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Smile without a reason why: functional specialisation and income distribution along global value chains

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Smile without a reason why: functional specialisation and income distribution along global value chains

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Abstract. This paper addresses two questions namely, first, the extent to which the very participation in Global Value Chains (GVCs) has penalised labour as a globally insourced production input, and, second, what happened to between-occupation functional inequality. We combine input-output (I-O) tables and labour income along the production stages of global value chains. We focus on foreign labour requirements in manufacturing industries and distinguish across four production stages, namely fabrication, marketing, R&D and managerial functions to map the relative specialisation patterns of different production sub-systems. Our results show that GVCs are hierarchically structured, with advanced countries specialising in upstream functions along global production networks. Fabrication workers are the biggest losers in this process, accounting for most of the drop in labour share in developed and developing countries. Considering that production workers make up more than 50% of the workforce in both advanced and developing countries, the labour share loss of blue-collar workers is a major driver of the increasing global wage inequality.

Keywords: Labour Share · Global Value Chains · Functional Specialisation · Comparative Advantages · Income Inequalities · International division of Labour
JEL classification: F14; J31; O14

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1 Introduction

Is the functional income distribution constant or does it change over time? This question regarding the alternative dynamics of income distribution has been addressed in a renowned contribution by Kaldor (1955). Quoting the Preface of Ricardo's *Principles*, Kaldor emphasizes that understanding the laws that govern distributive shares is the paramount challenge of Political Economy. Furthermore, Ricardo presents a theory of income distribution in which shares in the total value are expected to exhibit time-varying dynamics. However, Kaldor disagrees with Ricardo's expectation on the trends in the shares of income distribution:

> Ricardo prefaced his statement by a reference to the historical fact that "in different stages of society the proportions of the whole produce of the earth which will be allotted to each of these (three) classes under the names of rent, profit and wages will be essentially different." To-day, a writer on the problem of distribution, would almost be inclined to say the opposite-that " in different stages of (capitalist) society the proportions of the national income allotted to wages, profits, etc., are essentially similar ". The famous " historical constancy " of the share of wages in the national income-and the similarity of these shares in different capitalist economies, such as the U.S. and the U.K.-was of course an unsuspected feature of capitalism in Ricardo's day. But to the extent that recent empirical research tends to contradict Ricardo's assumption about the variability of relative shares, it makes the question of what determines these shares, more, rather than less, intriguing. [Kaldor, 1955; p. 83]

In another famous contribution, Kaldor (1967) lists the so-called stylized facts of contemporary capitalism, which include the constant distribution of shares between capital and labour. In the past decade, there has been renewed attention towards the temporal and cross-country dynamics of distributive shares. Contrary to Kaldor's conjectures, however, a more recent body of empirical evidence supports dynamics more in line with Ricardo's prediction, indicating non-stable income shares. Particularly, extensive documentation exists regarding the decline in the share of product accruing to labour since the 1970s (Karabarbounis and Neiman, 2014). More recently, due to the increased availability of data, similar trends have been detected in developing countries as well (Guschanski and Onaran, 2023; van Treeck, 2020; Dao et al., 2020).

Such Kaldor "puzzle" entails both substantial implications in terms of the theoretical consistency of the marginalist approach, but also normative ones in terms of equality and distributive justice. Various alternative explanations have been proposed thus far to interpret the evidence, encompassing factors such as technical change, bargaining power and institutional dimensions, structural change, and globalization. Concentration and market power have been the most intensively researched areas in the last five years. Conversely, the role of rising international integration even if often addressed, still demands a clear and comprehensive understanding of the effects of global production chains on the distribution of value added. Furthermore, while the overall decline in the labour share has garnered attention, less attention has been given to understanding the divergent paths of occupations in upper-hierarchical versus bottom-hierarchical positions regarding their ability to capture value along the production process. This paper addresses two questions, namely first, the extent to which the very participation in Global Value Chains (GVCs) has favoured or disfavoured labour as a globally insourced production input, and, second, what happened to between-occupation functional inequality.

To address the latter questions, in line with Timmer et al. (2019) and Chen et al. (2018), we combine input-output (I-O) tables and labour income along production stages of global value chains. We focus on foreign labour requirements and distinguish across four production stages, namely fabrication, marketing, R&D and managerial functions to map the relative specialisation patterns of different production sub-systems. Each stage of production is defined by means of sectoral-level occupational classifications deriving from the International Standard Classification of Occupations (ISCO).

We then compute two proxies of inequality: functional income distribution, mapping the overall labour share along GVCs, and occupational inequality tackling the occupation-specific evolution of wage remuneration along GVCs.

Our results show that GVCs are hierarchically structured, with advanced countries' workers receiving a higher share of value from global production networks. The asymmetric positioning allows advanced countries to benefit from functional specialisation in upstream tasks, which partially offsets the decline in their labour share. However, production workers are the biggest losers in this process, accounting for the largest decline in labour share, in both developed and developing countries. Considering that production workers make up more than 50% of the workforce in both advanced and developing countries, the labour share loss of blue-collar workers gives rise to increasing global wage inequality.

Overall, we contribute to the literature on GVCs' role in social "downgrading" and provide further evidence of the emergence of the "smile curve" due to the fragmentation of productions. In fact, while wage compression strategies ease country GVCs' participation, especially in developing countries, the hierarchical structure of these chains, with headquarters and R&D activities concentrated in advanced countries and production activities outsourced to developing countries, exacerbates asymmetries across functions and workers' remuneration.

Our contribution offers several novel insights. Firstly, we introduce a novel measurement approach to quantify labour share along Global Value Chains. Secondly, we account for the labour share at different production stages, distinguishing them based on their functions. Thirdly, we decompose the overall labour share to identify various sources of variation, including within and between occupations, as well as between value chains. Fourthly, we estimate the econometric impact of GVC participation, considering other potential channels identified in the literature. Overall, our study provides a comprehensive theoretical and empirical framework that considers the hierarchical division of labour inputs and their respective remunerations. Our approach in the same ways resonates with the perspective of *dependency theory*, which posits that GVCs crystallize power asymmetries and unequal production processes into unequal distribution processes, but explicitly link it with *technology-gap theories* of trade and international investment.

The remaining sections of the paper are structured as follows: Section 2 looks at alternative channels behind labour share decline; Section 3 describes the data and methodology employed; Section 4 presents descriptive statistics on labour share dynamics while Section 5 proposes a shift-share analysis; Section 6 investigates potential determinants by means of a parsimonious econometric analysis; Section 7 concludes.

2 State of the art: alternative channels of labour share decline

The factors contributing to the decline in the labour share can be broadly divided into five (possibly inter-linked) groups: the technological channel, the institutional channel, the structural change channel, the globalization channel, and finally, the GVCs channel.[1] It is important to note that our aim is not to provide a comprehensive examination of the entire literature related to these channels. Instead, we focus on the mechanisms and contributions that are relevant to our empirical framework. Furthermore, let us emphasize that these determinants might be interconnected, and their interaction may amplify their overall effects.

2.1 The technology channel: the role of comparative advantage

The idea that technology and technological change play a significant role in shaping both specialisation and income distribution can be traced back to classical political economy (Ricardo, 1819).

The original Ricardian framework is a labour-only model with (implicit) full employment and perfect competition. On those grounds, it is shown that comparative advantages based on cross-sector, within-country, relative labour productivities, drive inter-country specialisations, yielding welfare gains for all.

Historically, the ways the model has been refined and built upon, mostly involved the incorporation of a full neoclassical apparatus, maintaining the equilibrium assumptions, but bringing in multiple "factors of production" linked together by an invariant functional relation, the canonic production function.

Its power is that it provides an integrated (although deeply misleading) account of the relationships between factor endowments, observed relative input intensities, and input remunerations. In that vein, the Heckscher-Ohlin (H-O) model and the Stolper-Samuelson (SS) theorem suggest that countries can increase efficiency by specialising in the production of goods that utilize their relatively abundant factors of production, resulting in a rise in the returns for the intensively-demanded factors.

It happens that, even granting all the assumptions, such theory does not find much empirical support. In fact, the so-called *Leontief "paradox"* (Leontief, 1951) is as near to a flat falsification as social sciences can get.

In fact, the drawbacks are more profound. "Production functions" are a doubtful construct in general, and with that any straightforward link between technology, input intensities and distributive shares[2]. More specifically concerning the relationships between technologies, specialisations and the distribution of returns, in a world characterised by profound technological asymmetries, the evidence is quite at odds with the prediction of any factor endowment theory: see Dosi and Tranchero (2021); Vivarelli (2014); Dosi et al. (1990) and, even with less distrust at its basics, Feenstra and Hanson (1999) and Wood (1995). All this notwithstanding, such basic theoretical workhorse has been recently used also to intercept changes in international specialisation and income distribution.

[1] On purpose, we leave aside the treatment of rising market power (Autor et al., 2020; Barkai, 2020) as "the superstar firms channel" is not comparable with our empirical setting and our level of analysis.

[2] Much more on that in Dosi (2023).

As known, in a market where competition is perfect, employment is full, and production functions are well-behaved, the theory suggests the equilibrium distribution of income is determined by *comparative advantage*, determined by relative endowments, and more recently, by technological progress, supposedly captured by movements of the production function itself. Although these assumptions are rarely satisfied in the real world, these mechanisms are still at the heart of several neoclassical models (Jones and Kim, 2018).

For instance, the skill-biased technical change (SBTC) literature proposes that since the early 1980s, technological change has disproportionately benefited individuals with advanced skills (or education). Specifically, the introduction of new machinery, computers in that phase, appeared to augment the productivity of skilled labour while reducing the demand for unskilled ones. This shift towards skilled labour, it is argued has contributed to the observed increase in personal income inequality between high- and low-skilled workers (Card and DiNardo, 2002; Autor et al., 2003). The task-biased technical change (TBTC) hypothesis, on the other hand, refers to technological advancements that lead to the automation of certain tasks or jobs (Goos et al., 2014; Autor and Dorn, 2013). TBTC can lead to job displacement, as modern technologies can often perform certain tasks more efficiently than humans. Both theories point to the fact that automation and computerization tend to replace tasks that are more routinised and complement tasks that require higher-level skills or personal proximity. This generates a decline in the demand for medium-low skilled types of workers, which can in turn lead to lower labour share in those industries where their use is extensive.

There is a significant body of empirical research investigating the relationship between technological change and the evolution of labour share (most often under the lenses of some changing 'production function'). Several researchers have argued that capital-augmenting technological progress has contributed to the declining labour share (Raurich et al., 2012; Driver and Muñoz-Bugarin, 2010; Arpaia et al., 2009; Bentolila and Saint-Paul, 2003). Karabarbounis and Neiman (2014) attribute the fall in labour share to the decline in the relative price of investment goods, which makes it more efficient to substitute capital for labour. However, these findings crucially rely on the assumption that the elasticity of substitution between capital and labour is greater than one, which is at odds with several empirical studies (Kohler et al., 2018; Rowthorn, 1999) [3]. Other studies have suggested that the relationship between technology and the labour share may be more complex and not mediated by tasks and routinised activities, with various contributions finding a negligible impact of technology on the labour share (Guschanski and Onaran, 2021; Tytell and Jaumotte, 2007; Economic Commission, 2007).

2.2 The institutional channel: the role of bargaining power

A competing explanation for the decline in the labour share focuses on the role of *bargaining power* of workers. Under non-decreasing returns and asymmetric power between firms and workers, the distribution of income might well be the outcome of a negotiation process between firms and workers, possibly represented by labour unions and mediated by the presence of labour market institutions. Workers, whenever protected by strong unions and pro-labour institutions, are better able to negotiate wage increases in line with productivity, helping to maintain a constant labour share.

[3] In fact, in a world generally characterised by quite sticky firm-specific technological capabilities "elasticities of substitution" might not be there at all (Dosi, 2023).

Empirically, there is a growing consensus on the role of labour market institutions in shaping labour share dynamics through the bargaining power channel. Several studies have found that factors such as strike activity, collective bargaining arrangements, minimum wages, and union density, affect the labour share (Guschanski and Onaran, 2021; Bengtsson, 2014; Stockhammer, 2013b; Kristal, 2010; Bentolila and Saint-Paul, 2003; Argitis and Pitelis, 2001). In particular, union density – the percentage of unionized workers within a given population – has been shown to have a positive effect on the labour share at the country level (Guschanski and Onaran, 2021; Stockhammer, 2013a; Bengtsson, 2014; Stockhammer, 2013b). In addition, the evidence (Dao et al., 2020; Dimova, 2019) suggests that unions may have different effects on the wage-setting process for different skill groups protecting in particular low-skilled workers, thus reducing wage inequality.

The opposite drive on the same channel, reducing worker bargaining power, is the progressive flexibilization of the labour market and the concurrent retrenchment of the welfare state which exert a key role in the decline of the wage share (Bloise et al., 2022; Ciminelli et al., 2018; Jayadev, 2007)[4]. So, for example, Ciminelli et al. (2018) analyse the impact of the employment protection deregulation on the labour share using a dataset of major labour market reforms to employment protection, finding substantial negative effects.

2.3 The structural change channel

Changes in the overall labour share can be partly attributed to structural changes towards industries supposedly characterised by lower-paid jobs, or more capital-intensive ones, both in material and in immaterial capital, such as pharmaceutical and chemical sectors (Chen et al., 2018). de Serres et al. (2002) found that structural changes from manufacturing to services accounted for most of the shift in the labour share of advanced economies pointing to deindustrialisation as a major determinant of the fall. The importance of the rise of services is confirmed by Arpaia et al. (2009) and Riccio et al. (2022) in the context of GVC integration. Rodrik (2016) emphasises that the manufacturing sector was historically characterised by a higher unionisation level, thus strengthening the labour movement[5].

In a similar vein, financialization (i.e. structural change towards the financial sector) exacerbates both deindustrialisation (Botta et al., 2022) and labour share decline, as highlighted by a recently booming literature (Pariboni and Tridico, 2019; Stockhammer, 2017; Lazonick, 2012, for a full account of possible mechanisms). At the micro level, the financialization of firms involves strategies including cutting wages through increased flexibility in the labour market, accumulating financial assets through share buy-back, highly leveraged mergers and acquisitions and increasing involvement in financial activities. Consequently, firms may perceive financial activities to be more profitable than their core business, prompting them to reallocate resources away from the industrial sector. Moreover, the financial ownership structure of firms can influence decisions regarding closures and layoffs, disproportionately affecting workers compared to traditional industrial ownership structures.

[4] However, the importance of the welfare state is often measured using overall government spending, which does not consider changes in spending composition. Kristal (2010) used government civilian spending, but this still does not capture specific details in spending, such as the type of benefits and cash transfers, which affect differently workers' welfare and bargaining power of labour.

[5] In this sense, deindustrialisation might represent a threat not only to workers but more in general to democracy (Rodrik, 2013). We tend to agree.

At the same time, increasing evidence points to the role of the shift in the occupational structure in determining the labour share fall (Guschanski and Onaran, 2023; Reshef and Santoni, 2023; Dao et al., 2020; Dimova, 2019). Such evidence reveals that the impacts of the decline in labour share vary across different occupations, with elementary occupations classified as "routine-intensive" experiencing a significant decrease in their share. The analysis of shifts in the occupational structure is closely linked to the aforementioned technological channel and, even more prominently, to the globalization channel, which will be discussed in the following paragraph.

2.4 The globalization channel

What has been the impact of "globalization" of production on income distribution?

Overall, globalization does not appear to exert any positive impact on labour income. Studies have highlighted the adverse effects of trade liberalization and integration on personal income inequality in both developed and developing countries (Roser and Crespo Cuaresma, 2016; Jaumotte et al., 2013; Meschi and Vivarelli, 2009; Feenstra and Hanson, 1996; Wood, 1995; Freeman, 1995). Moreover, numerous studies have found significant negative impacts of globalization on functional income distribution at all levels of development (Jayadev, 2007; Harrison, 2005; Rodríguez and Rodrik, 1999).

International political economy highlights that the transformation in the bargaining positions of labour and capital is also due to their different mobility structure (Pariboni and Tridico, 2019; Stockhammer, 2013b; Rodríguez and Rodrik, 1999).

The point is quite intuitive. If production is relocated from a high-wage, highly unionised, country, say Sweden, to another low-wage one with no independent union, say China, the worker bargaining power is bound to decline worldwide.

This perspective explains the concurrent decline in the labour share in both developed and developing countries and suggests that, in contrast to (neo)classical trade theory, even integration among similar countries can affect income distribution. For a given capital-output ratio, globalization can impact the relative bargaining power of capital versus labour. For instance, trade liberalization through the removal of barriers can increase the mobility of capital by reducing relocation costs, thereby increasing the credibility of the threat to workers of being laid off (e.g. Jayadev, 2007; Harrison, 2005). Rodríguez and Rodrik (1999) also shows, extending the bargaining channel to a global context, that trade liberalization benefits capital. The shifts in income distribution occur because of the augmentation and redistribution of rents, rather than the equalization of factor costs as proposed in the Stolper-Samuelson theorem. [6].

2.5 The GVCs channel: the role of the international division of labour

Yet another reason for the failure of the SS theorem to capture the distributional effects of globalization is the shift that occurred in the nature of trade since the 1980s with the emergence of GVCs (Gereffi, 1999). This process, also referred to as the globalization "second unbundling" (Baldwin, 2011), involves the increased trade of intermediate inputs rather than final products

[6] Interestingly, Epstein and Burke (2001) argue that redistribution can occur without changes in production locations due to threat effects.

and is enabled by decreasing communication and transportation costs. As a result, firms are able to divide production into various stages and take advantage of cost disparities across countries for different inputs (Grossman and Rossi-Hansberg, 2008; Feenstra and Hanson, 1996).

The literature has extensively examined the relationship between participation in GVCs and the evolution of wages and productivity (Pahl and Timmer, 2019; Gereffi, 1999). Results from these studies provide valuable insights into the complex relationship between GVC participation and functional income distribution.

Some studies have found that GVC participation has had a positive impact on productivity, both at the firm and sector level, in both advanced and developing countries. GVCs may provide advanced countries with access to a greater variety of cheaper inputs (Grossman and Rossi-Hansberg, 2008) and emerging economies with access to higher-quality imported inputs and increased knowledge spillovers (Tajoli and Felice, 2018; Foster-McGregor et al., 2016). In addition, international fragmentation of production allows for the leveraging of economies of scale through specialisation (Criscuolo and Timmis, 2017). Empirical evidence has supported the finding that these productivity gains extend to both manufacturing and service functions (Milberg and Winkler, 2011; Amiti and Wei, 2009). On the other hand, evidence on the impact upon wages and labour conditions - along value chains is somewhat limited (Milberg and Winkler, 2011). From a firm's perspective, reducing production costs is often a primary consideration in the decision to relocate production abroad. As such, offshoring often occurs not surprisingly in countries with cheap labour, leading to lower unit labour costs (Gimet et al., 2015; da Silveira, 2014). At the same time, Shepherd (2013) argues that overall GVC integration leads to widening wage inequality by driving up wages for skilled workers compared to unskilled ones, who make up the majority of the workforce. Milberg and Houston (2005) argue that relying on low unit labour costs can be a *"low-road"* strategy for developing countries to succeed in the global economy, while the *"high-road"* strategy involves specialising in innovative manufacturing sectors and upgrading towards knowledge-intensive activities, which requires higher levels of absorptive capabilities and efforts. Pavlínek (2020) has highlighted the potential risks associated with the reliance of developing countries on low labour costs to attract Foreign Direct Investment (FDI). This strategy could impede emerging countries from obtaining an advantageous position within the global economy, as it reinforces their role as a low-cost production centre susceptible to competition from other developing nations with even cheaper labour costs.

Some studies link the worsening tendency of wages (and particularly those of unskilled workers) with the properties of a purported production function, and the derived factor demand. So for example, Dao et al. (2020) suggest that increased participation in GVCs is associated with rising capital intensity, particularly in emerging and developing economies.

Elsby et al. (2013) suggest that the global decline in labour shares can be understood by considering that tasks that are labour-intensive in advanced economies are relatively capital-intensive compared to existing tasks in the economies to which they are offshored, leading to an increase in capital shares in both sending and receiving economies. This idea aligns with that proposed by Wood (1995) and Feenstra and Hanson (1996) who argue that low-skilled tasks offshored from advanced economies are considered relatively high-skilled tasks in recipient emerging economies.

The problem concerning all this literature is that canonic production functions are nowhere to be seen, either at the micro or at the macro levels. Heterogeneity and technology gaps are very general properties that apply both across countries, but also within countries and within single sectors and activities. Typically, one observes at all levels of observation, techniques that are dominated by others, regardless of relative prices. In fact, developing countries tend to be less efficient in the use of both labour and capital - i.e. they tend to display also higher capital/output ratios than more advanced counterparts (for a more in-depth discussion see Dosi (2023) and specifically on China Yu et al. (2015)). Under these circumstances, trade flows tend to be driven by sector- and activity-specific absolute advantages/disadvantages and by relative labour costs (Dosi et al., 1990; Dosi and Tranchero, 2021). If anything, "globalisation" strengthens those patterns, also allowing the "visible hand" of multinational investment to exploit the foregoing trade-offs on the grounds of the technologies that MNCs are able to master internationally.

All this bears straightforward implications in terms of the functionally related international division of labour as well. In fact, research on the *smile curve hypothesis* (Mudambi, 2008) has highlighted the challenges that emerging economies face in achieving functional upgrading within GVCs. One aspect of upgrading, which is central to economic development, involves diversifying production towards more complex goods (Pietrobelli and Rabellotti, 2010). Conversely, GVC integration tends to favour task specialisation, with advanced countries undertaking high-value added and knowledge-intensive tasks, such as managerial and R&D activities, while leaving more routine-intensive and low-value added occupations to developing countries (Stöllinger, 2021; Timmer et al., 2019). The inability to move up along the value chain is particularly detrimental for developing countries, as a country's position in the GVC also affects the scale, composition, and wages of labour engaged in GVC activities (UNCTAD, 2013). At the same time, the adoption of modern technologies by offshoring MNCs in developing countries can diminish the comparative advantage of those low-income countries in traditional manufacturing sectors. Simultaneously, cost-cutting strategies implemented within GVCs can exert downward pressure on the income share received by developing countries. These processes disproportionately impact low-skilled workers in developing countries (but also developed ones), making them particularly vulnerable to adverse effects on their remuneration and employment prospects.

3 Data and Methodology

3.1 Data

We use industry-level input-output tables from the World Input-Output Database (WIOD) (Timmer et al., 2014) and the Socio and Economic Account (SEA) to obtain employment, value added, capital, and labour compensation data for 43 countries (plus one "Rest of the World" category) and 56 sectors. These data are available for the period from 2000 to 2014 and are classified at the 2-digit level using the NACE Rev. 2 classification system. The WIOD (2016 Release) provides final demand data as the sum of five categories: household final consumption expenditure, non-profit organisation expenditure, government expenditure, gross fixed capital

formation, and changes in inventories and valuables. Gross output data is also provided by the WIOD[7].

Occupation data come from Timmer et al. (2019). The authors, building upon the national accounts and labour force surveys, construct an extensive dataset which divides country-industry employment figures into four broad occupation classes: R&D, Managerial, Fabrication and Marketing activities. The data also includes the contribution of each occupational category to the overall wage bill in each industry. Information on occupational structure spans over the period 1999-2011 for 41 out of 43 countries and 35 industries covered by WIOD. We use these data to obtain employment and wage figures disaggregated at the occupation level for each country-industry pair.

In this study, we limit the analysis to manufacturing industries in 41 countries between 2000-2007, grouped into "developed" and "developing" (plus transition, ex-socialist) ones. Our analysis focuses solely on the manufacturing sector as the four production stages are more akin to describing manufacturing activities. For instance, while fabrication workers within the manufacturing sectors are mainly blue-collar workers, in the service sector, this class of workers encompasses from trade helpers and practitioners to drivers and soldiers.

Furthermore, we decided to exclude the post-crisis (2008-2011) period, although available, for two reasons. Firstly, we recognize the short-run counter-cyclical nature of the labour share, which could bias our results during this period. The literature on labour share shows that wages are less flexible than profits, resulting in a short-term increase in the labour share after a downturn. As shown in Riccio et al. (2022), this cyclical dynamic reverted to its pre-crisis trend around 2010, leaving no room for meaningful inclusion of the post-crisis years. Secondly, Timmer et al. (2021) highlights a significant decline in GVC participation since the 2008 crisis. Thus, we are focusing our analysis on what the GVC literature considers the last upswing in GVC integration.

3.2 Methodology

Let us begin by constructing the main variable of interest, namely the share of value added going to labour throughout the whole production process. We employ the information from I-O tables containing data on intermediate products that flow across industries as well as across countries. In the first step, we employ Leontief (1936) methodology to compute the world-wide contributions to final production. Then we trace the value added share going to labour in the different production stages of GVCs building upon the approach of Chen et al. (2017) and Timmer et al. (2014). Chen et al. (2017) propose to disentangle the value added in trade between income shares of labour, tangible and intangible assets. Reshef and Santoni (2023) directly track the factor shares in value added considering the input-output structure of production. We advance with respect to the literature proposing a measure of labour share along foreign backward linkages.

As depicted in figure 1, we split the whole production process into three stages:

[7] To eliminate the effect of price dynamics, we use a specific deflation method to convert the WIOD data from current prices to constant prices (2000 base year). Further details on the deflation procedure can be found in Appendix B.

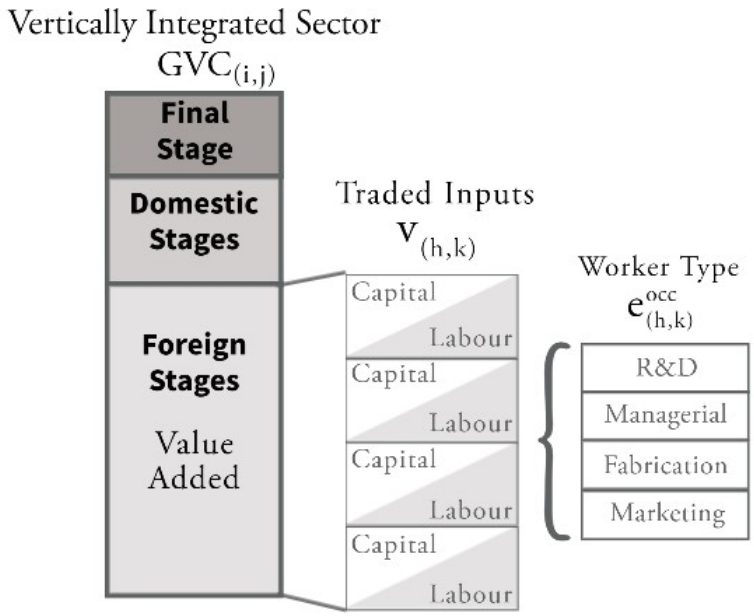

Fig. 1. Income decomposition in a vertically integrated sector

1. the final stage of production (*Fin*) which identifies the country-industry pairs receiving inputs from other domestic and foreign industries to finalise the production process. We identify global value chains based on the final stage of production;
2. domestic stages of production (*Dom*) that comprise manufacturing inputs produced in the same country of the final stage and thus that do not cross the border;
3. the foreign stages of production (*For*) that encompass traded intermediaries produced in foreign countries.

The sum of value added across these stages of production coincides with the value contained in the final product. Afterwards, we decompose the value added in each stage into income payments for labour and capital (as shown in figure 1). Our units of analysis are GVCs defined as the country-industry pairs where the final stage of production takes place (e.g. the GVC of cars finalised in the German automotive industry). In this investigation, we confine our analysis to the dynamics of the foreign stages of production. Our decomposition method is based on the approach presented by Chen et al. (2017) and Timmer et al. (2014), which is an extension of the method proposed by Leontief (1936) for multiple countries. The fundamental input-output identity states that the total output (denoted by vector q) is equal to the sum of the intermediate inputs needed for production (described by matrix $\boldsymbol{A}q$) and the final demand (consumption) levels in each industry (described by vector fd). In other words:

$$q = (\boldsymbol{I} - \boldsymbol{A})^{-1} fd = \boldsymbol{L} fd \tag{1}$$

where $\boldsymbol{I}$ is the identity matrix and $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ is known as the Leontief inverse or "total requirements matrix." The vectors q and fd each have ij elements, where j represents the number of countries and i represents the number of industries in each country. The matrix $\boldsymbol{A}$ is an ij x ij matrix with input coefficients that describe how many intermediates are needed from any country-industry to produce one unit of output. The Leontief inverse allows us to determine the total output of all industries required in the production process of a specific final product. For

example, let z be an ij-dimensional column vector with a 1 in the element corresponding to the production of cars in Germany and 0s elsewhere. Then $\boldsymbol{A}z$ represents the intermediate inputs (both domestic and foreign) needed to produce one car in Germany, such as tires, engines, and transmissions. However, this is just the first round of production since these intermediates also need to be produced using inputs coming from other country-industries. By summing over all rounds, we can determine the total output of all industries (in all j countries and i industries) required to produce cars through $(\boldsymbol{I} - \boldsymbol{A})^{-1}z$, this geometric series represents the convergence of the sum over all rounds. Alternatively, in order to measure the contribution in terms of value added instead of gross output, we need to pre-multiply the Leontief inverse by $\hat{v}$, a diagonalized vector accounting for the value added to output ratios in each country-industry pair. In this way, we obtain the matrix with direct and indirect value added contributions to each final production.

$$\boldsymbol{V} = \hat{v}\,\boldsymbol{L}\,\hat{fd} \tag{2}$$

The columns of this matrix are defined as international production subsystems, or vertically integrated sectors (Momigliano and Siniscalco, 2017; Pasinetti, 1973) and represent the value added incorporated in intermediate production stages induced by the production of final goods. In the final step, we compute the labour share of each vertically integrated sector (i, j), such as the labour share of the entire German Automotive value chain, or a subset of it, such as the labour share of inputs coming from developing countries. Thus, we use the elements $v_{h,k}$ of the value added matrix $\boldsymbol{V}$ as weights to derive the GVC labour share as follows:

$$LS_{(i,j)} = \sum_{(h,k)\in(i,j)} \frac{v_{(h,k)}}{\sum_{(h,k)\in(i,j)} v_{(h,k)}} ls_{(h,k)} \tag{3}$$

where $v_{(h,k)\in(i,j)}$ represents the input from industry h in country k contributing to the value chain of subsystem i in country j. Therefore, $LS_{i,j}$ - the labour share of the subsystem (i, j) - is computed as the weighted sum, in terms of valued added shares, of the labour shares ($ls_{(h,k)}$) across industries inside the vertically integrated sector (i, j). In this paper, we focus on the imported inputs of each chain thus considering only intermediates such that $k \neq j$.

4 Descriptive Statistics

4.1 Overall labour share decline

Figure 2 offers a first insight into the dynamics of the labour share in vertically integrated sectors from 2000 to 2007. The unit of analysis is the vertical value chain as defined by its final stage of production; we focus on income distribution shifts in the foreign stages with a focus on manufacturing. Points lying below the bisector are chains in which the labour share has fallen while the opposite holds for points above the red line. The figure shows that there was a decline in the labour share in almost all of the chains during this time period. However, first, workers producing intermediate inputs in advanced countries were able to secure a significantly larger share of value compared to their counterparts in developing countries. This share ranges from 0.55 to 0.75 for advanced countries, while in developing countries it only reached 0.55 as the maximum value. This documented drop in the vertical dimension is in line with previous research that has consistently found that advanced economies tend to have higher

labour shares (Reshef and Santoni, 2023; Riccio et al., 2022; van Treeck, 2020; Dao et al., 2020). Second, the decline in labour share in developing countries was much more pronounced compared to developed ones. Both phenomena highlight the lack of international convergence in labour share within GVCs and across groups of countries.

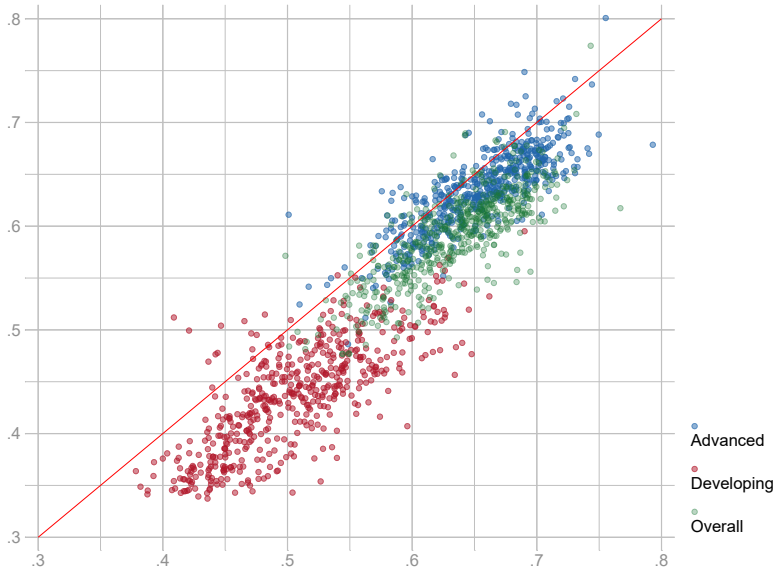

Fig. 2. Points represent the labour share in 2000 (on the x-axis) and 2007 (on the y-axis) in each $GVC_{(i,j)}$ foreign stages. Observations are grouped into inputs produced by advanced and developing countries.

The labour share declines whenever productivity increases more than wages. Figure 3 examines wage and productivity growth within global value chains to shed light on the heterogeneous decline in labour share across development levels. We use the intersectoral value added requirements matrix as a weight to compute the wage and productivity of the backward linkages of each chain. The figure compares growth in these two variables between 2000 and 2007, with the unit of analysis being the global value chains and inputs split between advanced and developing countries. Points above the red line indicate cases in which productivity gains, along each given GVC, have exceeded increases in labour input remuneration. The observed dynamic confirms a general decline in the labour share. The figure vividly highlights the notion of a worldwide decoupling between productivity and wages, as previously noted in the literature (Dosi et al., 2020; Economic Commission, 2007). While productivity growth presents quite similar profiles between advanced and developing countries' inputs, - supporting the efficiency driver behind GVCs - wage growth is extremely different. The difference between the two distributions, as such, might hint at the strategic use that "firms" on top of the chain make of GVC participation: similar productivity growth across inputs, ensured by strict control of the production process and digital monitoring (Kano et al., 2020; Foster et al., 2018), are matched by asymmetric inputs remuneration according to the country of location of a particular activity. Therefore, the larger decline in the labour share in developing countries must be attributed to the lower wage growth compared to productivity gains. Symmetrically, developing countries have engaged in wage compression strategies in order to secure and expand their participation in GVCs.

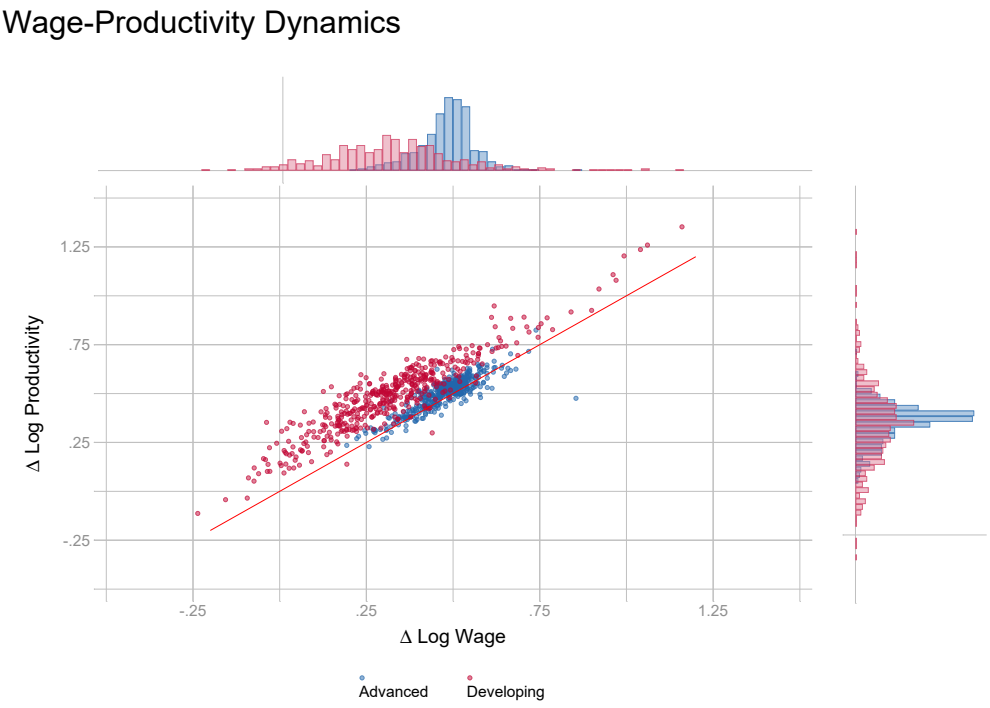

Fig. 3. Productivity-Wage dynamics in GVCs' foreign stages between 2000 and 2007, disaggregated by development level.

How is the labour share distributed across occupations/functions?

As shown in table 1, we have analysed the changes in employment levels and implied labour shares for four different occupation categories: R&D, Managerial, Fabrication and Marketing activities. The implied labour share is calculated by dividing the specific wage for a particular occupation by the industry-level productivity. Therefore, we look at how the overall value added is distributed across functions. The contribution of each group of occupations/function per value chains is given by Timmer et al. (2019). Our analysis reveals two key trends. First, we observe a generalized decline in the labour share for each occupation, in both developed and developing countries. Therefore, if anything, profits have gained from GVCs, while the labour share, independently from the functions, experienced a decline. Second, so-called upstream occupations in production chains according to the "smile curve" literature (Meng, Ye, and Wei, 2020; Rungi and Del Prete, 2018; Mudambi, 2008), such as R&D and managerial activities, have experienced the largest declines in developing countries. It is worth noting that these activities are characterized by particularly high relative labour shares and, despite the decline, they remain far above those in downstream occupations. In addition, in contrast with any Stolper-Samuelson hypothesis on "factor price equalisation", wages in fabrication activities have fallen even in developing countries, where they constitute the largest share of the employed labour force and experience higher demand.

4.2 Functional specialisation along GVCs

By tracking the employment levels at each stage of production, we can account for the functional specialisation dynamics in the foreign stages of each global value chain. This allows us,

	Advanced			Developing		
	$EmpSh^{occ}_{2007}$	LS^{occ}_{2007}	ΔLS^{occ}	$EmpSh^{occ}_{2007}$	LS^{occ}_{2007}	ΔLS^{occ}
R&D	0.160	0.826	-0.084	0.044	0.896	-0.152
Management	0.068	1.429	0.046	0.038	1.001	-0.366
Fabrication	0.577	0.478	-0.042	0.763	0.324	-0.052
Marketing	0.195	0.633	0.025	0.155	0.423	- 0.150

Table 1. Employment share, implied labour share and its shift in four broad occupation categories.

for example, to determine the share of fabrication workers needed to produce the wheels that will be used to construct a car in the automotive industry in Germany. We can then use this information to investigate the "revealed comparative advantage" of inputs from advanced and developing countries in order to detect, for each given chain, the patterns of specialisation.

When we split the production process into pre-production (i.e. upstream) and post-production (i.e. downstream) activities, inputs from developed countries tend to be specialised in upstream activities as R&D and managerial functions, more knowledge-intensive but also responsible for decision-making and control of the chain. Figure 4, which compares the revealed comparative advantage (RCA) of foreign inputs from advanced and developing countries, clearly shows it. These specialisation patterns have become more pronounced over the years of observation. Our findings align with those in the global value chain literature, according to which upstream functions are more concentrated in developed countries, and the opposite for downstream functions (Stöllinger, 2021; Timmer et al., 2019). In fact, we confirm the existence of a smile curve specialisation pattern in developed countries (top panel) and a slightly reversed hump-shaped pattern in developing countries (bottom-panel), emerging at the end of the period.

We then examine the relationship between functional specialisation and relative wage by occupation within the context of global value chains. The Stolper-Samuelson (SS) theorem predicts that as a country becomes more specialised in providing some occupations/functions, its relative wage in these activities would increase. We may test the adequacy of this prediction in a GVCs context by analysing the relationship between changes in backward linkages' RCA and their relative wage. A positive relationship between RCA and relative wages would corroborate it. The degree of specialisation in each given occupation is a standard Balassa index that takes into account occupations and their sectoral distribution. Therefore, the RCA is computed as the deviation of industry-specific averages.

$$RCA^{occ}_{(h,k),t} = \frac{e^{occ}_{(h,k),t} / e_{(h,k),t}}{\sum_k e^{occ}_{(h,k),t} / e_{(h,k),t}} \tag{4}$$

where RCA is the Revealed Comparative advantage by occupation in each of the backward linkage (h,k) of each GVC (i,j). The graph presented in Figure 5 illustrates the correlation between changes in relative wages and Revealed Comparative Advantage (RCA) per each functional category during the period under examination. Contrary to the canonical theoretical prediction, our analysis reveals signs of a negative relationship, if any, between the two variables. This negative correlation is particularly evident in the case of R&D activities for

both advanced and developing countries. Furthermore, the data indicate that relative wages in developing countries are growing only for R&D workers. In contrast, in developed countries, managerial occupations are those growing the most, followed by marketing.

Overall, our findings challenge the conventional assumption that there is a positive relationship between changes in relative wages and specialisation patterns. Thus, we must further study of the dynamic relationship between wages, comparative advantages, and occupation structure along GVCs. In the next section, we advance along these lines.

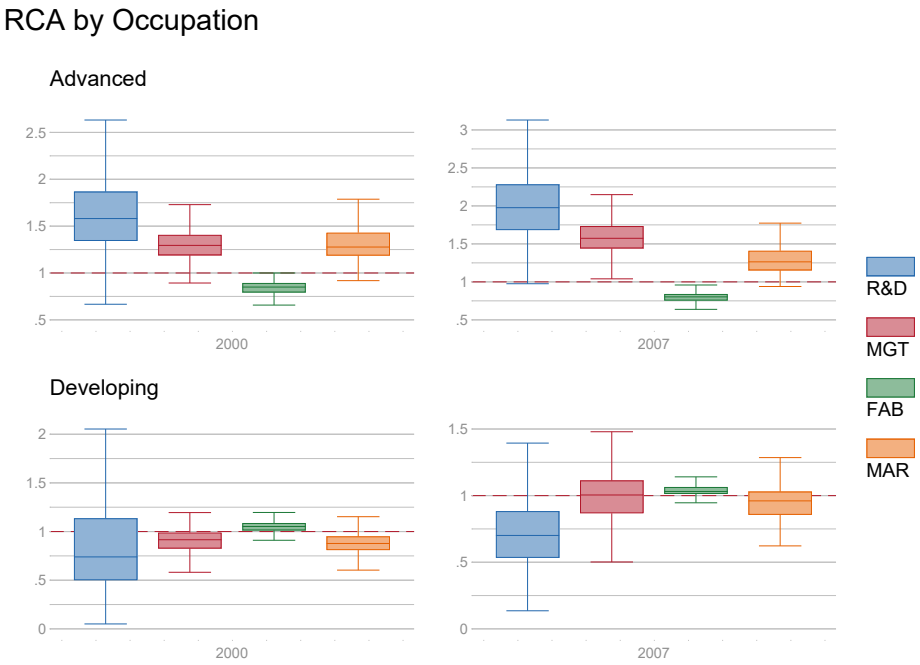

Fig. 4. Functional specialisation patterns on GVCs' foreign stages. The figure presents initial and final year distributions divided between advanced and developing countries.

5 Shift-Share analysis

So far, we have documented a large and generalised drop in the labour share across all functions of interest, affecting both developed and developing countries. However, changes in the vertical labour share can happen for different reasons.

To account for the different sources of change, we undertake a shift-share analysis divided into three components. In eq. 3 we define the foreign labour share as the weighted average of the labour share in all the foreign labour inputs, using value added as weights. Next, we track different wage dynamics for each of the four functions. Thus, in eq. 5 we decompose the overall variation in three components:

– *between-input* (GVC reshuffling) component: tracks the recombination of inputs along the chain, keeping fixed the country-industry-specific labour share and its occupation structure. It can be interpreted as a form of GVCs' structural change.

Fig. 5. Relative wage and specialisation dynamics by function and development level.

– *within-occupation* component: accounts for changes in occupation-specific labour share keeping fixed GVCs' inputs composition and the occupational structure. It accounts for input-specific wage-productivity dynamics.
– *between-occupation* (within-input) component: it measures the effects of changes in functional specialisation and concentration of types of productive inputs in specific countries, keeping fixed the structure of inputs and the wage-productivity relative changes.

$$\Delta LS_{(i,j),t} = LS_{(i,j),t} - LS_{(i,j),t-1} = \Delta \sum_{(h,k,)\in(i,j)} \sum_{occ} \overbrace{\frac{v_{(h,k),t}}{\sum_{(h,k)} v_{(h,k),t}}}^{vash_{(h,k),t}} \underbrace{\frac{e^{occ}_{(h,k),t}}{e_{(h,k),t}}}_{empsh^{occ}_{(h,k),t}} \overbrace{\frac{w^{occ}_{(h,k),t}}{v_{(h,k),t}}}^{\frac{w^{occ}_{(h,k),t}}{\pi_{(h,k),t}} = ls^{occ}_{(h,k),t}} =$$

$$= \overbrace{\sum_{(h,k,)\in(i,j)} \sum_{occ} \Delta vash_{(h,k),t} \left(\widehat{empsh^{occ}_{(h,k),t}\, ls^{occ}_{(h,k),t}} \right)}^{BetweenInputs} +$$

$$+ \overbrace{\sum_{(h,k,)\in(i,j)} \sum_{occ} \Delta empsh^{occ}_{(h,k),t} \left(\widehat{vash_{(h,k),t} ls^{occ}_{(h,k),t}} \right)}^{BetweenOccupation} +$$

$$+ \overbrace{\sum_{(h,k,)\in(i,j)} \sum_{occ} \Delta ls^{occ}_{(h,k),t} \left(\widehat{vash_{(h,k),t} empsh^{occ}_{(h,k),t}} \right)}^{WithinOccupation} \tag{5}$$

Where the notation (i, j) refers to sector i in country j performing the final stage of production, and (h, k) refers to the different stages in industry h of country k producing the inputs then used by (i, j). We also use the categories of occupation (Occ) in our analysis to disaggregate the industry-specific wage bill. The variables v, e, w π represent value added, employment, wages and productivity, respectively. While $empsh$ and $vash$ are employment and value added shares. The Δ refers to changes between 2000 and 2007. The decomposition procedure is fully described in Appendix C.

Figure 6 presents the results of the shift-share analysis described in equation 5. The top panel of the figure illustrates the overall outcomes of the shift-share analysis, displaying within-occupation, between-occupation and between-inputs components and their respective sum which correspond to the overall change in the labour share. The bottom panels provide a more detailed breakdown of the shifts by occupation, allowing for a deeper understanding of the role of functional specialisation. Our units of analysis are GVCs which we divide into foreign inputs coming from advanced and developing countries, respectively. Then, we aggregate results using GVCs value added as weights.

Our analysis reveals that virtually all occupations have experienced a decrease in their within components, indicating that workers across all industries have seen a decline in bargaining power relative to capital. This trend holds across advanced and developing countries, despite their different specialisation patterns. The most affected group is fabrication workers, which alone account for most of the labour share decline in both advanced and developing countries.

The shift-share analysis adds to the picture the relevance of the between-occupation component, the only one presenting a positive contribution. In fact, our analysis shows that in advanced countries, the reshuffling towards upstream occupations has *partially* offset the loss in the within-occupation component. In contrast, in developing countries, the between-occupation reshuffling has not been enough to counteract the decline in the within-component labour share.

The decline in foreign inputs from developing countries is more than four times larger than the one of intermediaries produced in advanced countries. During the same period, that very increase of the penetration of developing countries' inputs in global value chains has contributed to a greater worldwide decline in the labour share (Riccio et al., 2022). The latter phenomenon is revealed by the between-input component which has a negative impact on worldwide labour income, due to a shift in production towards inputs with lower labour shares, in line with the wage compression strategies often undertaken in developing countries. Notably, R&D workers in advanced countries are the only group that benefits from these changes.

6 Econometric setting

So far, we have documented that the largest contribution in the vertical labour share decline derives from the within-occupation component, while the between-occupation component exerts a (lesser) positive contribution, - i.e. only the reshuffle toward upstream R&D and managerial functions have favoured labour income, driven by R&D occupations in advanced countries-. In this section, to further assess the determinants of the labour share decline along GVCs' and in particular the role of occupational reshuffling, we perform a cross-country panel regression that

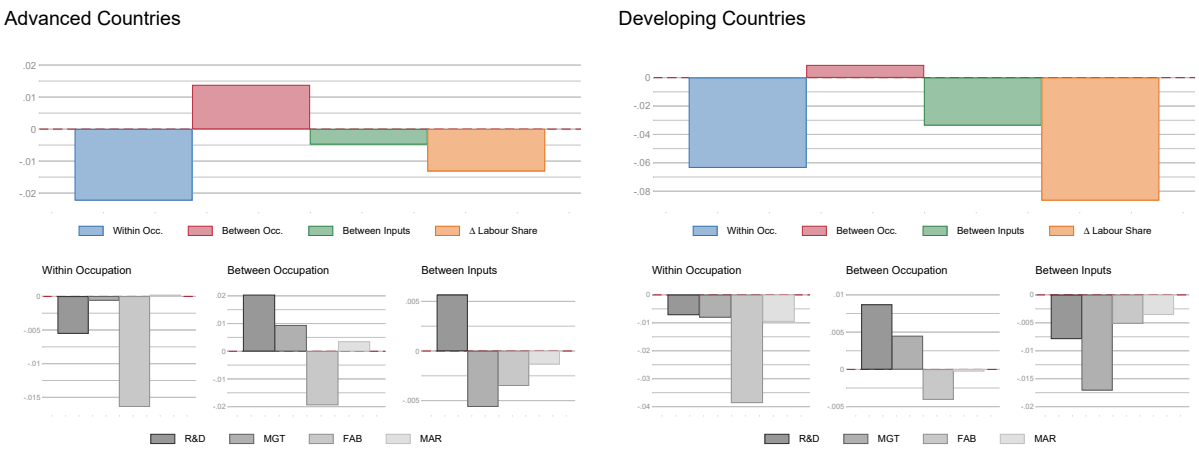

Fig. 6. Shift-share analysis presented in eq 5 aggregated at manufacturing level using GVCs' value added.

relates changes in the labour share with changes in the potential alternative channels discussed above in the literature review. Our goal is to disentangle the effects of functional specialisation and occupational asymmetries upon remuneration as distinct from other determinants, such as technological change, worker bargaining power and sheer GVCs participation, with global value chains as the units of analysis.

Since we are interested in understanding the changes in labour share, we estimate a first-difference equation while controlling for the initial values of the dependent variable. This approach has the advantage of eliminating any potential non-stationarity problem. Additionally, we include country-specific fixed effects in the analysis. To construct our explanatory variables, we take advantage of the rich I-O structure and calculate them as a weighted average of the foreign backward linkages of each chain. We use two estimation settings: a cross-country regression for the change between 2000 and 2007, and a year-by-year panel analysis with time-fixed effects added to the estimation framework. The equation to be estimated will be:

$$\begin{aligned}\Delta LS_{(i,j),t} = \alpha_1 LS_{(i,j),t-1} + \alpha_2 \Delta Kemp_{(i,j),t} + \alpha_3 \Delta GVCsh_{(i,j),t} + \alpha_4 \Delta RDSI_{(i,j),t} \\ + \alpha_5 \Delta Union_{(i,j),t} + \alpha_6 \Delta FinalDemand_{(i,j),t} + \gamma_j + \epsilon_{(i,j),t}\end{aligned} \tag{6}$$

Where (i, j) refers to the final step of each chain and is used as the identifier of each observation, t is the time subscript. Δ refers to either 7-year changes in the variables or year-by-year changes in the second estimation strategy. The initial period labour share is introduced as a control to account for potential convergence in GVCs' labour share. In order to partially capture technological change, we introduce the shift in the capital per worker of the chain (i, j) [8].

Our main variable of interest is the Relative Downstream Specialisation Index (RDSI) which is inspired by the one introduced by Stöllinger (2021), however with respect to a different type of data structure (Foreign Direct Investments). The index is expected to capture the role of

[8] Recall that some scholars suggest heterogeneous effects across occupation types with capital expected to be complementary to high-skill-non-routinazable tasks while substituting low-skill workers: see, among the others, Autor and Dorn (2013) and Acemoglu and Autor (2011).

functional specialisation along value chains and it measures occupation's recombination over time across backward linkages. The main advantage of this variable is that it synthesizes the Revealed Comparative Advantage in the four broad occupations into a single indicator. We compute therefore the $RDSI$ for each input (h,k) contributing to (i,j) and aggregate using employment share along each chain (i,j). The numerator of the index incorporates downstream functions (production and post-production functions), while the denominator covers upstream functions.

$$RDSI_{(i,j),t} = \sum_{(h,k,)\in(i,j)} \frac{e_{(h,k),t}}{\sum_{(h,k,)} e_{(h,k),t}} \frac{RCA^{FAB}_{(h,k),t} + RCA^{MAR}_{(h,k),t}}{RCA^{R\&D}_{(h,k),t} + RCA^{MGT}_{(h,k),t}} = \sum_{(h,k,)\in(i,j)} \frac{e_{(h,k),t}}{\sum_{(h,k,)} e_{(h,k),t}} RDSI_{(h,k),t} \tag{7}$$

Note that an input (h,k) having an $RCA = 1$, in say fabrication functions, has exactly the average share of fabrication workers of its industry h (following 4). On the same line, having an $RCA = 1$ in all functions means that the industry h in the country k has precisely the average industry-specific occupational structure. In this case, the $RDSI$ would take value 1. An $RDSI$ higher than 1 means that the input more intensively activates downstream occupations. While a positive value of $\Delta RDSI$ means that the chain is relatively specialising in downstream tasks. In our econometric exercise, the $RDSI$ is meant to gouge the impact of the smile curve distribution of occupations on labour share dynamics[9]. Appendix D proposes some descriptive evidence of the dynamics of RDSI across development levels.

Beyond occupational specialisation, another relevant variable in our inquiry is GVC penetration, measured by the share of value added from foreign inputs. The literature suggests that wage compression strategies might favour GVC integration. Symmetrically, we test the effect of GVC integration on the labour share. We expect that greater penetration of foreign inputs might be linked with a sustained labour share drop.

In order to account for the institutional channel we include a measure of workers' bargaining power, namely the unionisation rate along the chain. We employ the ICTWSS dataset (Visser, 2019), which gives information on unionisation coverage across countries and broad sectors. We match this data with the employment requirements in foreign contributions to compute a measure of vertical unionisation along the chain. For instance, if a particular chain, say the textile industry in Italy is employing 10 workers from the metal industry in China with a union density of 30% and 10 workers from the machinery industry in Germany, with a union density equal to 20%, the overall unionisation density of the chain will be 25%. Although a rough measure, it is one of the few statistics hinting at the degree of bargaining power of workers. We expect this variable to have a positive effect on the labour share.

Finally, we introduce a measure of the change in the final demand of the chain. The variable captures the extent to which changes in market performance, say a sale increase, affect the labour share dynamics. We use the information of WIOD on final demand, aggregating both domestic and foreign consumption, investments, and government expenditure. Table 2 presents the descriptive statistics of the variables employed in the regression analysis.

[9] As a robustness check, we perform the same econometric analysis substituting the RDSI with $RFSI = {RCA^{FAB}}/{(RCA^{R\&D}+RCA^{MGT}+RCA^{MAR})}$ as in Stöllinger (2021) and RCA^{FAB} alone obtaining consistent results.

		Advanced				Developing			
		mean	σ	min	max	mean	σ	min	max
ls	Labour share	0.683	0.045	0.532	0.817	0.459	0.063	0.336	0.687
Kemp	Capital per worker (Mln. $)	144.81	54.38	66.73	601.38	19.05	8.19	3.05	188.59
GVCsh	GVC Penetration (%)	0.102	0.067	0.013	0.313	0.021	.036	0.000	0.157
RDSI	Downstream Specialisation	0.601	0.093	0.387	1.207	1.018	0.360	0.423	3.695
RCA^{RD}	RCA R&D	2.235	0.446	1.071	4.989	1.222	0.536	0.195	3.815
RCA^{MGT}	RCA Management	1.223	0.1916	0.659	2.711	0.888	0.160	0.149	1.450
RCA^{FAB}	RCA Fabrication	0.832	0.047	0.667	0.989	1.029	0.037	0.851	1.233
RCA^{MAR}	RCA Marketing	1.249	0.186	0.892	2.298	0.922	0.096	0.535	1.897
UD	Union Density (%)	27.517	6.499	15.629	59.876	23.935	5.469	13.453	54.430
fd	Final Demand (Mln. $)	13893	39455	-1515	447616	13893	39455	-1515	447616

Table 2. Descriptive statistics of the variables used in the regression analysis, level.

In the second empirical exercise, we investigate occupation-specific dynamics, changing our dependent variable. We maintain the same econometric framework but substitute as the dependent variable the implied labour share by occupation. The implied labour share for occupation k is the labour share that remunerates only workers of that type. In this case, we use occupation-specific RCA^{occ}, according to the following specification:

$$\Delta LS^{occ}_{(i,j),t} = \alpha_1 LS^{occ}_{(i,j),t-1} + \alpha_2 \Delta Kemp_{(i,j),t} + \alpha_3 \Delta GVCsh_{(i,j),t} + \alpha_4 \Delta RCA^{occ}_{(i,j),t} + \alpha_5 \Delta Union_{(i,j),t} + \alpha_6 \Delta FinalDemand_{(i,j),t} + \gamma_j + \epsilon_{(i,j),t} \tag{8}$$

6.1 Baseline analysis

Table 6.1 presents the results of the regression analysis from equation 6. Equation 6 was estimated using data for the entire period (columns 1-3) as well as on a year-on-year basis (columns 4-6). In the latter case, we add year-fixed effects. The use of the yearly dataset allows for a larger number of observations. Additionally, we have split the analysis for inputs coming from developing (columns 2 and 5) and advanced countries (columns 3 and 6) separately, in addition to the analysis on the weighted average of all foreign stages. The results obtained from both estimation procedures are consistent with each other.

Our analysis reveals a general trend of downward convergence of the labour share across different countries and development levels, as revealed by the negative coefficient of the lagged variable in the regression analysis. Changes in capital intensity, as measured by the capital-to-employment ratio in the backward linkages, have a contrasting impact across different development levels. The regression analysis yields a positive relationship in advanced countries, indicating a broad complementarity between capital and labour. On the other hand, a negative

impact is observed in developing countries. These results will be further investigated in the occupation-specific regression analysis presented in Table 4. Our analysis further shows that the penetration of global value chains, measured by the share of value added coming from foreign stages, negatively impacts the labour share. This is evidence of the cross-country dynamics within GVCs leading to wage compression. The estimation results show negative coefficients in both advanced and developing countries, but the impact is greater in the latter.

Notably, increasing functional specialisation in downstream occupations (positive changes in the index) has a negative impact on the labour share in both advanced and developing countries. The negative impact of specialising in fabrication and marketing functions is more pronounced in developing countries than in advanced ones. The variable tracking the union density along the chain shows contrasting tendencies. On average, it seems to have a positive impact, especially in advanced countries, but further analysis at the occupation level is needed. Lastly, changes in final demand have a negative impact on the labour share. We interpret this result as a consequence of market pressure to maintain competitiveness obtained via wage "moderation".

6.2 Occupation-level analysis

In order to further understand the dynamics of the labour share by occupational categories, table 4 presents the results of the same analysis, now with occupation-specific implied labour share as the dependent variable. Looking at the right-hand side, the only difference is that we now substitute the relative downstream specialisation with occupation-specific revealed comparative advantage (RCA^{OCC}), calculated using equation 4. The results are presented with a breakdown by development level.

Looking at the results by broad occupational categories, we do not observe any convergence dynamic of developing countries. The positive coefficient estimated for the initial period labour share suggests a widening gap within occupation across chains. In contrast, all functional categories show a negative sign in advanced countries revealing *downward convergence* within occupational classes. The highest coefficients are for R&D, management, and marketing, while fabrication lags behind. Regarding our "technology proxy," the estimated coefficients of changes in capital per worker are consistent with the results in Table 4. We find negative coefficients for 3 out of 4 categories in developing countries, while the coefficients for advanced countries are mostly positive but not significant. Interestingly, the coefficient for capital per worker in fabrication operations in developing countries is positive, suggesting, a somewhat counter-intuitively, potential complementarity. Increased GVC participation negatively affects all functions in developing countries, while the impact on advanced countries' workers is mixed and not significant.

Considering the relationship between the RCA and labour share, we estimate negative coefficients for fabrication workers. This coefficient is particularly high in developing countries. The only occupation category for which we estimate an unambiguously positive relationship is R&D workers. Even when looking at the other upstream category, managerial workers, the results point to a negative relationship.

Final demand shows widespread negative coefficients in developing countries, while only for fabrication workers in advanced countries. This might be due to the downward pressure

	(1)	(2)	(3)	(4)	(5)	(6)
	7 year			**Year-on-Year**		
	Foreign	Developing	Advanced	Foreign	Developing	Advanced
$InitLS$	-0.305***	-0.399***	-0.232***	-0.047***	-0.034***	-0.052***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta Kemp$	0.030**	-0.073***	0.031*	0.051***	-0.002	0.046**
	(0.023)	(0.000)	(0.069)	(0.001)	(0.801)	(0.025)
$\Delta RDSI$	-0.061***	-0.214***	-0.119***	-0.054***	-0.200***	-0.041**
	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.035)
ΔUD	-0.016	0.004	0.013*	0.002	0.068***	0.008***
	(0.293)	(0.862)	(0.062)	(0.868)	(0.000)	(0.002)
ΔGVC	0.003	-0.035***	-0.012**	-0.012**	-0.021***	-0.016***
	(0.733)	(0.003)	(0.019)	(0.024)	(0.000)	(0.008)
ΔFD	-0.020***	-0.046***	-0.028***	-0.007***	-0.009***	-0.010***
	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)
Obs.	511	511	511	3,618	3,618	3,618
R-sqr	0.691	0.703	0.613	0.631	0.669	0.530
Country FE	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	YES	YES	YES

Table 3. Regression results for eq. 6. P-value in parentheses, clustered at the country level. * p<0.1, ** p<0.05, *** p<0.01. Columns 1 to 3 are estimated using only initial and final period data, while from 4 to 6 are estimated using year-on-year observation. Results are presented for the whole foreign stages and then for advanced and developing inputs separately.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	R&D		**Managerial**		**Fabrication**		**Marketing**	
	Dev.	Adv.	Dev.	Adv.	Dev.	Adv.	Dev.	Adv.
$InitLS$	-0.059	-0.275***	0.416***	-0.212***	0.163***	-0.142**	0.102***	-0.212***
	(0.251)	(0.000)	(0.000)	(0.000)	(0.000)	(0.022)	(0.005)	(0.000)
$\Delta Kemp$	-0.111***	-0.040*	-0.159***	0.052	0.070***	-0.031	-0.101***	0.044**
	(0.000)	(0.083)	(0.001)	(0.100)	(0.000)	(0.263)	(0.004)	(0.043)
ΔRCA^{occ}	0.171***	0.060*	-0.311***	-0.122**	-1.868***	-0.272**	-0.119	0.363***
	(0.000)	(0.065)	(0.001)	(0.014)	(0.000)	(0.018)	(0.103)	(0.000)
ΔGVC	-0.039**	-0.012	-0.144***	-0.014	-0.046***	0.020**	-0.076***	-0.011
	(0.038)	(0.272)	(0.000)	(0.280)	(0.000)	(0.050)	(0.001)	(0.279)
ΔUD	-0.198***	-0.427***	-0.163*	-0.308***	0.089***	0.166**	-0.131***	-0.027
	(0.000)	(0.000)	(0.056)	(0.000)	(0.000)	(0.050)	(0.002)	(0.791)
ΔFD	-0.022**	-0.011	-0.070***	0.002	-0.014**	-0.041***	-0.061***	-0.003
	(0.020)	(0.103)	(0.000)	(0.712)	(0.022)	(0.000)	(0.000)	(0.653)
Obs.	511	511	511	511	511	511	511	511
R-sqr.	0.646	0.615	0.704	0.522	0.767	0.596	0.651	0.433
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 4. Regression results for eq. 6 disaggregated at the occupation level. p-value in parentheses, clustered at the country level. * p<0.1, ** p<0.05, *** p<0.01. Results are presented for advanced and developing inputs separately.

on workers' share of value added due to competition in final good markets that stimulates cost/wage reduction strategies.

A very interesting piece of evidence relates to backward union density changes. The estimation procedure returns positive coefficients for fabrication workers in both advanced and developing countries, while it is negative for all other groups. We interpret the result as evidence of the effectiveness of union density for the most vulnerable workers in the chains. At the same time, upstream occupations appear to be penalised by increased union density, hinting at an asymmetric bargaining power process. Overall, in line with the literature, unionisation helps in lowering wage inequality.

7 Concluding remarks

In this paper, a novel reconstruction of the labour share along GVCs, matched with functional-level data, allows a new empirical investigation of the impact of the asymmetric power structures entailed by GVCs upon the remuneration of labour inputs.

Our methodology enables us to look at a quite heterogeneous country sample, documenting the strong compression in the labour share generated within GVCs. In addition to the detrimental effect in terms of the overall functional income distribution, when accounting for the distinct functions along the chain, say upstream and downstream ones, we clearly document a remarkable loss for "downstream" production workers.

We extensively examine the adverse impacts of global value chains on labour shares from various dimensions.

First, we observe a general decline in the vertical labour share during the whole period under investigation (2000-2007) at the peak of the globalisation phase, with developing countries experiencing more significant effects.

Second, relatedly, we find no evidence of any "factor-price equalisation" as implied by the Stolper-Samuelson theorem as well as by all theories predicting equalizing effects of greater international integration via both trade and Direct Foreign Investments. On the contrary, divergence and polarization seem to dominate.

Third, when disaggregating among different groups of labour inputs, GVCs appear to exert a particularly strong negative impact on lower-paid functions/workers.

Fourth, our econometric estimates highlight the negative contributions of foreign value added penetration and specialisation in downstream occupations. Consistent results are obtained from both the first difference and year-to-year estimates. We examine their influence while accounting for alternative factors such as technological and institutional variables that could have contributed to the decline in the labour share. Notably, when conducting the analysis by distinct occupations, we observe a clear negative effect of downstream functional specialisation on the corresponding occupation labour share.

The bottom line of our whole analysis is that a general consequence of deepening GVCs is the increasing capture of value by capital and corresponding compressed share of labour - as the outcome of both trade specialisation along value chains and the explicit investment strategies of MNCs. For sure, the search for increased overall efficiency - *in primis* via higher labour productivities - along the whole value chain, is a major driver of the growth of the value chains themselves, as already predicted by technology gap theories concerning trade in general, whether within or outside GVCs. If anything, globalisation and, together, within GVCs international division of labour has reinforced such tendencies. At the same time, the pass-through from productivity to wages seems generally negligible, both in advanced and developing countries (with just a few potential exceptions, such as R&D workers in advanced countries). Overall, production workers appear to be the big losers, irrespectively of the level of development.

Among the factors we analysed, trade unions play a significant role in providing a counterbalancing effect on the labour share. Notably, this effect is substantial for the most vulnerable segment of the workforce, namely production workers. The results highlight the importance

of empowering trade unions and strengthening their role in advocating for fair labour practices and improved working conditions within GVCs. Reverting the current trend represents the most pressing policy challenge.

Indeed, urgent actions are needed to address the power and centralization of multinational corporations in determining labour standards, production practices, and remuneration. Reshaping these dynamics is crucial to ensure social justice and equity both within GVCs and in the economy at large.

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Appendix

A Country Coverage

Code	Country	*Development*	*Country Group*	*Code*	Country	*Development*	*Country Group*
AUS	Australia	1	Advanced	LVA	Latvia	0	Developing
AUT	Austria	1	Advanced	MEX	Mexico	0	Developing
BEL	Belgium	1	Advanced	MLT	Malta	1	Advanced
BGR	Bulgaria	0	Developing	NLD	Netherlands	1	Advanced
BRA	Brazil	0	Developing	POL	Poland	0	Developing
CAN	Canada	1	Advanced	PRT	Portugal	1	Advanced
CHE	Switzerland	1	Advanced	ROU	Romania	0	Developing
CHN	China	0	Developing	RUS	Russian Federation	0	Developing
CYP	Cyprus	0	Developing	SVK	Slovakia	0	Developing
CZE	Czech Republic	0	Developing	SVN	Slovenia	0	Developing
DEU	Germany	1	Advanced	SWE	Sweden	1	Advanced
DNK	Denmark	1	Advanced	TUR	Turkey	0	Developing
ESP	Spain	1	Advanced	USA	United States	1	Advanced
EST	Estonia	0	Developing				
FIN	Finland	1	Advanced				
FRA	France	1	Advanced				
GBR	United Kingdom	1	Advanced				
GRC	Greece	1	Advanced				
HUN	Hungary	0	Developing				
IDN	Indonesia	0	Developing				
IND	India	0	Developing				
IRL	Ireland	1	Advanced				
ITA	Italy	1	Advanced				
JPN	Japan	1	Advanced				
KOR	Republic of Korea	1	Advanced				
LTU	Lithuania	0	Developing				
LUX	Luxembourg	1	Advanced				

Table A2. Country code, development level (1=Advanced; 0= Developing plus "transition," ex-socialist).

B Deflation procedure

WIOD tables are provided in current prices and in previous year's prices. Building upon the contribution by Dietzenbacher and Hoen (1998) and the recent insights by Los et al. (2014) and Timmer et al. (2021), among others, we implement the so-called RAS-method to deflate WIOD (2016 Release) tables moving from current to constant price (the base year is 2000). RAS-procedure essentially exploits the fact that all the margins of the Input-Output table are already known in constant prices (gross output, value added, final demand), as price deflators for them are largely available. What is crucially missing is the deflation of the so-called $\boldsymbol{A}$ matrix of intermediate deliveries. The procedure consists of a bi-proportional projection method, developed originally to update a given matrix in order to satisfy exogenously row and column sums (which in I-O tables result in the aforementioned 'margins'). RAS-method proceeds iteratively, i.e., recursively updating a matrix in current prices converging to a matrix in constant prices, given row and column totals in constant prices. As such, the procedure is completed once the sums of the cells in each row and in each column are close to the totals previously exogenously identified. Following Timmer et al. (2021), we actually use the Generalised RAS algorithm (Temurshoev et al., 2013; Lenzen et al., 2007; Junius and Oosterhaven, 2003) because the standard RAS-procedure cannot deal with negative values; moreover, the row and column sums over all industries in all countries should be identical, given the I-O accounting identity (worldwide value added should equal worldwide final demand), and this is likely not to be the case given the different sources from which the price deflators originate. More information on GRAS method can be found in Temurshoev et al. (2013).

We first deflate gross output, value added and final demand (the row and column sums of I-O tables). Price deflators for output and value added are provided by the SEA dataset, while deflators for final demand components (household consumption, government consumption and investment) are taken from United Nations (UN) National Accounts, following Timmer et al. (2021). Deflation is computed row-wise, meaning that we use deflators of the producing country. We use industry gross output deflators also to deflate intermediate consumption. All deflators have been previously converted in US dollars, being the WIOD table measured in such units, with exchange rates that can be found on the WIOD website. Once we have deflated all the components of the I-O table, we run the convergence algorithm iteratively to get the WIOD table in 2000 constant prices. We checked that the magnitudes of intermediaries' flows for our 2000 constant prices table (2000 base year) were equal to the 2000 table in current prices. Then, we did the same iterative check for the 2001 constant prices (2000 base year) table in comparison with the 2001 previous year prices provided by WIOD. Although impossible to obtain identical values given the various sources of deflators and an iteration algorithm at work, magnitudes were largely approximating, hinting at a satisfactory deflation procedure.

C Shift-Share Analysis

Widely used shift-share decompositions disaggregate the overall shift in two components: a within component that accounts for the dynamics inside the unit of observation, keeping fixed the composition; a between component that tracks the role of changes in the composition, assuming constant within sector variation. For two generic variables a and b Dietzenbacher and Los (1998) show that:

$$\begin{aligned} &\Delta\, ab = (\, a'\, b') - (\, a\, b) = \\ &= (a' - a)\, \big(\frac{b' + b}{2}\big) + (b' - b)\big(\frac{a' + a}{2}\big) = \end{aligned} \tag{1}$$

We aim to decompose the vertical labour share's shift into three components. The between-input component accounts for changes in input composition, while two within-components track inputs' specific dynamics. The first is the between-occupation component, which tracks the impact of workers' recombination across occupations — the second accounts for occupation-specific labour share shifts.

Firstly, we decompose the labour share $LS_{(h,k)}$ in each stage of production in the country h and industry k to produce the final good j in the country i. To lighten the exposition we will refer to the value added share of each input as $v = {va_{(h,k)}}/{\sum_{(h,k)} va_{(h,k)}}$. While we refer to occupation share within each input as $e = {e^{occ}_{(h,k)}}/{e_{(h,k)}}$. Finally, we define occupation specific labour share as $l = {(w^{occ}_{(h,k)} e^{occ}_{(h,k)})}/{va_{(h,k)}}$. Note that to further simplify the exposition we omit the summations both over occupation (within each input) and over inputs (across the GVCs). However, we have defined value added and employment share such that we can first decompose the labour share of each stage and each occupation and then sum them up to the whole vertical labour share variation. We use equation (1) to cyclically decompose the change in labour share LS in three alternative ways:

$$\begin{aligned} &\Delta LS = LS' - LS = v'(\, e'\, l') - v(\, e\, l) = \\ &= (v' - v)\, \big(\frac{e'l' + el}{2}\big) + (e'l' - el)\frac{v' + v}{2} = \\ &= (v' - v)\, \big(\frac{e'l' + el}{2}\big) + (e' - e)\big(\frac{l' + l}{2}\big)\big(\frac{v' + v}{2}\big) + (l' - l)\big(\frac{e' + e}{2}\big)\big(\frac{v' + v}{2}\big) \end{aligned} \tag{2}$$

$$\begin{aligned} &\Delta LS = LS' - LS = e'(\, v'\, l') - e(\, v\, l) = \\ &= (e' - e)\, \big(\frac{v'l' + vl}{2}\big) + (v' - v)\big(\frac{l' + l}{2}\big)\big(\frac{e' + e}{2}\big) + (l' - l)\big(\frac{v' + v}{2}\big)\big(\frac{e' + e}{2}\big) \end{aligned} \tag{3}$$

$$\begin{aligned} &\Delta LS = LS' - LS == l'(\, v'\, e') - l(\, v\, e) = \\ &= (l' - l)\, \big(\frac{v'e' + ve}{2}\big) + (v' - v)\big(\frac{e' + e}{2}\big)\big(\frac{l' + l}{2}\big) + (e' - e)\big(\frac{v' + v}{2}\big)\big(\frac{l' + l}{2}\big) \end{aligned} \tag{4}$$

Nothing that $\Delta = \frac{\Delta}{3} + \frac{\Delta}{3} + \frac{\Delta}{3}$ using (2), (3) and (4) and rearranging the terms we obtain:

$$\Delta LS = LS' - LS = (v'\, e'\, l') - (v\, e\, l) =$$
$$= \overbrace{(v' - v)\, \frac{1}{3}\left[2(\frac{e' + e}{2}\frac{l' + l}{2}) + \frac{e'l' + el}{2}\right]}^{Between-Inputs} +$$
$$+ \overbrace{(e' - e)\, \frac{1}{3}\left[2(\frac{v' + v}{2}\frac{l' + l}{2}) + \frac{v'l' + vl}{2}\right]}^{Within-Input\ but\ Between-Occupation} + \tag{5}$$
$$+ \overbrace{(l' - l)\, \frac{1}{3}\left[2(\frac{v' + v}{2}\frac{e' + e}{2}) + \frac{v'e' + ve}{2}\right]}^{Within-Input\ and\ Within-Occupation}$$

D Relative Downstream Occupation Specialisation Index (RDSI)

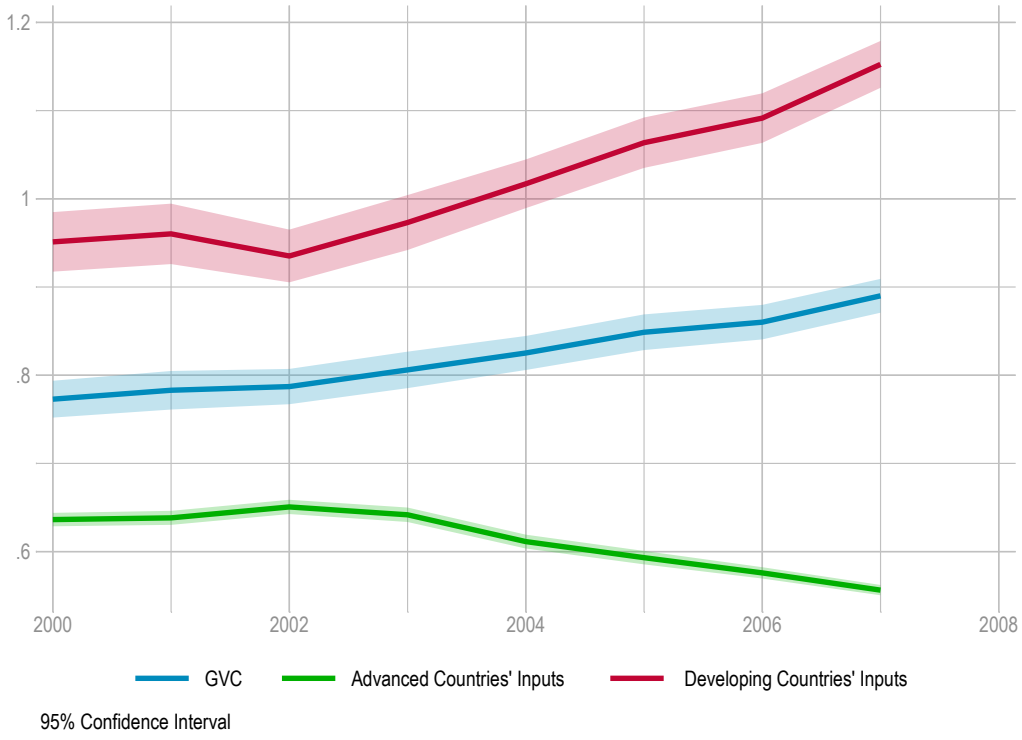

Fig. A1. Dynamics of relative downstream specialisation index disaggregated by development level of input origin.

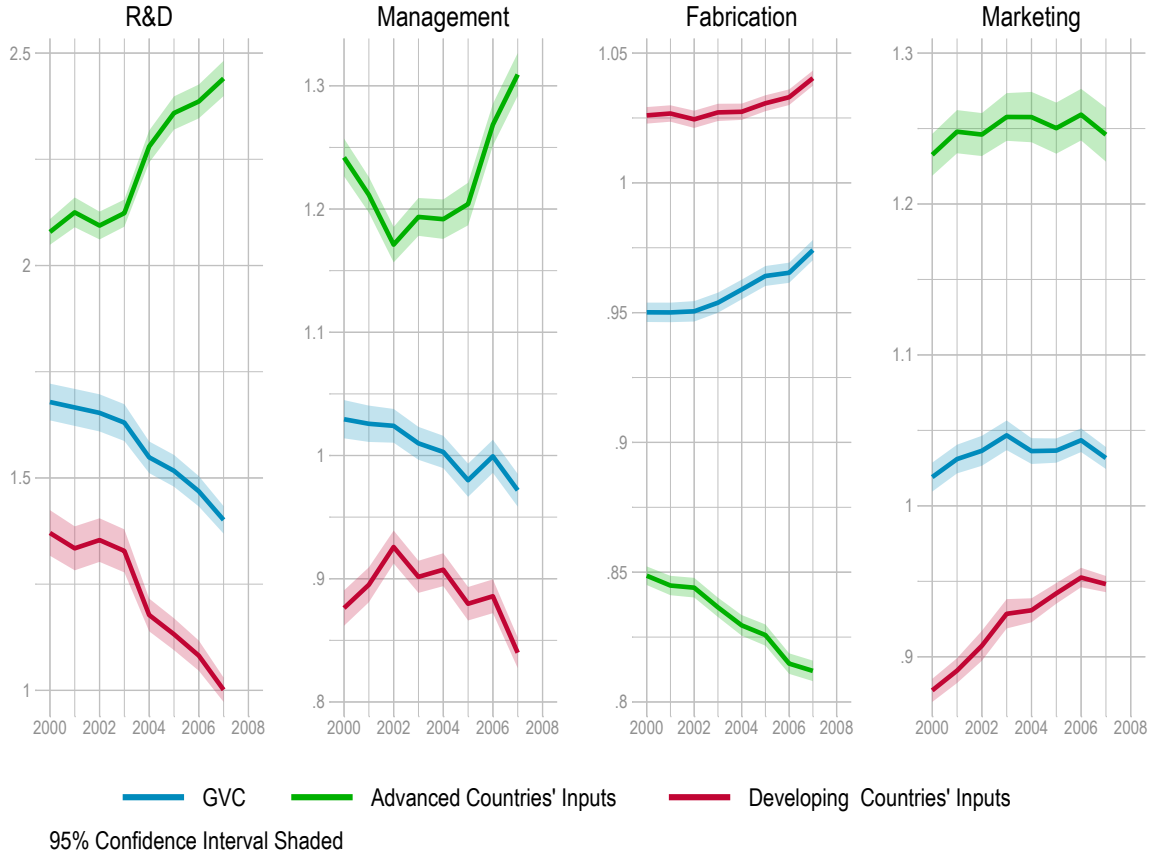

Fig. A2. Dynamics of revealed comparative advantage in the four functions disaggregated by development level of input origin.