant to this paper focuses on the macroeconomic effects of international production fragmentation. In the Global Value Chain tradition, participation in global production can be growth-enhancing due to cost reductions and higher efficiency. While this strand agrees on the relevance of production fragmentation for economic gains, there is disagreement about the overall benefits of the effect. On the one hand, scholars argue that GVCs are likely to benefit all participating countries and industries involved, albeit to varying degrees depending on the industry's position in the value chain (Grossman and Rossi-Hansberg, 2008; Guerrieri and Caffarelli, 2012; Pahl and Timmer, 2019a; World-Bank, 2019). On the other hand, following scholars in economic sociology, economic geography, and organizational studies, mostly drawing upon dependency theory, stronger inter-industry linkages may lead to specialization, "lock-in," and "mutual dependence" in low value-added activities (Gereffi et al., 2005; Milberg and Winkler, 2010; Simonazzi et al., 2013; Sydow et al., 2009). As a result, firms are struggling to improve their relative performance, falling behind their peers. Sectors and countries end up in asymmetric positions due to power asymmetries in production chains, whereby value-added flows asymmetrically, with poorer countries stacked into periphery traps.

While theories on buyer–seller relationships are mostly based on firm-level studies (Farrell and Klemperer, 2007; Klemperer, 1987; Lonsdale, 2001; Svensson, 2004), yet another set of studies traces structural asymmetries in the international division of labor, production interdependencies, and divergence at the industry-country level, dating back to the pioneering work of Young (1928) and Kaldor (1970, 1980). A strong implication of this literature is that these relations are affected by initial conditions and productive compositions in production chains, with net transfers from poorer to richer regions. Following Myrdal (1957), lead countries tend to benefit from integration, while underdeveloped ones are in danger and are priced out by cheap imports, exacerbating international inequalities. Both trends are self-amplifying according to positive and negative feedback loops (Arthur, 1994; Kaldor, 1970; Krugman, 1987, 1991). On the one hand, positive feedback loops and mechanisms of cumulative causation fuel leaders; while, on the other hand, negative loops trap followers into weak positions. Due to path-dependency and stronger persistence between followers and leaders, the evolutionary structuralist tradition (Cimoli and Porcile, 2013; Cimoli et al., 2009; Dosi et al., 1994; Pavlínek, 2017; Weber et al., 2022) predicts divergence from

economic integration, unless non-market-based institutions, beyond relative prices, such as industrial policies, overturn market outcomes.

Our study explores this direction. We analyze the impact of input–output linkages on divergence, granted initial industry and country heterogeneity in influencing this relationship. We thereby seek to capture the unequal opportunities to exploit foreign inputs that may explain structural polarization mechanisms in reaction to European and global integration.

Several empirical studies have stressed the importance of distinguishing the macro sector and the geographic composition of input–output linkages. A common finding in this literature is that the forces of an open economy emanate primarily from manufacturing, as this is also the sector that is more exposed to international competition, knowledge spillovers, and specialization (Bernard and Jones, 1996; Duarte and Restuccia, 2010; Rodrik, 2012). In addition, changes in the geographic composition of imports could affect price dynamics and product quality, and thus sectoral inequalities. For instance, the effects of European integration might differ from the effects of integration outside Europe, both in terms of timing and magnitude. A case in point is the recent literature on the so-called China shock, in which rising imports from China have negative and long-lasting effects on unemployment across entire industries in the United States (Autor et al., 2013). These effects largely stem from China's integration into international value chains during the last decade. To take into account both changes in the relevance of manufacturing vs. services, and the area of geographical origins of vertical integration, we will consider both aggregates separately and distinguish vertical integration originating in Europe and outside of it.

3 Data and methodology

In this section we describe the data and methodology used to construct our dataset for European industries from 1970–2014, which we will then use to study the relationship between economic integration and sectoral convergence and divergence in Europe. The Appendix provides further methodological details about the specific data sources and computations regarding all variables used in the empirical analysis.

3.1 Data sources and construction

We construct an unbalanced sectoral panel for 19 sectors in 14 European countries over the period 1970 to 2014. The dataset comprises information from the World Input–Output Database (WIOD), Socio-Economic Accounts, EU-KLEMS, and Penn World Tables (9.1). The restriction of the observation period is due to the lack of gap variables before 1970 and missing input–output data since 2014. This section focuses on the data for the main variables, while we provide technicalities of the data construction and a detailed description of all variables, as well as summary statistics, in the Appendix A.

To construct measures of vertical integration, we rely on all available releases (2013, 2016, and March 2022) from the World Input–Output Database (WIOD), which we aggregate to obtain consistent measurements and units of analysis for the whole period. The main challenge is to reclassify the older releases (2013 and 2016) that have a more fine-grained industry classification to the same level as the recently released Long-Run World Input–Output Database (LR-WIOD) covering the period 1965–2000. This task is not easy, because the WIOD 2016 release differs in the way national accounts are measured (i.e., method, statistical units) since it is rooted in the 2008 System of National Accounts (SNA), while the former releases use the 1993 SNA concepts, precluding comparisons at disaggregate levels. However, we make them comparable in two dimensions. First, we aggregate the 56 sectors and 43 countries of the WIOD 2016 release to the same sectoral level as the LR-WIOD 2022 release. Second, we allocate countries that appear in the WIOD 2016 release but not in the LR-WIOD 2022 release to the "Rest of the World" category. We proceed with the WIOD 2013 release accordingly and aggregate the 35 sectors and 40 countries to the same aggregation level as the WIOD 2022 release. We carefully check that in industries and years, when the three vintages overlap (typically in 2001 and 2012 when IO tables transitioned into new frameworks), the series matches well. The aggregated input–output tables consist of 23 sectors and 25 countries (of which one is the "Rest of the World" category) and span 45 years.

The second step in our data construction is to link the input–output tables with sectoral data on value-added, employee compensation, and the number of employees, by country and industry. These data come from the EU KLEMS database (2011 release) and Socio-Economic Accounts (2014 and 2016 releases). The matching of the IO data and sectoral information was conducted via the two-digit industry affiliation linkage from 1970 to 2014.

While employee compensation includes gross wages and salaries payable in cash or kind and the value of contributions to pensions payable by employers, self-employed workers earn mixed incomes comprising partly labor compensation and partly profits. The dataset follows conventional approaches to assign part of the mixed-income earned by self-employed workers to the labor share and the residual to profits. The employee compensation of self-employed workers is thus estimated by assuming similar wages as employees. Sectoral employee compensation and value-added are adjusted for domestic inflation at the base year 2000 using sectoral price deflators in these databases and converted into international US dollars using market exchange rates from the Penn World Tables (9.1).

3.2 Conceptual framework and methodology

3.2.1 Vertical integration

The measurement and concept of "vertical integration" refer to the relevance of cross-industry production links activated by demand inputs along the value chain. Here, we use the input–output tables to measure the strength of these linkages by decomposing the value-added of a sector by all stages of production according to the industry and location where the value-added originated. Given the long time span we adopt, we next identify structural breaks in the time series of this measure following the techniques developed by Bai and Perron (2003).

We build on the work by Pasinetti (1973, 1980) and compute the amount of value-added needed to produce a certain amount of final output from the Leontief (1936) framework. In matrix notation, we start by calculating the matrix of technical coefficients (with sector-country subscripts omitted):

$$\mathbf{A} = Z\hat{x}^{-1} \tag{1}$$

where $\hat{x}^{-1}$ represents the inverse of the diagonalized gross output vector. The gross output of each industry is given by the sum of intermediate and final demand that can be consumed, invested, or exported:

$$\underbrace{x}_{\text{gross output}} = \underbrace{\mathbf{A}x}_{\text{intermediate demand}} + \underbrace{d}_{\text{final demand}} \tag{2}$$

Solving by x where I is the identity matrix gives the Leontief inverse:

$$x = \underbrace{(\mathbf{I\text{-}A})^{-1}}_{\text{Leontief inverse } (\mathbf{L})} \quad d \tag{3}$$

Each element $l_{i,j}$ of L records the direct and indirect amount of a specific input produced in sector i required to satisfy an additional unit of demand for a specific output produced in sector j. Since intermediates need to be produced themselves, again involving production factors and intermediates, L accounts for the infinite sequence of inputs into all the inputs. We then construct the matrix of contributions in terms of value-added by weighting L with the amount of value-added in the gross output:

$$\mathbf{VI} = \hat{va}\hat{x}^{-1}\mathbf{L}\hat{d} \tag{4}$$

where $\hat{va}$ is the diagonalized value-added vector, $\hat{x}^{-1}$ again represents the inverse of the diagonalized gross output vector, and $\hat{d}$ is the diagonalized demand vector. Equation 5 depicts a schematic outline for the structure of the value-added computations:

$$\underbrace{\begin{bmatrix} vi_{11} & vi_{12} & \cdots & vi_{1n} \\ vi_{21} & vi_{22} & \cdots & vi_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ vi_{m1} & vi_{m2} & \cdots & vi_{mn} \end{bmatrix}}_{\mathbf{VI} = \text{Vertical Integration}} = \underbrace{\begin{bmatrix} \frac{va_{11}}{x_{11}} & 0 & \cdots & 0 \\ 0 & \frac{va_{22}}{x_{22}} & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & \frac{va_{mn}}{x_{mn}} \end{bmatrix}}_{\text{Value-added coefficients}} * \underbrace{\begin{bmatrix} l_{11} & l_{12} & \cdots & l_{1n} \\ l_{21} & l_{22} & \cdots & l_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ l_{m1} & l_{m2} & \cdots & l_{mn} \end{bmatrix}}_{\text{Leontief coefficients}} * \underbrace{\begin{bmatrix} d_{11} & 0 & \cdots & 0 \\ 0 & d_{22} & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & d_{mn} \end{bmatrix}}_{\text{Final demand}} \tag{5}$$

VI is a square 575 × 575 matrix (23 sectors and 25 countries). Each entry vi_{nm} records the purchases by sector n of sector m products. As standard, the columns show the value-added needed from each sector to produce a unit of the final output of the corresponding sector, while the rows depict how each sector's output is allocated to others. We focus on the column vectors as we are mainly interested in the outsourcing and composition of "production sources" of individual industries. As compared to the Leontief coefficients, we focus on value-added terms rather than the inputs themselves. With this method, we consider the international structure of interdependencies but also the relative importance of their economic dimension captured by an industry's backward linkages.

The value-added contributions within the columns can be broken down into value-added

originating from the same industry (that we define as "direct") and value-added originating from other industries (that we define as "indirect"), as well as value-added originating from the same country in which the industry is located (defined as "domestic") or from abroad (defined as "foreign") (Cresti and Virgillito, 2022). We limit our attention to indirect foreign value-added scaled by the total value-added of the domestic economy. The choice is motivated by the fact that we are interested in understanding patterns of integration among different industries and services deriving from foreign inputs, and in synthesis, accounting for the gradual penetration of services into manufacturing processes. However, our methodology is quite flexible, and can account for the direct component as well. Our total vertical measure of integration from foreign indirect value-added of each industry reads as:

$$VI_{jc} = \frac{\sum_{i=1}^{n} vi_{ijc}^{\leftarrow foreign}}{va_{jc}} \tag{6}$$

where VI_{jc} represents the column sum of the foreign indirect vertically integrated value-added multipliers normalized by total value-added in purchasing industry j and destination country c. This measure will capture how much of industries' value-added is produced in the context of foreign indirect GVC participation (backward linkages) compared to the total value-added generated in that industry. It generally lies between zero and one, although it can theoretically exceed one because the nominator includes multiplier effects in response to increasing demand, while the denominator does not account for multiplier effects. We follow this path to net out the size of an industry by dividing the measures by industries' total value-added, while keeping the information on inter-industry linkages, in line with the logic of IO modeling to capture the interdependencies between sectors.

We decompose VI_{jc} threefold according to the region of origin: as one unique region aggregating all foreign countries, as integration within Europe, and as integration outside Europe. The first measure aims to capture the overall share of foreign integration of each industry from all trading partners and does not reveal the geographical origin of integration. We subset according to geography by setting the numerator as the integrated value-added multiplier, alternating between both sets of regions (Europe and outside Europe) while keeping the denominator at the total value-added. Given our input–output tables, Europe comprises 14 countries of our sample, while outside Europe includes those new member states that have recently joined the European Union plus a Rest of the World region. We calculate these measures for all 14 European countries and focus our analysis on manufacturing and

services sectors, removing agriculture, construction, mining, and energy sectors from our sample. Of course, these activities are still explicitly accounted for as inputs in manufacturing and services sectors, in line with the modeling of input–output linkages across industries. An overview of our IO tables and a list of all sectors, including the abbreviations of sector names we use in the figures, can be found in Appendix B.3.

Structural breaks and selection of episodes. After having computed industry-level vertical linkages, we are interested in the long-run evolution and eventual structural breaks in vertical integration. Considering the non-homogenous process in economic integration over time, we expect to find distinct episodes, or phases, of vertical integration that might have a distinct effect on European industries. Hence, while we take a long-term perspective, starting from the 1970s, searching for structural breaks in vertical integration is part of our empirical methodology. We then validated the identified phases by means of a historical appraisal of the processes at stake.

To identify potential episodes in our measure of vertical integration, we use structural break tests in the spirit of Bai and Perron (2003). The general idea behind structural break tests is to identify breaks in which coefficients change from one stable relationship to another, occurring at random dates, by running a local OLS regression in the neighbourhood of each time step. We intend to identify possible structural changes in vertical integration by running the following test for individual industries, one at a time:

$$vi_{t(i)} = c_i + \epsilon_{t(i)} \tag{7}$$

where vi_t is an industry-country-specific vertical integration measure in regime (i), c_i is the intercept, and ϵ_t is a random error term. The intercept c_i controls the mean of vi_t. Our goal is thus to identify long-lasting shifts in the mean of the level of vertical integration. When testing for the existence, number, and timing, the methodology carries out an F-test to examine whether or not a statistically significant break occurred. If it did, the sample splits in two (based on the estimated break date), and the procedure continues determining the exact number of breaks and their location within the new periods i using recursive selection methods. The test is "sequential" to determine the breaks, meaning that it adds one break each time the test is significant.

A natural problem with this approach is that it can detect breaks in years relatively close to each other, making it difficult to find common developments in all European industries.

There is no consensus in the literature about the optimal trimming value, which is the share of the series corresponding to the shortest time a break needs to last to qualify as "structural" (Garratt and Vahey, 2006; Hansen, 2001; Pahl and Timmer, 2019b; Roine and Waldenström, 2011). In this paper, we use a rule of thumb saying that breaks should last at least 30% of the sample period, which will be at least 13 years, for all industries. This way we capture long-term developments and mitigate the impact of business cycle fluctuations in identifying the regime length i. Appendix Table B.4 shows the results from the structural break tests. In total, the test identifies 378 breaks across all countries and industries. We find strong evidence of a structural change sometime between 1999 and 2001, with 165 breaks, representing 62% of the sample, and weaker evidence of a structural change between 1982 and 1987, with 89 breaks (35% of the sample). Overall, these results provide strong statistical evidence in favor of long-lasting shifts in vertical integration in Europe around 1985 and 2000, which correspond to the average around these years where the test identifies the most breaks. Hence, we split our 45-year sample period at the estimated break dates: 1970–1984, 1985–1999, and 2000–2014. Identifying such three distinct episodes of vertical integration helps in accounting for structural shifts occurring inside the process of economic integration.

3.2.2 Measures of within-sector divergence

To provide an empirical analysis of convergence versus divergence patterns among European industries, we construct two gaps measures, one in labor productivity and another one in wage per employee. Labor productivity is measured as the industry's value-added per worker, and wage per employee as employee compensation over the number of employees in that same industry. We look at two gap measures in order to have an accounting of both productive performance and input remuneration. Gaps in these indicators are measured as the absolute deviation of each industry's value around the industry's sample means. Formally, sector i's productivity and wage gap is given by:

$$Productivity\ gap_{ict} = \left| \ln \left(\frac{value\ added}{employees}_{ict} \right) - \overline{\ln \left(\frac{value\ added}{employees}_{itEU} \right)} \right| \tag{8}$$

$$Wage\ gap_{ict} = \left| \ln \left(\frac{wage}{employees}_{ict} \right) - \overline{\ln \left(\frac{wage}{employees}_{itEU} \right)} \right| \tag{9}$$

where subscripts c and t correspond to country and time. We calculate these distance

indicators within each industry and country and use them to indicate whether productivity and wage levels were tending to converge or diverge around the average. While simple to implement, this measure has two main advantages over conventional inequality measures like the Gini coefficient or the standard deviation. First, it provides a measure for each sector-country without the need to group the data across countries, leading to the loss of variation in the sample, therefore accounting for within-sector variation. In addition, it is relatively robust to outliers, a problem often encountered when using standard deviation where extreme values receive a strong weight through the squaring of the differences (Pham-Gia and Hung, 2001). Using absolute values allows us to value both positive and negative values in the same way, providing a distance measure of the extent to which our observation points are spread around the sample average. As a robustness check, we also use absolute distances around the median, deviations from the weighted mean, and percentile ratios as alternative indicators of dispersion. The main levels and trends remain robust to all these exercises.

After constructing the measure of foreign indirect vertical integration and sectoral inequalities, we end up with a panel dataset composed of 19 sectors, 14 countries, over 45 years. The final choice of the 14 countries, although entering into different phases within the economic union, is motivated by giving an account of patterns of heterogeneity of a growing block of countries presenting dissimilarities among them, but still operating under a market economy. Therefore we exclude from the analysis the Visegrad block.

An alternative between-sector inequality measure would also provide valuable information on the patterns of heterogeneity unfolding among the countries of interest. In that case, however, the measure would have been, first, less distinct from the variable of vertical integration among heterogeneous industries, our independent variable, as we shall see; and, second, between-sector inequalities are more appropriate to capture and address the process of within-country structural change, rather than convergence in productive performance along each given industry.

4 Evolution of vertical integration and sectoral inequalities in Europe since 1970

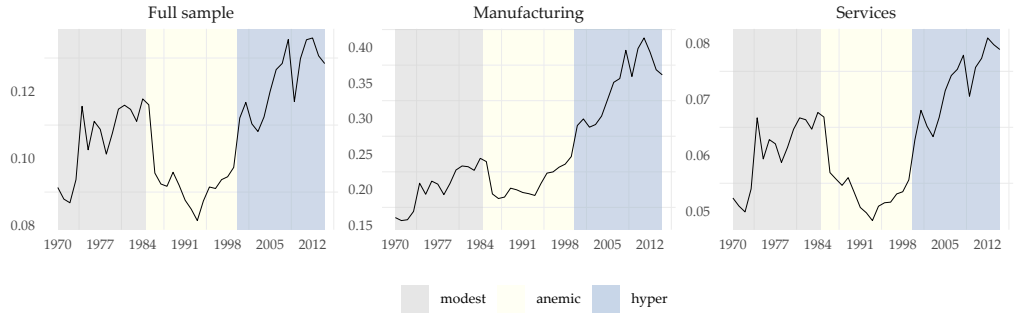
We now start documenting the long-term trends in vertical integration and within-industry gaps in labor productivity and wages from 1970–2014. While it would be unreasonable to claim that 45 years of data are nearly enough to draw out the main facts about long-run economic evolutions, we believe these data can meaningfully and appropriately reflect modern trends in European industries. The past half-century has witnessed unprecedented economic integration shaping the prevailing landscape of production and division of labor. From this perspective, we aim to exhibit some key empirical trends that have emerged over the past half-century.

4.1 Vertical integration

Figure 1 displays the evolution of the value-added-weighted average of foreign indirect vertical integration for the entire sample and broken by macro sectors over 1970–2014, with the three different episodes indicated by the shaded area. The average vertical integration increases until the mid 1980s, then declines gradually until the early 1990s, and remains relatively stable until the late 1990s. After 2000 the average shows a remarkable increase in integration. Although the evolution is similar in manufacturing and services, vertical integration has increased much faster in manufacturing and is also an order of magnitude more pronounced than in services. Remember, however, that vertical integration here is measured as indirect inputs deriving from other industries, therefore, the distinct levels of integration between the two macro-aggregates here also reflect the servitization of manufacturing industries. In addition, in this section we will look at the patterns of total integration, independently from geographical origin (within or outside Europe).

In sum, although a structural break test is a virtuously inductive way of examining data that does not exploit theoretical insights except those involved in variable selection, the results are broadly consistent with visual inspection and qualitative interpretation of historical events. The estimated breaks in vertical integration split the series into three samples with different economic environments: a period of modest increase from 1970 to 1984; a period of "anemic" globalization (1985–1999); and a period covering the most recent decade of hyper-globalization (2000-2014). Below, we detail the three episodes.

Figure 1: Evolution of indirect foreign vertical integration by broad sector



The graph shows the evolution of vertical integration weighted by sectoral value-added for 14 European economies, for the sample average, and by broad sector (manufacturing and services activities) from 1970 to 2014. The three periods identified by shading reflect those identified by the structural break tests carried out in the earlier section.

Modest integration

The first era covers the period 1970–1984 and is characterized by modestly increasing economic integration, despite economic disruptions and high inflation. On the one hand, it marks the emergence of international production networks in Europe with massive transformations in technologies, notably the intensified use of computers and microprocessors resulting in lower costs of offshoring (R. Feenstra, 1998). The oil crisis in 1973 partly intensified the existing tendencies towards the international relocation of production, as was often the case in times of recession and price pressure (Sturgeon and Memedovic, 2010). In the same year, Denmark, Ireland, and the United Kingdom joined the European Community, followed by Greece in 1981, raising the number of member countries to ten. In parallel, the Union experienced shifts in economic policy from state intervention and Keynesian demand management to neoliberal and market-oriented policies. The enlargement of the Union and the new policy setting promoted international competition and reinforced the pursuit of further integration (Buch-Hansen and Wigger, 2010). Overall, this context helps explain why integration underwent cyclical swings and rose modestly during this otherwise rather crisis- and high-inflation-ridden period.

Anaemic integration

The second period, between 1985 and 1999, is characterized by the relative stability of vertical integration, with a slightly declining trend in the first half and an increasing trend in the second half of the period. One possible explanation for this non-uniform trend is the dismal growth in the wake of neoliberal competition policies and the accompanying

specialization in lower-value-added activities in the catching-up process of less industrialized countries in the first half of the period (Cohen and Centeno, 2006). Lains (2003) documents the case of the Portuguese economy and how its accession to the European community during the 1980s caused relative productivity declines due to specializations in less dynamic industries with negative consequences for terms of trade and economic growth. However, in the second half of the 1990s, integration progressed with German reunification and the reconciliation between East and West (Bergeijk, 2015). Nevertheless, due to the destructive mix of neoliberal policies, low growth, and political isolation, this was for long stretches a period of "anemic" globalization. While, qualitatively, the resulting anaemic integration path tends to follow services rather than manufacturing, in terms of quantitative relevance the bulk of integration occurs mainly in manufacturing.

Hyper integration

The third phase begins at the turn of the twenty-first century and extends until 2014, the last year for which we have data. Vertical integration is increasing throughout that period by about ten percentage points. This increase, which broadly coincides with the era of "hyper globalization" often elaborated in the literature (Bachas et al., 2022; Rodrik, 2019), is very steep. One might focus on the European causes of this development, underscored by the broad consensus among European policymakers to promote economic integration, the introduction of the single currency, and the enlargement of the Union to include Eastern European countries, entailing the erosion of their trade barriers, the dismantling of central planning, and their integration into the production models of the European core (Piketty, 2018; Simonazzi et al., 2013); or, on the other hand, the rise in vertical integration can also be seen as due to international developments like China's WTO accession in 2001 and its integration into value chains in Europe. The descriptive evidence is consistent with both main trends—European and international—and confirms the widely documented notion that inter-industry linkages have intensified over the past decades. Notably, the measure well identifies the 2008 crisis.

The evolution of vertical integration for all industries in our sample is provided in Appendix B.1. The anaemic period is mostly driven by the drop in integration of Food and Minerals. These two industries are highly exposed to covariation with price commodities, being naturally more similar to natural resources. Indeed, the drop phase since 1980 is

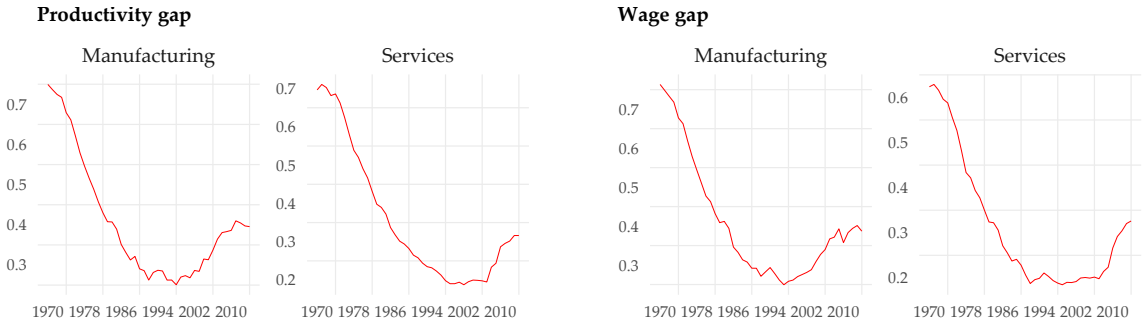
the anti-climax, or the burst, of the commodity super-cycle starting in the seventies (Erten and Ocampo, 2013). The remaining industries tend to show an overall increasing trend in vertical economic integration, with steeper trends in the first and second periods.

4.2 Sectoral divergence

We now turn to analyse the second pattern of interest, namely within-sector divergence/convergence. Figure 2 plots the time series for average distance in labor productivity and wages in the period 1970–2014. According to the constructed measure, in case of convergence toward the industry average, the gap should decrease, and the opposite in case of divergence. Inspection of the figure suggests that disparities were sizeable during the 1970s, representing up to 70% of the average. This gap decreased strongly during the late 70s until the mid 90s, indicating a process of convergence during this period. Since then, the gap has increased again, pointing towards an ongoing fragmentation between countries within industries during the past decade. This "U" turn and implied cessation of the convergence during the mid 1990s sits well with the evidence regarding the peak period of globalization experienced by many European industries since the late 1990s—also consistent with rising vertical linkages documented in Figure 1.

Notably, the gap increases more strongly in productivity than in wages, but the overall trend of rising divergence during the peak period of globalization is consistent in both variables. In addition, while manufacturing in both series turns around 2000, the turning point for services is after the 2008 crisis. The difference in timing is indeed supportive of the choice to look at the two aggregates independently.

Figure 2: Sectoral gaps by macro sectors: simple average



The figure depicts the evolution of average sectoral gaps relative to the sample average in productivity (left panel) and wages (right panel) over the period 1970–2014.

The measure is silent about the type of convergence, whether versus low or higher average values. In addition, the average dispersion might mask substantial heterogeneity across industries. Appendix figures B.2 and B.3 show the distribution of labor productivity and wages for all sectors by period. With some notable exceptions, we observe a rightward movement, implying a general increase in economic development for all countries. This rightward shift was accompanied by the thickening in the middle of the distribution between 1985–1999, and a flattening of the tails in 2000–2014, implying increasing dispersion during that period. This change from asymmetric to almost symmetrical distributions between the first two eras and back again to a skewed distribution in the period of hyper-globalization seems to be more pronounced among industries more exposed to vertical integration, like textiles, leather, and footwear or electrical and optical equipment, and to a lesser extent in services sectors; however, changes in these indicators are by nature subtle. The evolution of the gaps for all individual industries in our sample is provided in Appendix Figure B.4.

While our focus throughout this paper is on the distance to the mean, we check the robustness of the indicator by constructing measures of divergence based on the distance to the median, the distance to the weighted mean, and percentile ratios. On the one hand, the sample median is less sensitive to heavy tails than the sample average, which could lead to substantial changes in the indicator in the presence of outliers. On the other hand, using absolute deviations from the weighted sample mean, where the weights are sectoral employment, can be used to assess whether our indicator changes when accounting for the size of each industry in the computation of the gap. The appendix Figure B.5 illustrates the average time series of these alternative measures. Sectoral disparities relative to the sample median and deviations from the weighted mean are similar to dispersions around the average, both in terms of levels and trends across broad economic sectors. The percentile ratios suggest that rising dispersion since the late 1990s is largely due to a rise in the 90–10 gap, while the 50–10 gap and the 90–50 gap exhibit a smaller rise in divergence. This indicates a stronger increase in divergence between the leading and poor-performing industries. We conclude that sectoral divergence trajectories in Europe based on distance about the mean are solid and robust to several alternative inequality measures.

5 Understanding the sources of divergence: the role of vertical integration

We now investigate the link between foreign indirect vertical integration and the dynamics of productivity and wage divergence in Europe via an econometric setting. Our starting point is to carry out panel estimations to identify responses in the gap variables to increasing input–output linkages. Next, we explore potential heterogeneities to understand the mechanisms underpinning the connection. We estimate the following equation:

$$gap_{j,c,t} = \alpha_0 + \beta_1 gap_{j,c,t-1} + \beta_2 vi_{j,c,t-1} + X'_{c,t}\tau + \mu_{jc} + \theta_t + \epsilon_{j,c,t} \tag{3}$$

where $gap_{j,c,t}$ corresponds to productivity and wage gaps in the two-digit industry j, country c, and year t, and $vi_{j,c,t-1}$ represents foreign indirect vertical integration, one period lagged. $X'_{c,t}$ is a time-varying vector of control variables including (log) gross domestic product per capita and (log) population both as linear and squared terms to capture potential non-linearities in the effects of economic development and country size. μ_{jc} and θ_t are sector-country and time fixed effects. The former allows controlling for unobservable industry-country heterogeneities that do not vary over time, while the latter account for aggregate shocks and trends that are common to all industries. Finally, $\epsilon_{j,c,t}$ are robust standard errors that are clustered at the two-digit sector level.

Because our specification includes sector-country fixed effects, the coefficient of interest, β_2, captures the effect within a given sector-country of being exposed to vertical integration over time. A positive coefficient suggests that the indirect vertical integration of a sector pushes the latter to move away from the average, leading to divergence, and a negative coefficient implies instead convergence brought about by vertical integration. As said, however, this identification strategy may not provide satisfactory results due to structural breaks in vertical integration. To recall, while vertical integration featured a modest rise in the first period, followed by relative stability in the second and a marked increase in the last, there might be counteracting tendencies affecting sectoral gaps depending on the strength of integration. These heterogeneous trends motivate our systematic analysis of the impact of vertical integration over the three episodes introduced above, namely 1970–1984, 1985–1999, and 2000–2014, in the remainder of the paper. Estimating the equation over the whole

sample period and then splitting the sample allows us to detect whether parameters vary depending on structural changes in economic vertical integration.

5.1 Baseline: whole sample period

The results for the whole panel, without imposing a break date and pooling all episodes, are reported in Table 1. The top row shows that the effect on productivity gaps remains insignificant, while it is positive and significant for wage gaps. The inclusion of control variables does not alter this picture but points in the same direction. A quick interpretation would conclude that global production fragmentation leads to divergence in wages but that there is no correlation with productivity gaps. As such, these results already disprove expected convergences due to integration. Table 1, however, masks distinctive trends in vertical integration over time that could affect the relationship between the variables in individual episodes. Specifically, the era of hyper-globalization during the 2000s might have affected convergence quite differently from the relative stability in integration from 1984–1999. We need to consider a different strategy and estimate the effects of distinct episodes of vertical integration to characterize the relationship between sectoral convergence/divergence and vertical integration for the observation period.

Table 1: Impact of vertical integration on gap: whole sample

	Dependent variable:			
	Productivity gap		Wage gap	
	(1)	(2)	(3)	(4)
VI foreign	−0.00005	−0.0001	0.004***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Controls	-	Yes	-	Yes
Country FE	Yes	Yes	Yes	Yes
Country*Sector FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Observations	11,946	11,946	11,952	11,952
Adjusted R^2	0.539	0.581	0.526	0.542
Note:			*p<0.1; **p<0.05; ***p<0.01	

5.2 Baseline: accounting for structural breaks and the changing role of vertical integration

Accordingly, in this section we are interested in whether the episodes of economic integration, introduced above, really matter. The available data show three episodes that have witnessed remarkably different trends. The previous setup in itself, however, does not reveal whether the effect found for the baseline will vary according to these episodes that have "hit" European industries. We are thus keen to determine the changes in the relationship between integration and convergence over time.

Table 2: Impact of vertical integration on gap: sub-samples

	Dependent variable:					
	Productivity gap			Wage gap		
	1970-84	1985-99	2000-14	1970-84	1985-99	2000-14
	(1)	(2)	(3)	(4)	(5)	(6)
VI foreign	0.032***	−0.008***	0.006***	0.049***	−0.001	0.006***
	(0.005)	(0.002)	(0.001)	(0.003)	(0.002)	(0.0003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Sector*Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,982	3,981	3,983	3,982	3,987	3,983
Adjusted R^2	0.920	0.707	0.656	0.891	0.687	0.638
Note:						*p<0.1; **p<0.05; ***p<0.01

We begin our presentation of results with an overview of the estimations in each of our three time intervals. Columns 1–3 of Table 2 show the effects for productivity gaps, and columns 4–6 for wage gaps. In each interval, we have almost 4,000 observations for individual sectors. As shown in the top row of the table, we estimate positive and significant effects for the first and third intervals, while they are negative or remain insignificant in the second period. Since we observe rising vertical integration in the first and last periods and relative stability in the second, there are countervailing forces affecting sectoral divergences: vertical integration exacerbates within-sector inequalities in periods of greater vertical integration, while there is little or no effect on equalization in periods of relative stability in vertical integration. However, rising dispersion implies that there are both "winners" and "losers" from globalization, a fact that we will further investigate in the next section.

At this stage, we conclude that industries tend to diverge in periods of deeper vertical integration, which is also compatible with the evolutionary structuralist theory and against the prediction of new-new trade theories (Ocampo and Taylor, 1998). The result tells us that the increasing process of fragmentation of production has been impacting differently

within industries across countries. Against the expected convergence from participation in GVCs, the input mix in sourced value-added, both in terms of the composition of suppliers and countries of origin, deeply affects the overall industry performance and input remuneration. This occurs in periods of harsher vertical integration, highlighting that the greater opportunities to mix the bundle of sourced inputs do not equally affect industries and the firms therein: while some industries can benefit from higher opportunities of sourcing an input mix from indirect suppliers located abroad, others suffer from GVCs. The results, therefore, suggest the emergence of neo-dualism within industries along European production structures. The tendency of vertical integration to increase divergence holds even in the first period characterized by convergent gaps, that is, holding other factors fixed which induce convergence, such as GDP per capita and population size.

Next, we make sure our baseline holds up by using alternative gap measures as the dependent variable. First, we test the impact of vertical integration on the gap around the median. Since the sample median is less sensitive to outliers than the sample average, exchanging the dependent variable could substantially impact the coefficients if the baseline findings do not hold. Appendix Table B.5 shows that the coefficient on vertical integration remains effectively unaltered, both in terms of direction and statistical significance. Alternatively, we also use absolute deviations from the weighted sample mean as dependent variable, where the weights are sectoral employment. This way, we can assess whether our results change when accounting for the industry's size in the distance to the average. Again, appendix Table B.6 shows that the estimated coefficients have the same signs and magnitudes as in the baseline specification. Therefore, the baseline specification is robust and independent of the use of alternative measures of sectoral inequality. Taken together, the relationship between vertical integration and divergence found in the original estimation also holds when accounting for distance to the median and deviations from the weighted sample mean as the dependent variable. We now expand our focus beyond the average to study factors contributing to heterogeneities in the relationship between vertical integration and industry divergence.

5.3 Introducing heterogeneities

The results presented above might hide heterogeneous effects across industries, reflecting different sectoral characteristics such as the type of sector, the origins of imports, and the

nature of gaps, whether positive or negative. To shed light on such differences, we replicate the analysis for manufacturing and services separately, for vertical integration from other source regions as well as by positive and negative gaps.

5.3.1 Manufacturing vs. Services

Here we examine how vertical integration affects sectoral gaps differently in manufacturing and services industries. Since foreign inter-industry linkages are low in the services sector compared to manufacturing, we would expect any forces of globalization to be stronger in manufacturing than in services, to the extent that divergence is driven by vertical integration. This view is also consistent with the theoretical mechanisms elaborated in the existing literature, like, for instance, lock-in, dependence, and dynamic returns, which tend to be stronger in manufacturing than in services. Therefore, we should expect the impact to be more pronounced in manufacturing than in services.

Table 3: Impact of vertical integration on gap: by broad sector

	Dependent variable:											
	Productivity gap						Wage gap					
	1970-84		1985-99		2000-14		1970-84		1985-99		2000-14	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VI foreign	0.034***	0.399	−0.008**	−0.283	0.007***	0.145	0.051***	−0.247	−0.001	−0.046	0.006***	0.168
	(0.005)	(0.388)	(0.003)	(0.395)	(0.001)	(0.249)	(0.003)	(0.370)	(0.002)	(0.187)	(0.0004)	(0.193)
Broad sector	Man.	Ser.	Man.	Ser.	Man.	Ser.	Man.	Ser.	Man.	Ser.	Man.	Ser.
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector*Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,512	1,470	2,511	1,470	2,513	1,470	2,512	1,470	2,517	1,470	2,513	1,470
Adjusted R^2	0.922	0.918	0.691	0.788	0.677	0.560	0.901	0.844	0.695	0.614	0.653	0.569

Note: *p<0.1; **p<0.05; ***p<0.01

Table 3 shows evidence in line with these arguments. The positive effect of vertical integration on sectoral gaps is entirely driven by manufacturing, with muted or null effects in services sectors. This implies that an increase in integration via input–output linkages increases the sectoral gap (relative to the mean) in manufacturing but not in the services sector. This effect is not only statistically significant but also economically relevant. The coefficient of 0.007 in column 5 indicates that a ten-percentage-point rise in an industry's vertical integration increases its distance to the mean by around 7 percent. Between the second and third periods we examine, the gaps in productivity and wages have increased by around 16 percent, suggesting that the rise in vertical integration accounts almost for half of the increase in the observed dispersion in our data.

The fact that we find positive and statistically significant effects of vertical integration on sectoral gaps in manufacturing, holding fixed an array of factors, lends support to mechanisms that are more prevalent in manufacturing and to a lesser extent in services. Among them, mutual dependence, feedback loops, and lock-in effects, in which further integration and reliance on foreign inputs lower the mobility along the value chain, make it difficult for firms to switch to new industries or adopt new technologies (Arthur, 1994; Kaldor, 1970; Young, 1928). Such lock-in effects can lead to persistent differences in performance across countries and industries, as the high sectoral interdependence creates a barrier to entry for firms in other countries or industries, and also because suppliers can only be changed at high cost (Heinrich, 2014). The evidence of a positive relationship between vertical integration and sectoral gaps in manufacturing thus suggests that lock-in effects play a role in shaping industry performance across European countries. And they clearly act in both directions: as a positive externality for winners and as a negative externality for losers. In a way, the divergence across industry-country from the average signals the existence of high-performing/high-paying production chains coexisting with low-performing/low-paying ones. Being our gap measures on the "output" (demand) side, while the vertical integration measure on the "input" (supply) side, the distinct results between manufacturing and services are in line with a mix of strategies in sourcing inputs and the creation of stable and high- (low-)quality buyer–seller relationships in manufacturing value chains. As a side note, the interpretation of labor productivity in services is always more subtle.

5.3.2 The role of the geography of integration

The focus on foreign indirect vertical integration is motivated by the fact that international input–output linkages are best captured by considering both integration from low- and high-income countries. Hence, our empirical approach reveals robust links for aggregating different regions that might have integrated with European industries at different times. However, the changing picture of the trade partners of the EU is a possible confounding factor when pooling countries' integration with different income levels over the whole observation period. Therefore, we split the foreign vertical integration measure alongside the origins of inputs, for different episodes, and repeat the same analysis.

Table 4 compares the impact of growing vertical integration from within and from outside European industries. European vertical integration mainly affects sectoral divergence in the

third period but not in the first. When considering vertical integration originating outside Europe, the first period displays positive effects while the second and third period point in the same direction as the main results, although with different magnitudes, particularly in the last period. A possible explanation for the differential effects according to origin of imported inputs in the first period might be the distinct trends of vertical integration experienced by European industries during the 1970s. The data presented in Appendix table B.2 indicate that the bulk of the integration in the first period originates outside Europe, while European integration has been more stable when compared to non-European integration, but increasing in the last period.

Notably, while European vertical integration, originating from ex-ante more similar countries as compared to extra-European ones, should be more favorable in bringing economic convergence, this is not verified by our results. Higher vertical integration among a group of 14 relatively similar EU countries does not foster convergence, while, on the contrary, it has a strong diverging effect, particularly in the last period. This holds for both labor productivity and even wages. Notably, the wage gap in the first period is the most responsive variable to non-European vertical integration. The result, involving developed countries regulated by sectoral bargaining and, in general, with strong trade unions, is quite discomforting evidence of the negative pressure on labor remuneration exerted by GVCs (Riccio et al., 2022). Finally, the high intensity of the coefficient in both gaps for EU integration in the third period proves that, in a phase of hyper globalization, winning European industries have gained at the cost of losing ones, therefore becoming progressively more and more heterogeneous among them.

Table 4: Impact of vertical integration on gap: by origin of vertical integration

	Dependent variable:											
	Productivity gap						Wage gap					
	1970-84		1985-99		2000-14		1970-84		1985-99		2000-14	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VI EU-14	−0.010		−0.019***		0.030***		0.015		0.002		0.021***	
	(0.016)		(0.006)		(0.006)		(0.014)		(0.005)		(0.001)	
VI non-EU-14		0.065***		−0.011**		0.008***		0.091***		−0.003		0.007***
		(0.006)		(0.004)		(0.001)		(0.004)		(0.003)		(0.0004)
Origin of VI	EU	non-EU	EU	non-EU	EU	non-EU	EU	non-EU	EU	non-EU	EU	non-EU
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector*Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,982	3,982	3,981	3,981	3,983	3,982	3,982	3,982	3,987	3,987	3,983	3,982
Adjusted R^2	0.920	0.921	0.707	0.707	0.656	0.656	0.890	0.891	0.687	0.687	0.638	0.638

Note: *p<0.1; **p<0.05; ***p<0.01

5.3.3 Differential effects by winning and losing industries

In this section, we further examine what causes the positive impact of vertical integration on divergence. One key mechanism through which vertical integration fuels sectoral inequalities rests with the uneven opportunities for poor-performing industries relative to their strong-performing counterparts. We aim to explore this argument by decomposing the total effects for industries below the average and those above the average in terms of wages and productivity. Therefore, we identify the sectors above the average and those below the average for each year and re-estimate the effect of vertical integration on sectoral gaps for each group. This way, we determine whether industries react differently to vertical integration depending on their performance relative to the "average" European industry.

Table 5 shows the differential effects of negative and positive gaps. The positive distance obtained in the baseline is predominantly driven by sectors with above-average performance, as suggested by the stable coefficients and lower standard errors. However, the effects for the lower-performing industries are also largely positive, indicating that these industries tend to lose even more ground in terms of productivity and wages following a rise in vertical integration. These results point to heterogeneous mechanisms depending on the industries' relative performance, which supports structural polarization as a potential mechanism (Myrdal, 1957). The idea is that the interdependence of sectors via input–output linkages affects the bottom and top ends of the distribution differently. Suppose that countries inside the same industry are differently able to capture the gains from vertical integration, that is, continental countries can increase the gains from foreign input penetration by lowering their costs, but also by expanding their market presence and capacity, while, on the contrary, peripheral countries lose their capacity to recombine inputs more efficiently due to competition, decrease their value-added, and also experience losses in terms of market shares. These dynamics induce increasing positive gaps for winners and increasing negative gaps for losers, leading to divergence. The results highlight the presence of vicious cycles due to declining opportunities for poorly performing industries/countries to move along the productivity ladder, as documented in the structural evolutionary literature (Cimoli and Porcile, 2013; Cimoli et al., 2009; Pavlínek, 2017).

However, when we try to dissect the winners and losers in each period, we need to consider that growth rates along the distribution of productivity and income are not stable across industries and countries, meaning that there is significant churn within the distribution.

Table 5: Impact of vertical integration on gap: by performance

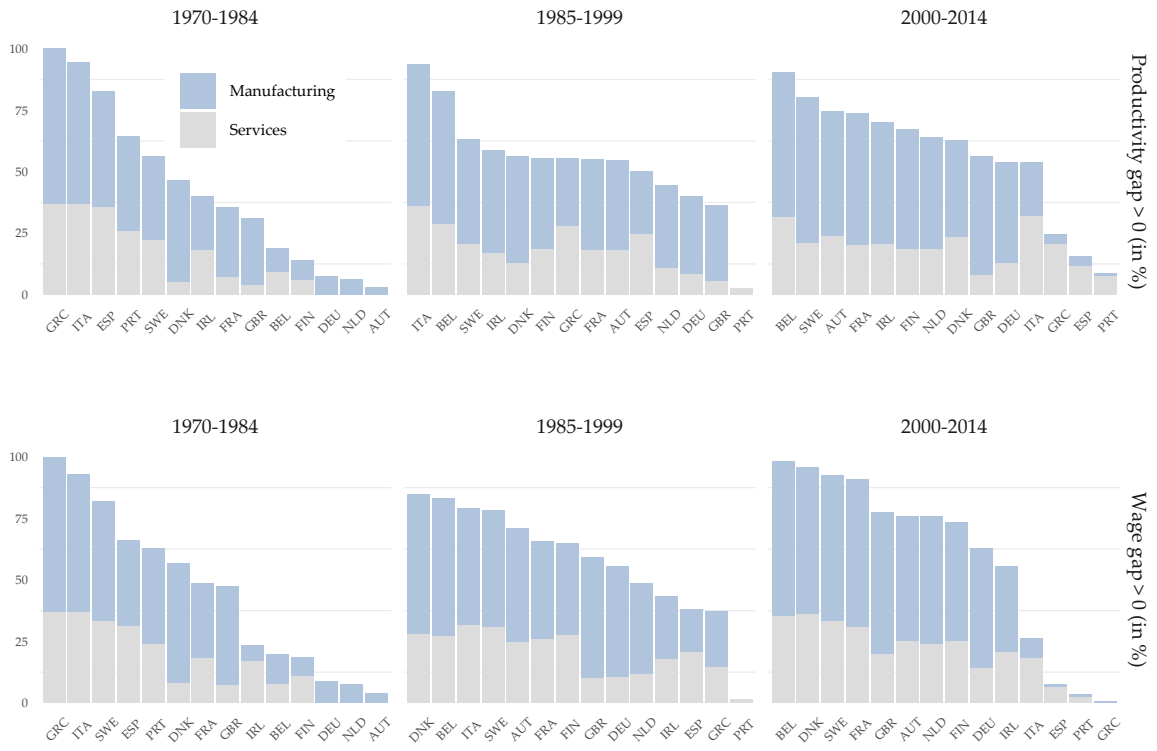
	Dependent variable:											
	Productivity gap						Wage gap					
	1970-84		1985-99		2000-14		1970-84		1985-99		2000-14	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VI foreign	0.043**	0.022***	−0.179***	−0.003	0.011*	0.006***	0.017	0.042***	0.004	−0.001	−0.001*	0.011***
	(0.020)	(0.002)	(0.053)	(0.002)	(0.006)	(0.001)	(0.015)	(0.006)	(0.007)	(0.002)	(0.001)	(0.0003)
Sign of gap	<0	>=0	<0	>=0	<0	>=0	<0	>=0	<0	>=0	<0	>=0
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector*Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,271	1,711	1,851	2,130	1,718	2,265	2,165	1,817	1,680	2,307	1,599	2,384
Adjusted R^2	0.927	0.948	0.750	0.775	0.719	0.692	0.928	0.915	0.725	0.730	0.736	0.586

Note: *p<0.1; **p<0.05; ***p<0.01

Figure 3 illustrates that the average industry-country composition changed significantly over the three periods. To account for the prevalence of losing versus winning industries, we compute the share of positive gaps across countries in the three episodes. The first period shows positive gaps for southern European countries, suggesting a significant catching up during this episode. Some countries experienced substantial economic growth during the 1970s, as was the case in Greece, Portugal, and Spain during the economic miracle and their opening up to world markets, and in Italy when the economy took off by joining the club of highly industrialized countries (Ardeni and Gallegati, 2023; Lains, 2003). In addition, these differences in wage and productivity levels between southern and northern European countries in the first interval also reflect differences in price levels. Southern countries in particular, like Greece and Portugal, exhibited low prices, resulting in comparatively high real wages and value-added, while countries like Germany or Austria faced higher domestic prices, partly eroding their higher nominal wages and value-added. However, the composition of countries changes radically in the second period, where all catching-up countries, except Italy, have a decreasing share of positive gaps, while northern European countries like Sweden, Denmark, and Austria tend to increase their share of positive gaps. The last period is relatively straightforward: none of the southern European countries features positive gaps, while northern European countries dominate the positive gaps. This evidence deeply militates in favor of the changing composition of the landscape of winners and losers in terms of performance and wage remuneration over time.

The positional reshuffle during the period of high globalization is relatively striking because of the magnitude and persistence of the divergence. The fact that Italy, Greece, Spain, and Portugal do not even record 10% of their manufacturing industries performing above

Figure 3: Share of positive gaps by country and episode



This figure compares the share of positive gaps across countries in the three episodes. The top panel depicts the share of positive productivity gaps and the bottom panel shows the share of positive wage gaps. The light blue bar shows the positive gaps in manufacturing and the grey bars show the positive gaps in services sectors. The countries are ranked by their overall share of positive gaps in each period.

the average in 15 years, indicates that strong-performing industries tend to maintain their relative advantages throughout this period and that the gaps between followers and leaders do not reflect a transitory phenomenon. The divergence is particularly pronounced in manufacturing, implying an erosion of productive capabilities in the south of Europe. Moreover, this evidence is also backed by our Appendix table B.7, where we list the five leading and laggard industry countries for each period. While Europe's top-performing and top-paying industries since 2000 are Pulp in Ireland, Petrol in Austria, and Electronics in Finland, and thus exclusively situated in the North of Europe, the laggard sectors include mainly manufacturing industries in Europe's so-called peripheral countries, like textiles, chemicals, and plastic industries in Portugal and Greece.

The distinction in terms of winning and losing industry-country helps in explaining and reconciling our findings with the alternate fates of European growth trajectories across member states. Some of them were able to improve their position along the productivity ladder, while

others began falling behind, although at the beginning of the period lagging countries were converging. Hence, while in the first two periods there was some intradistribution mobility of positions of countries belonging to the European top performers, we note a strong persistence in the distribution since 2000, discouraging convergence. This evidence is supportive of the existence of a process of uneven organization of production chains among geographically identifiable areas, with the core countries experiencing rising performance, and peripheral ones experiencing a decrease. The uneven geography of production is then directly reflected in an uneven geography of labor input remuneration, with crystallizing wage divergences over time.

6 Conclusions

The impact of economic integration upon the convergence of countries, in terms of productivity and income, has been one of the most contentious issues throughout the history of political economy. The conventional wisdom, at least since Smith (1776), envisioned mutual gains from economic openness, through trade, or, at the very least, through poorer countries catching up due to stronger competition and better access to capital—as explicit in the neoclassical tradition. The empirical evidence, however, is weak and inconclusive, casting doubt on the theoretical paradigm.

By combining sectoral input–output data and cross-country disparities in productivity and wages for European industries over the period 1970–2014, this paper analyzes the nexus between vertical integration and sectoral dispersion. Our novel database reveals that vertical integration displays rising trends in the 1970s, followed by relative stability in the 1990s and a remarkable increase since the early 2000s. Sectoral inequalities narrowed until the late 1990s and have trended upward since then. Although aggregate dispersion has followed a similar pattern in manufacturing and services since 1970, disparities have increased much faster in manufacturing in the last decade.

Using panel fixed effects estimations, we find that sectoral divergence increases in periods of higher vertical integration. These effects are mainly driven by manufacturing industries that integrate outside Europe in the first period, and globally in the most recent period of hyper-globalization. However, even integration among EU countries amplifies divergence. Lock-in effects in laggard positions coupled with positive feedback loops and increasing

returns for leading positions are potential mechanisms which explain why the fruits of rising vertical integration are shared unequally between poor-performing industries and frontier industries. Our analyses thus reveal that international production fragmentation can be a powerful factor in understanding the drivers of different cross-country economic trajectories, and that the forces pushing inequality up or down hinge on the uneven division of labor and the productive activities along the value chain. Results hold both in terms of performance and input remuneration.

Our findings speak against the existing standard policy recipe of pushing further integration in the pursuit of catch-up and convergence, which derives from the standard theory of comparative advantage and new and new-new trade theories (Dosi et al., 2022). According to our results, some sector-countries seem to benefit when integrating across borders, while others get trapped. These channels seem to operate differently across sectors, but on aggregate they tend to accentuate international inequalities. The self-perpetuating character of this mechanism suggests that overcoming structural polarization in Europe requires an active industrial policy that takes international production fragmentation into account when assessing the costs and benefits of further economic integration and its effect on inequalities. In particular, the positioning of core countries which are benefiting from GVC participation should be compared with that of countries located in the periphery, so as to design equalizing policies: for example, moving the management of production chains by lead companies from core to periphery countries, or alternatively reducing the value capture of lead versus parent companies. So far, lead firms are almost all located in the core of Europe, while parents are in the periphery. Overcoming such asymmetric positioning in the management of European production chains would actually foster integration and convergence.

The limitations of our analysis include, first, the lack of firm-level data, which could allow us to better grasp the actual strategies pursued by firms to gain from the process of fragmentation of production and locate firms along production chains; second, the analysis of the composition of the vertical integration indicator, assessing not only the origin but also the quality of inputs sourced from abroad, for example distinguishing productive inputs via Pavitt classes, and also assessing for the fraction of manufacturing versus services sourced inputs. Indeed, one unexplored channel in this paper is how the different weights of high-productive versus low-productive inputs enter into final demand and affect performance measures. This information might indeed explain why in the last period the core of Europe

systematically over-performs the periphery. Future extensions would entail the study of the impact of vertical fragmentation of production on functional income distribution, to understand over the long run if capitalists or workers gained more by the integration into GVCs. Related to this, we will assess how European countries differ in such distributions of gains.

References

Amsden, A. H. (1991), "Diffusion of Development: The Late-industrializing Model and Greater East Asia". *The American Economic Review*, 81, 2, 282–86.

Ardeni, P. G. and Gallegati, M. (2023), "On Italian Economic Development: What the Long-term Says About the Short-term". *Italian Economic Journal*.

Arthur, W. (1994), *Increasing Returns and Path-Dependence in the Economy*. University of Michigan Press.

Autor, D. H., Dorn, D., and Hanson, G. H. (2013), "The China Syndrome: Local Labor Market Effects of Import Competition in the United States". *American Economic Review*, 103, 6, 2121–68.

Bachas, P., Fisher-Post, M. H., Jensen, A., and Zucman, G. (2022), "Globalization and Factor Income Taxation". *National Bureau of Economic Research*.

Bai, J. and Perron, P. (2003), "Computation and Analysis of Multiple Structural Change Models". *Journal of Applied Econometrics*, 18, 1, 1–22.

Balassa, B. (1966), "Tariff Reductions and Trade in Manufacturers among the Industrial Countries". *The American Economic Review*, 56, 3, 466–73.

Baldwin, R. E. (2006), *Globalisation: The Great Unbundling(s)*. Tech. rep. Economic Council of Finland.

Baldwin, R. E. and Venables, A. J. (1995), "Regional Economic Integration". *Handbook of International Economics*, 3, 1597–1644.

Baldwin, R. and Freeman, R. (2022), "Risks and Global Supply Chains: What We Know and What We Need to Know". *Annual Review of Economics*, 14, 153–80.

Barro, R. J. (2015), "Convergence and Modernisation". *The Economic Journal*, 125, 585, 911–942.

Ben-David, D. (1993), "Equalizing Exchange: Trade Liberalization and Income Convergence". *The Quarterly Journal of Economics*, 108, 3, 653–679.

Bergeijk, P. A. van (2015), "Visible and Invisible Walls: World Trade Patterns and the End of the Cold War". *Acta Oeconomica*, 65, 2, 231–47.

Bernard, A. B. and Jones, C. I. (1996), "Productivity Across Industries and Countries: Time Series Theory and Evidence". *The Review of Economics and Statistics*, 78, 1, 135.

Blair and Miller (1983), "Spatial Aggregation in Multiregional Input-Output Models". *Environment and Planning A: Economy and Space*, 15, 2, 187–206.

Bontadini, F., Evangelista, R., Meliciani, V., and Savona, M. (2022), "Patterns of Integration in Global Value Chains and the Changing Structure of Employment in Europe". *Industrial and Corporate Change*.

Buch-Hansen, H. and Wigger, A. (2010), "Revisiting 50 Years of Market-making: The Neoliberal Transformation of European Competition Policy". *Review of International Political Economy*, 17, 1, 20–44.

Cimoli, M., Dosi, G., and Soete, L. (1990), "Technological Gaps, Institutional Differences and Patterns of Trade: A North–South Model". *Frontiers on Innovation Diffusion*. Ed. by F. Arcangeli. Oxford University Press.

Cimoli, M. and Porcile, G. (2013), "Technology, Structural Change and BOP-constrained Growth: A Structuralist Toolbox". *Cambridge Journal of Economics*, 38, 1, 215–37.

Cimoli, M., Dosi, G., and Stiglitz, J. E. (2009), "The Political Economy of Capabilities Accumulation: The Past and Future of Policies for Industrial Development". *Industrial Policy and Development*. Ed. by M. Cimoli, G. Dosi, and J. E. Stiglitz. Oxford University PressOxford, 1–16.

Cohen, J. N. and Centeno, M. A. (2006), "Neoliberalism and Patterns of Economic Performance, 1980–2000". *The ANNALS of the American Academy of Political and Social Science*, 606, 1, 32–67.

Cresti, L., Dosi, G., Riccio, F., and Virgillito, M. E. (2023), *Italy and the Trap of GVC Downgrading: Labour Dependence in the European Geography of Production*. Tech. rep. Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced …

Cresti, L. and Virgillito, M. E. (2022), "Strategic Sectors and Essential Jobs: A New Taxonomy Based on Employment Multipliers". *Available at SSRN*.

— (2023), *Weak Sectors and Weak Ties? Labour Dependence and Asymmetric Positioning in GVCs*. Tech. rep. Laboratory of Economics and Management (LEM) Working Paper Series, Sant'Anna School of Advanced Studies.

Dosi, G., Fabiani, S., Aversi, R., and Meacci, M. (1994), "The Dynamics of International Differentiation: A Multi-country Evolutionary Model". *Industrial and Corporate Change*, 3, 1, 225–42.

Dosi, G., Virgillito, M. E., and Yu, X. (2022), "Gains from Trade or from Catching-up? Value Creation and Distribution in the Era of China's WTO Accession". *Eurasian Business Review*, 1–48.

Duarte, M. and Restuccia, D. (2010), "The Role of the Structural Transformation in Aggregate Productivity". *Quarterly Journal of Economics*, 125, 1, 129–73.

Dutt, A. (1989), "Uneven Development in Alternative Models of North–South Trade". *Eastern Economic Journal*, XV, 2.

Erten, B. and Ocampo, J. A. (2013), "Super Cycles of Commodity Prices since the Mid-nineteenth Century". *World Development*, 44, 14–30.

Farrell, J. and Klemperer, P. (2007), "Chapter 31 Coordination and Lock-In: Competition with Switching Costs and Network Effects". *Handbook of Industrial Organization*. Elsevier, 1967–2072.

Feenstra, R. (1998), "Integration of Trade and Disintegration of Production in the Global Economy". *Journal of Economic Perspectives*, 12, 4, 31–50.

Feenstra, Inklaar, R., and Timmer, M. P. (2015), "The Next Generation of the Penn World Table". *American Economic Review*, 105, 10, 3150–82.

Galli, R. (1997), "Is There Long-Run Industrial Convergence in Europe?" *International Review of Applied Economics*, 11, 3, 333–68.

Garratt, A. and Vahey, S. P. (2006), "UK Real-Time Macro Data Characteristics". *The Economic Journal*, 116, 509, F119–F135.

Gereffi, G., Humphrey, J., and Sturgeon, T. (2005), "The Governance of Global Value Chains". *Review of International Political Economy*, 12, 1, 78–104.

Gräbner, C., Heimberger, P., Kapeller, J., and Schütz, B. (2019), "Structural change in times of increasing openness: assessing path dependency in European economic integration". *Journal of Evolutionary Economics*, 30, 5, 1467–1495.

— (2020), "Is the Eurozone disintegrating? Macroeconomic divergence, structural polarisation, trade and fragility". *Cambridge Journal of Economics*, 44, 3, 647–669.

Grossman and Rossi-Hansberg, E. (2008), "Trading Tasks: A Simple Theory of Offshoring". *American Economic Review*, 98, 5, 1978–97.

Guerrieri, P. and Caffarelli, F. V. (2012), "Trade Openness and International Fragmentation of Production in the European Union: The New Divide?" *Review of International Economics*, 20, 3, 535–51.

Hansen, B. E. (2001), "The New Econometrics of Structural Change: Dating Breaks in U.S. Labor Productivity". *Journal of Economic Perspectives*, 15, 4, 117–28.

Heinrich, T. (2014), "Standard Wars, Tied Standards, and Network Externality Induced Path Dependence in the ICT Sector". *Technological Forecasting and Social Change*, 81, 309–20.

Johnson, P. and Papageorgiou, C. (2020), "What Remains of Cross-Country Convergence?" *Journal of Economic Literature*, 58, 1, 129–175.

Kaldor, N. (1970), "The Case for Regional Policies". *Scottish Journal of Political Economy*, 17, 3, 337–48.

— (1980), "The Foundations of Free Trade Theory and their Implications for the Current World Recession". *Unemployment in Western Countries*. Palgrave Macmillan UK, 85–100.

Klemperer, P. (1987), "The Competitiveness of Markets with Switching Costs". *The RAND Journal of Economics*, 18, 1, 138.

Krugman, P. (1987), "The Narrow Moving Band, the Dutch Disease, and the Competitive Consequences of Mrs. Thatcher". *Journal of Development Economics*, 27, 1-2, 41–55.

— (1991), "Increasing Returns and Economic Geography". *Journal of Political Economy*, 99, 3, 483–99.

Kutan, A. M. and Yigit, T. M. (2007), "European Integration, Productivity Growth and Real Convergence". *European Economic Review*, 51, 6, 1370–95.

Lains, P. (2003), "Catching up to the European Core: Portuguese Economic Growth, 1910–1990". *Explorations in Economic History*, 40, 4, 369–86.

Leontief, W. W. (1936), "Quantitative Input and Output Relations in the Economic Systems of the United States". *The Review of Economics and Statistics*, 18, 3, 105.

Lonsdale, C. (2001), "Locked-in to Supplier Dominance: On the Dangers of Asset Specificity for the Outsourcing Decision". *The Journal of Supply Chain Management*, 37, 2, 22–27.

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

Madsen, J. B. and Timol, I. (2011), "Long-Run Convergence in Manufacturing and Innovation-Based Models". *Review of Economics and Statistics*, 93, 4, 1155–71.

Meier, G. M. and Stiglitz, J. E. (2001), *Frontiers of Development Economics: The Future in Perspective*. World Bank Publications.

Melitz, M. J. and Trefler, D. (2012), "Gains from Trade when Firms Matter". *Journal of Economic Perspectives*, 26, 2, 91–118.

Milanovic, B. (2006), "Economic Integration and Income Convergence: Not Such a Strong Link?" *Review of Economics and Statistics*, 88, 4, 659–670.

Milberg, W. and Winkler, D. E. (2010), "Economic and Social Upgrading in Global Production Networks: Problems of Theory and Measurement". *SSRN Electronic Journal*.

Miller and Blair, P. (2009), *Input-output Analysis: Foundations and Extensions*. Cambridge University Press.

Myrdal, G. (1957), *Economic Theory and Under-Developed Regions*. Ed. by L. Duckworth.

Ocampo, J. A. and Taylor, L. (1998), "Trade Liberalisation in Developing Economies: Modest Benefits but Problems with Productivity Growth, Macro Prices, and Income Distribution". *The Economic Journal*, 108, 450, 1523–46.

Pahl, S. and Timmer, M. P. (2019a), "Do Global Value Chains Enhance Economic Upgrading? A Long View". *The Journal of Development Studies*, 56, 9, 1683–1705.

— (2019b), "Patterns of Vertical Specialisation in Trade: Long-run Evidence for 91 Countries". *Review of World Economics*, 155, 3, 459–86.

Panwar, R., Pinkse, J., and De Marchi, V. (2022), "The Future of Global Supply Chains in a Post-COVID-19 World". *California Management Review*, 64, 2, 5–23.

Pasinetti, L. L. (1973), "The Notion of Vertical Integration in Economic Analysis". *Metroeconomica*, 25, 1, 1–29.

— ed. (1980), *Essays on the Theory of Joint Production*. Palgrave Macmillan UK.

Patel, D., Sandefur, J., and Subramanian, A. (2021), "The New Era of Unconditional Convergence". *Journal of Development Economics*, 152, 102687.

Pavlínek, P. (2017), "Global Production Networks, Foreign Direct Investment, and Supplier Linkages in the Integrated Peripheries of the Automotive Industry". *Economic Geography*, 94, 2, 141–65.

Pham-Gia, T. and Hung, T. (2001), "The Mean and Median Absolute Deviations". *Mathematical and Computer Modelling*, 34, 7-8, 921–36.

Piketty, T. (2018), "Capital in the 21st Century". *Inequality in the 21st Century*. Routledge, 43–48.

Riccio, F., Cresti, L., and Virgillito, M. E. (2022), *The Labour Share along Global Value Chains: Perspectives and Evidence from Sectoral Interdependence*. Tech. rep. LEM Working Paper Series.

Rodrik, D. (2012), "Unconditional Convergence in Manufacturing". *The Quarterly Journal of Economics*, 128, 1, 165–204.

— (2019), "Globalization's Wrong Turn". *Foreign Affairs*, 98, 4, 26–33.

Roine, J. and Waldenström, D. (2011), "Common Trends and Shocks to Top Incomes: A Structural Breaks Approach". *Review of Economics and Statistics*, 93, 3, 832–46.

Sachs, J. D., Warner, A., Aslund, A., and Fischer, S. (1995), "Economic Reform and the Process of Global Integration". *Brookings Papers on Economic Activity*, 1995, 1, 1.

Sapir, A. (2011), "European Integration at the Crossroads: A Review Essay on the 50th Anniversary of Bela Balassa's Theory of Economic Integration". *Journal of Economic Literature*, 49, 4, 1200–29.

Selwyn, B. and Leyden, D. (2022), "Oligopoly-driven Development: The World Bank's Trading for Development in the Age of Global Value Chains in Perspective". *Competition & Change*, 26, 2, 174–96.

Simonazzi, A., Ginzburg, A., and Nocella, G. (2013), "Economic Relations between Germany and Southern Europe". *Cambridge Journal of Economics*, 37, 3, 653–75.

Slaughter, M. J. (2001), "Trade Liberalization and Per Capita Income Convergence: A Difference-in-differences Analysis". *Journal of International Economics*, 55, 1, 203–28.

Smith, A. (1776), "An Inquiry into the Nature and Causes of the Wealth of Nations". *The Glasgow Edition of the Works and Correspondence of Adam Smith, Vol. 2: An Inquiry into the Nature and Causes of the Wealth of Nations, Vol. 1*. Ed. by W. B. Todd. Oxford University Press.

Spolaore, E. (2013), "What is European Integration Really About? A Political Guide for Economists". *Journal of Economic Perspectives*, 27, 3, 125–44.

Sturgeon, T. and Memedovic, O. (2010), "Mapping Global Value Chains: Intermediate Goods Trade and Structural Change in the World Economy". *Unido*.

Svensson, G. (2004), "Interactive Vulnerability in Buyer-Seller Relationships: A Dyadic Approach". *International Journal of Physical Distribution & Logistics Management*, 34, 8, 662–82.

Sydow, J., Schreyögg, G., and Koch, J. (2009), "Organizational Path Dependence: Opening the Black Box". *Academy of Management Review*, 34, 4, 689–709.

Targetti, F. and Foti, A. (1997), "Growth and Productivity: A Model of Cumulative Growth and Catching Up". *Cambridge Journal of Economics*, 21, 1, 27–43.

Timmer, M. P., Erumban, A. A., Los, B., Stehrer, R., and De Vries, G. J. (2014), "Slicing Up Global Value Chains". *Journal of Economic Perspectives*, 28, 2, 99–118.

Weber, I. M., Semieniuk, G., Liang, J., and Westland, T. (2022), *Persistence in World Export Patterns and Productive Capabilities Across Two Globalizations*.

Williamson, J. G. (1996), "Globalization, Convergence, and History". *The Journal of Economic History*, 56, 2, 277–306.

Woltjer, P., Gouma, R., and Timmer, M. (2021), *Long-run World Input-Output Database: Version 1.1 Sources and Methods*. Tech. rep.

World-Bank (2019), *World Development Report 2020: Trading for Development in the Age of Global Value Chains*. Washington, DC: World Bank.

Young, A. A. (1928), "Increasing Returns and Economic Progress". *The Economic Journal*, 38, 152, 527.

A Data

We build a panel dataset with annual frequency for 14 European countries over the period 1970–2014. The countries covered in our dataset are Austria, Belgium, Germany, Denmark, Spain, Finland, France, the United Kingdom, Greece, Ireland, Italy, Netherlands, Portugal, and Sweden. All data come from exclusively publicly available sources. The following section presents a detailed description of all measures used in the empirical analysis, followed by a discussion of the main steps in the data construction.

A.1 Variable definitions and sources

- **Vertical integration**: Vertical integration is proxied by vertically integrated value-added as measured by the backward linkages of an industry. We focus on foreign inter-industry linkages, namely linkages originating from abroad and from other industries where the consuming industry itself is not directly active. Indirect foreign vertical integration is scaled by horizontal value-added. Data for the computation come from all available World Input–Output Database releases (2013, 2016, and 2022).
- **Employee compensation**: To measure wage per worker, we use compensation of employees as a share of total number of employees. Compensation of employees includes gross wages and salaries payable in cash or in kind, and the value of social contributions payable by employers. Compensation of self-employed is imputed by assuming similar wages as employees. Data is taken from the EU KLEMS (November 2009 release, updated March 2011) and the Socio Economic Accounts (2014 and 2016 releases) database.
- **Labor productivity**: In order to proxy the industries' labor productivity, output per worker is constructed by taking the ratio of value-added to the number of employees. Data is obtained from the EU Klems (2011 update of March 2009 release) and the Socio Economic Accounts (2014 and 2016 releases) database.
- **Gross domestic product**: In order to proxy the countries' economic development, GDP per capita is constructed by taking the ratio of GDP to the total population. GDP is measured at constant 2011 national prices in million US dollars and is taken from the Penn World Tables (9.1) database provided by Feenstra et al. (2015).

- **Population**: In order to proxy the countries' size, we use total population from the Penn World Tables (9.1) database provided by Feenstra et al. (2015).

A.2 Construction of IO tables

As mentioned in the main text, we use the LR-WIOD (2022 release), WIOD 2013, and WIOD 2016 releases side by side to compute our measure of vertical integration. Combining all available WIOD releases poses some challenges and limitations, in particular due to changes in industry classification and the system of national accounts (SNA). Changes in industrial classification prevent us from mapping industries one-to-one, while changes in SNA affect the way National Accounts are measured, including statistical units, price concepts, and measurement methods, precluding comparisons at a disaggregate level. While LR-WIOD and WIOD 2013 follow common industrial classification (ISIC Rev. 3.1) and SNA concepts (1993), WIOD 2016 uses ISIC Rev 4.1 and is rooted in statistics from SNA 2008. As a result, the former are equivalent in many respects, while the latter is challenging to incorporate, at least on a disaggregated level. At a more aggregate level, however, the levels and trends are similar, as emphasized by the creators of this database (Woltjer et al., 2021).

Our approach is thus to aggregate both industries and countries by row and column-wise summation using a combination of disaggregated and aggregate correspondence tables. The use of the 19 fairly aggregate sectors instead of a finer sectoral disaggregation allows for relatively similar aggregate trends of different vintages. Cross-linking the WIOD 2016 release to the other vintages is not always unambiguous. For instance, some activities like real estate in LR-WIOD are disaggregated into five different categories in WIOD 2016 such as information and communication (J), real estate activities (L), professional and administrative service activities (M and N), and other service activities (S). However, other service activities, S from WIOD 2016, map into other community, social, and personal services O in LR-WIOD. Hence, we cannot "dissect" the amount that goes from S into real estate and how much of it goes into other community services O. In this case we allocated the unambiguous industries, namely J, L, M, N to real estate, while we allocated other service activities, S, entirely to its LR-WIOD equivalent O. We did not detect major jumps in the years when the series overlapped, giving us confidence in our approach. Table B.3 presents the final industry list after aggregating the different WIOD releases and the corresponding abbreviations used in the text.

One potential problem which arises as a result of aggregation is that, in general, sector gross outputs obtained from the disaggregated system differ from those obtained by aggregating the total outputs in the original unaggregated system. This phenomenon is known as aggregation bias (see Miller and P. Blair (2009) and Blair and Miller (1983) for a discussion and mathematical computation of the bias). Since inter-industry linkages differ across sectors, the aggregation of industries implies aggregating also their technical coefficients, without taking into account their different requirements and reliance on other inputs, that is, their inter-industry linkages. By way of analogy, consider combining the automotive industry with the truck industry into one vehicle industry. If demand increases in the vehicle industry only due to demand in trucks, we would fall short of some inputs in the automotive industry because automotive and trucks have fairly different input requirements. Following the methodology outlined in Miller and P. Blair (2009), we compare the gross output of the aggregated and disaggregated system and do not find evidence of aggregation bias in our data, ensuring the validity of using fairly aggregate tables.

A.3 Sectoral productivity and wage data

We use the IO tables described above and cross-link them with sectoral data on the compensation of employees, value-added, and number of employees. These data are taken from EU-KLEMS (2011 update of the March 2009 release) and Socio-Economic Accounts (2014 and 2016 releases). EU-KLEMS and the SEA 2014 release are based on industrial classification ISIC 3.1, while the 2016 release of the Socio-Economic Accounts is based on ISIC Rev. 4. We use the same correspondence tables that we used for the WIOD releases to map the sectoral data to the 19 sectors in the IO tables. Although the LR-WIOD database also has value-added information that we use in our vertical integration computation, we prefer to take value-added from EU KLEMS for our gap variables over the period 1970–2007. This is because LR-WIOD does not include information on the number of workers and employee compensation, while EU KLEMS does. This way we can compute the sectoral gaps using only one data source, both in the nominator and denominator, avoiding any measurement problems that may arise in the use of different data sources in the same measure.

Nominal series of sectoral employee compensation and value-added are adjusted for domestic inflation using sectoral price deflators from EU KLEMS and the 2014 and 2016 SEA releases. Since base years differ across different sources, we chain these price indices to the new

Table 6: Chaining sectoral price indices, schematic example

year	EU KLEMS & SEA 14	SEA 16	Final price index
1970	55		55
...			...
1997	84		84
1998	86		86
1999	91		91
2000	100	84 * (100/84)	100
2001	110	86 * (100/84)	110
...	...	99 * (100/84)	...
2009	120	100 * (100/84)	120
2010		100 * (100/84)	119
2011		111 * (100/84)	132
2012		112 * (100/84)	133
2013		115 * (100/84)	136
2014		119 * (100/84)	141

benchmark year 2000 following four steps. First, we combine EU KLEMS and SEA 14 price indices with the same base year (1995=1). The new series spans from 1970–2009. Second, we change the base year of the combined series to 2000 by dividing each observation by the year 2000 multiplied by 100. This is the first year where the combined series overlaps with WIOD 2016. Third, we calculate the ratio of the base year of the combined price index and SEA 16 in the overlapping year. We then multiply the factor obtained with each of the values in SEA 16 and fill in the missing values from 2010–2014 with the new index. We illustrate a schematic example of our approach in Table 6.

B Tables and figures

Table B.1: Summary statistics of variables used in the empirical analysis (annual data)

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
Productivity (log)	11,967	11.00	0.81	10.54	10.92	11.38
Wage (log)	11,970	10.44	0.69	10.08	10.45	10.79
Productivity gap	11,967	0.39	0.48	0.11	0.25	0.48
Wage gap	11,970	0.37	0.44	0.11	0.24	0.46
Vertical integration foreign	11,953	0.35	1.48	0.06	0.13	0.30
Vertical integration Europe	11,953	0.15	0.40	0.03	0.07	0.16
Vertical integration non-Europe	11,952	0.21	1.16	0.03	0.06	0.13

Table B.2: Mean values of main variables by decade and broad industry

Variable	1970-84	1985-99	2000-14
Manufacturing			
Productivity gap	0.58	0.30	0.35
Wage gap	0.58	0.30	0.34
Vertical integration foreign	0.44	0.37	0.71
Vertical integration Europe	0.18	0.20	0.24
Vertical integration non-Europe	0.26	0.18	0.47
Services			
Productivity gap	0.57	0.26	0.24
Wage gap	0.48	0.22	0.23
Vertical integration foreign	0.09	0.08	0.11
Vertical integration Europe	0.04	0.04	0.05
Vertical integration non-Europe	0.05	0.03	0.06

Note: The table reports the average annual gaps in labor productivity, wage per worker, and vertical integration over three different periods, from 1970 to 1984, from 1985 to 1999, and from 2000 to 2014. The averages are broken down by manufacturing and services sectors.

Table B.3: Final industry list after aggregating the different WIOD releases

	ISIC	Two-digit industry description	Details	Abbreviation
Manufacturing				
1	15t16	Food, Beverages and Tobacco	Manufacture of food products and beverages, and tobacco products	Food
2	17t19	Textiles, Textile, Leather and Footwear	Manufacture of textiles, wearing apparel, dressing and dyeing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	Textiles
3	21t22	Pulp, Paper, Paper, Printing and Publishing	Manufacture of paper and paper products; Publishing, printing and reproduction of recorded media;	Pulp
4	23	Coke, Refined Petroleum and Nuclear Fuel	Manufacture of coke, refined petroleum products and nuclear fuel	Petrol.
5	24	Chemicals and Chemical Products	Manufacture of chemicals and chemical products	Chem.
6	25	Rubber and Plastics	Manufacture of rubber and plastics products	Plastic
7	26	Other Non-Metallic Mineral	Manufacture of other non-metallic mineral products	Metal
8	27t28	Basic Metals and Fabricated Metal	Manufacture of basic metals, fabricated metal products, except machinery and equipment	Machin.
9	29	Machinery, Nec	Manufacture of machinery and equipment n.e.c, e.g., general purpose machinery, engines and turbines, pumps, compressors, etc.	
10	30t33	Electrical and Optical Equipment	Manufacture of office, accounting and computing machinery; manufacture of electrical machinery and apparatus n.e.c.; manufacture of radio, television and communication; manufacture of medical, precision and optical instruments, watches and clocks;	Electrical
11	34t35	Transport Equipment	Manufacture of motor vehicles, trailers and semi-trailers Manufacture of other transport equipment	Trans. Equ.
12	Dnec	Manufacturing, Nec; Recycling	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plating materials; manufacture of furniture; manufacturing n.e.c.; receycling;	Other Man.
Services				
13	G	Wholesale and Retail Trade	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	Wholesale
14	H	Hotels and Restaurants	Hotels and restaurants	Hospitality
15	60t63	Transport and Storage	Land transport; transport via pipelines water transport, air transport, supporting and auxiliary transport activities; activities of travel agencies;	Trans. Stor.
16	64	Post and Telecommunications	Post and telecommunications	Telecom.
17	J	Financial Intermediation	Financial Intermediation	Financial
18	K	Real Estate, Renting and Business Activities	Real estate, renting and business activities	Real est.
19	LtQ	Community Social and Personal Services	Public administration and defence; compulsory social security education; health and social work; other community, social and personal service activities; activities of private households as employers and undifferentiated production activities of private households; extra-territorial organizations and bodies;	Other Serv.

Table B.4: Break test for vertical integration: top ten breakdates

Estimated breakdates	Number of breaks	Share of total sample (in %)
2000	77	29
2001	45	17
1999	43	16
1982	39	15
1987	20	8
1985	18	7
1983	12	5
1993	12	5
1994	9	3
1998	9	3
Total breaks	**378**	

Note: This table presents the results of the top ten estimated break dates using the Bai and Perron (2003) multiple structural break tests on vertical integration. The number of breaks is chosen through a sequential method and corresponds to distinct industry-country observations having a break in the estimated breakdate. The last column displays the number of breaks as a share of the total industry-country observations (266).

Table B.5: Impact of vertical integration on gap around the median

	Dependent variable:					
	Productivity gap			Wage gap		
	1970-84	1985-99	2000-14	1970-84	1985-99	2000-14
	(1)	(2)	(3)	(4)	(5)	(6)
VI foreign	0.054^{***}	-0.015^{***}	0.006^{***}	0.086^{***}	-0.012^{***}	0.006^{***}
	(0.004)	(0.003)	(0.001)	(0.006)	(0.001)	(0.0004)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Country*Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,982	3,981	3,983	3,982	3,987	3,983
Adjusted R^2	0.923	0.712	0.672	0.875	0.692	0.682
Note:						*p<0.1; **p<0.05; ***p<0.01

Table B.6: Impact of vertical integration on gap around the weighted mean

	Dependent variable:					
	Productivity gap			Wage gap		
	1970-84	1985-99	2000-14	1970-84	1985-99	2000-14
	(1)	(2)	(3)	(4)	(5)	(6)
VI foreign	0.034^{***}	-0.005^{*}	0.004^{***}	0.049^{***}	-0.006^{**}	0.005^{***}
	(0.004)	(0.003)	(0.0004)	(0.005)	(0.002)	(0.0005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Sector*Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,982	3,981	3,983	3,982	3,987	3,983
Adjusted R^2	0.926	0.711	0.644	0.897	0.692	0.661
Note:						*p<0.1; **p<0.05; ***p<0.01

Table B.7: Top performing and paying industries vs. laggard industries

	Productivity				Wage			
Country	Period	Sector	Broad sector	Productivity gap	Country	Period	Sector	Broad sector	Wage gap
Leader					**Leader**				
GRC	1970-1984	Wholesale	Ser.	2.74	GRC	1970-1984	Electrical	Man.	2.45
GRC	1970-1984	Electrical	Man.	2.72	DEU	1970-1984	Petrol.	Man.	2.19
GRC	1970-1984	Other Man.	Man.	2.61	GRC	1970-1984	Trans. Equ.	Man.	2.19
GRC	1970-1984	Hospitality	Ser.	2.60	ITA	1970-1984	Petrol.	Man.	2.14
DEU	1970-1984	Petrol.	Man.	2.36	GRC	1970-1984	Other Man.	Man.	1.96
DEU	1985-1999	Petrol.	Man.	1.60	DEU	1985-1999	Petrol.	Man.	1.84
GRC	1985-1999	Hospitality	Ser.	1.28	BEL	1985-1999	Petrol.	Man.	1.30
BEL	1985-1999	Petrol.	Man.	1.09	NLD	1985-1999	Petrol.	Man.	0.77
GRC	1985-1999	Wholesale	Ser.	1.06	FRA	1985-1999	Chem.	Man.	0.66
GRC	1985-1999	Real est.	Ser.	0.95	SWE	1985-1999	Textiles	Man.	0.58
IRL	2000-2014	Pulp	Man.	1.50	AUT	2000-2014	Petrol.	Man.	1.60
AUT	2000-2014	Petrol.	Man.	1.42	BEL	2000-2014	Petrol.	Man.	0.95
IRL	2000-2014	Chem.	Man.	1.34	IRL	2000-2014	Telecom.	Ser.	0.86
SWE	2000-2014	Petrol.	Man.	1.02	SWE	2000-2014	Electrical	Man.	0.78
FIN	2000-2014	Electrical	Man.	0.86	SWE	2000-2014	Petrol.	Man.	0.64
Laggard					**Laggard**				
FRA	1970-1984	Petrol.	Man.	-5.02	FRA	1970-1984	Petrol.	Man.	-4.67
PRT	1970-1984	Petrol.	Man.	-3.46	PRT	1970-1984	Petrol.	Man.	-3.98
FRA	1970-1984	Plastic	Man.	-1.27	FRA	1970-1984	Plastic	Man.	-1.60
NLD	1970-1984	Real est.	Ser.	-1.25	FRA	1970-1984	Machin.	Man.	-1.23
IRL	1970-1984	Petrol.	Man.	-1.13	GBR	1970-1984	Hospitality	Ser.	-1.19
FRA	1985-1999	Petrol.	Man.	-2.13	PRT	1985-1999	Petrol.	Man.	-2.19
PRT	1985-1999	Petrol.	Man.	-1.97	FRA	1985-1999	Petrol.	Man.	-1.80
PRT	1985-1999	Trans. Equ.	Man.	-1.18	PRT	1985-1999	Mineral	Man.	-1.07
IRL	1985-1999	Petrol.	Man.	-1.10	PRT	1985-1999	Trans. Equ.	Man.	-1.04
PRT	1985-1999	Other Man.	Man.	-1.06	IRL	1985-1999	Petrol.	Man.	-0.97
DNK	2000-2014	Petrol.	Man.	-1.24	GRC	2000-2014	Electrical	Man.	-1.19
PRT	2000-2014	Textiles	Man.	-1.14	PRT	2000-2014	Textiles	Man.	-1.12
GRC	2000-2014	Chem.	Man.	-0.98	GRC	2000-2014	Petrol.	Man.	-1.04
PRT	2000-2014	Other Man.	Man.	-0.96	PRT	2000-2014	Other Man.	Man.	-0.92
PRT	2000-2014	Chem.	Man.	-0.95	GRC	2000-2014	Plastic	Man.	-0.86

Figure B.1: Measures of foreign vertical integration

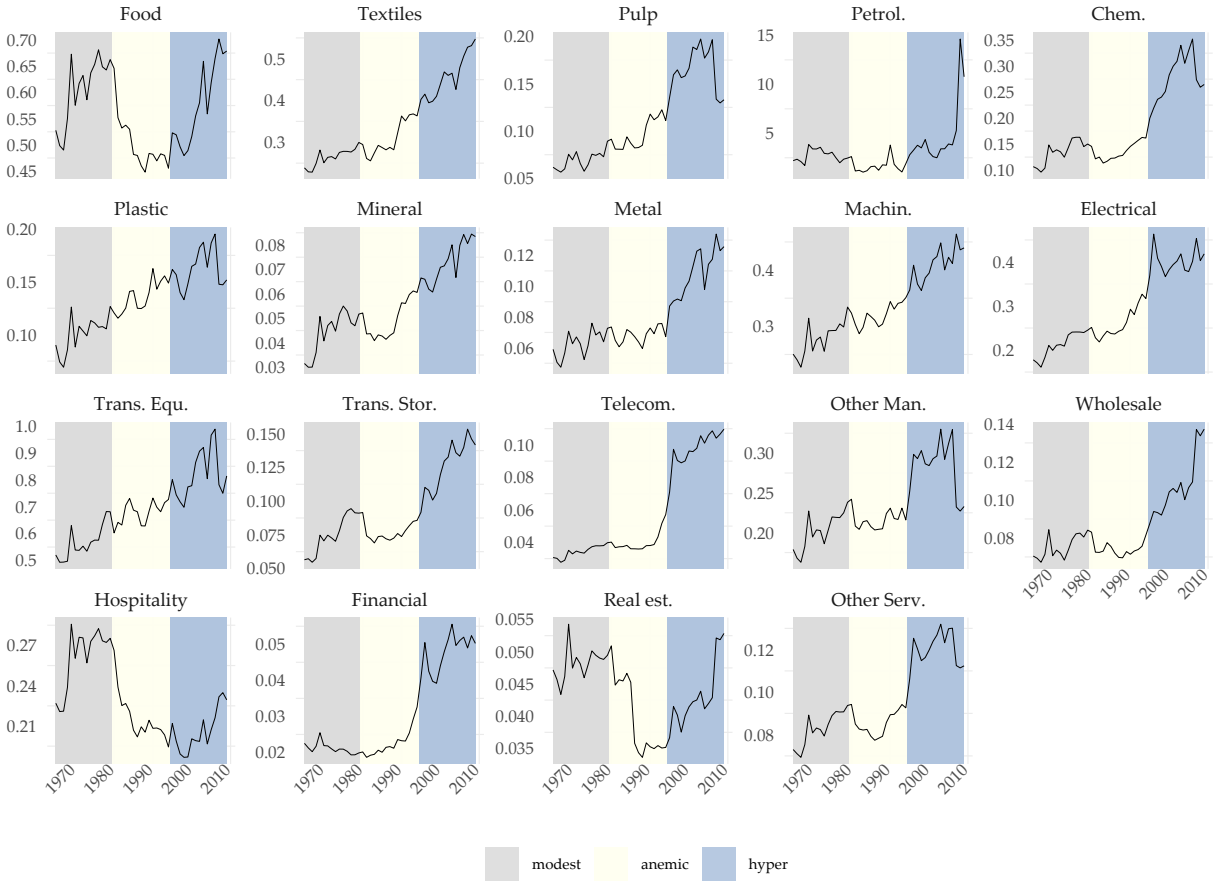


Figure B.2: Distribution of labor productivity by industry and episode

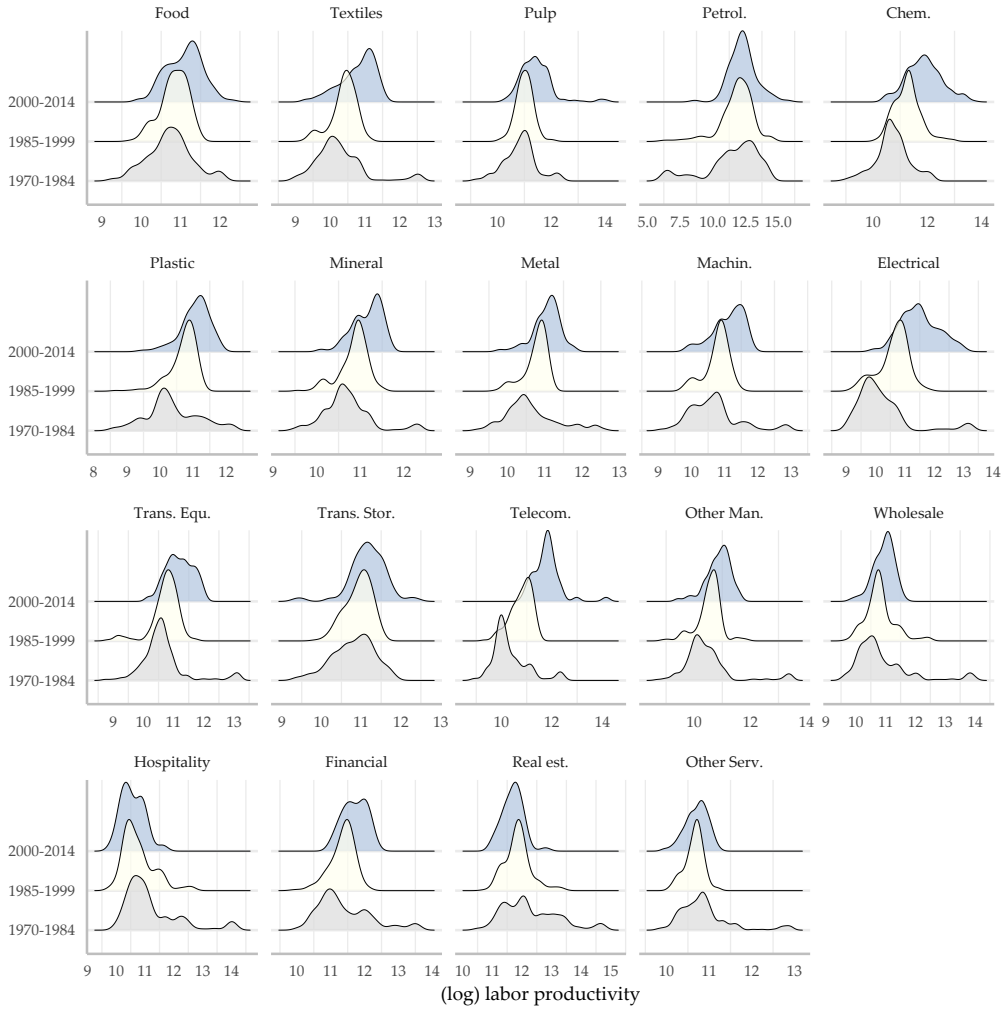


Figure B.3: Distribution of wage per employee by industry and episode

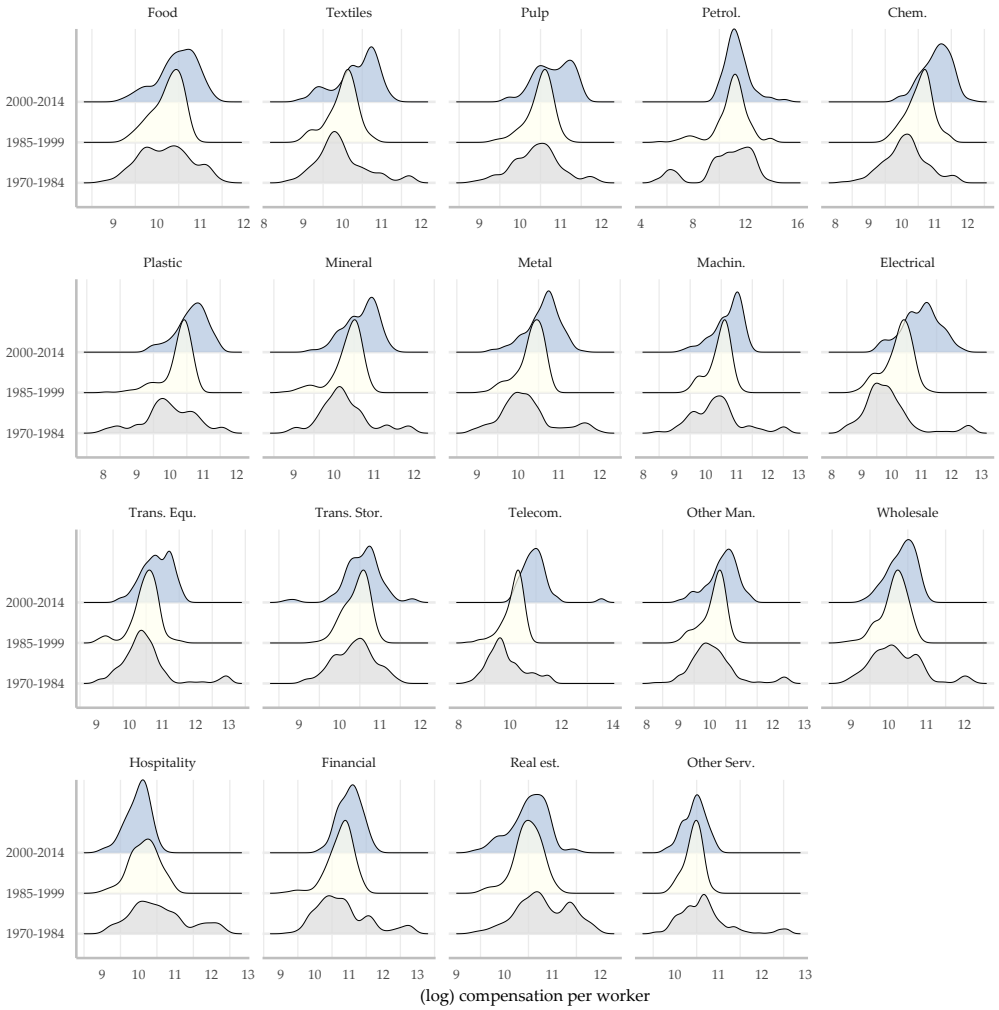
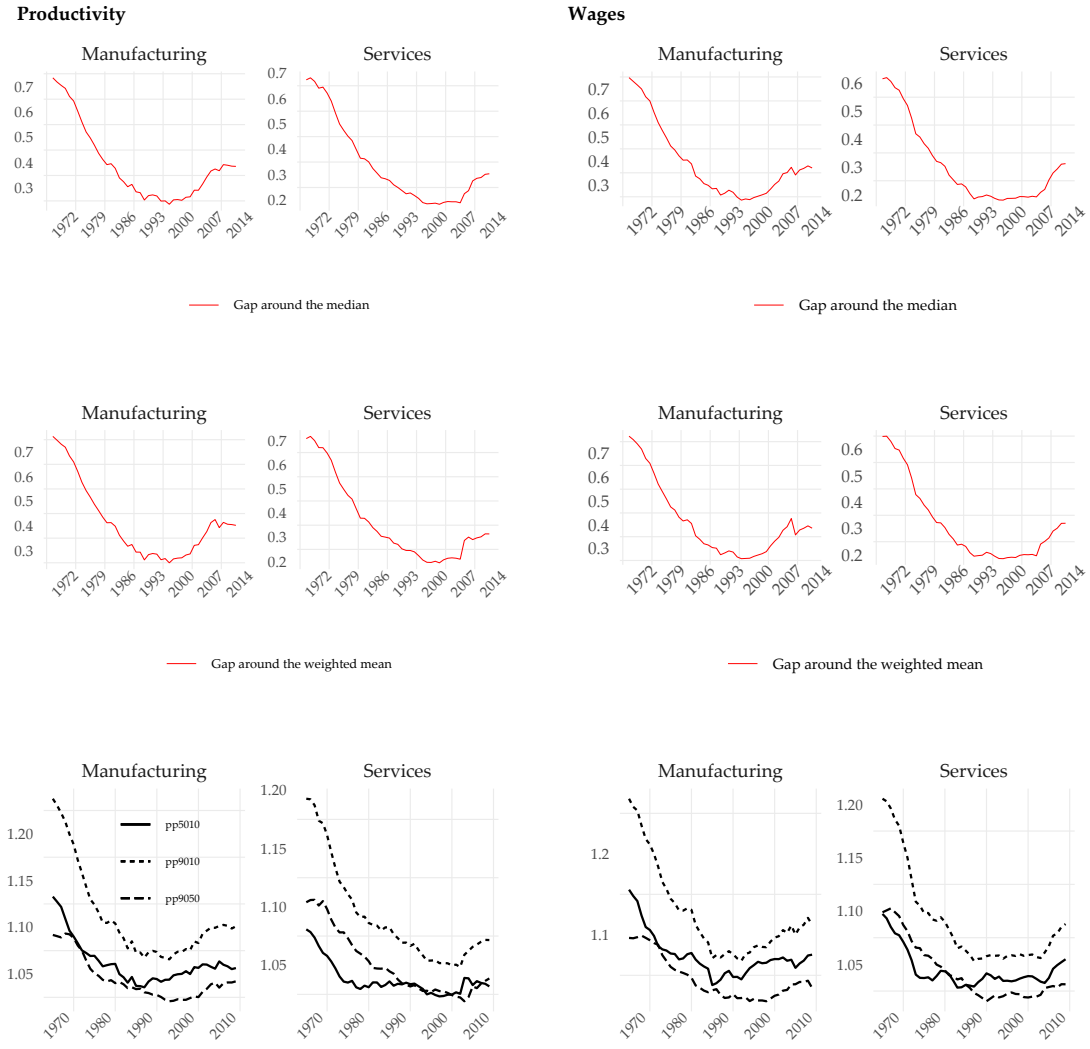


Figure B.4: Productivity and wage gaps

Figure B.5: Robustness checks using alternative divergence measures: Gap around the median, weighted mean, and percentile ratios



This figure compares the evolution of average sectoral gaps relative to the sample median (top panel), relative to the employment weighted average (middle panel), and percentile ratios over the period 1970–2014.