Smile Without a Reason Why: Functional Specialization and Income Distribution in Global Value Chains

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Abstract. This paper investigates the relationship between labour share fall and Global Value Chains (GVCs) rise focusing on the impact of international functional specialization. We combine input-output tables and labour income information in each stage of production to compute the wage share along GVCs. We focus on foreign manufacturing inputs documenting a widespread negative trend in labour income over the period 2000-2007. Although much of this fall is due to a general industry-level decoupling of wage and productivity dynamics, international reshuffling in the input structure had a sizable negative impact. Indeed, we show that firms increased their profits by offshoring production to lower-wage countries. On the other hand, functional specialization has partially offset these dynamics in advanced countries specializing in upstream occupations while it has worsened emerging market positions. Fabrication workers emerge as the worldwide losers in the reorganization of the international production networks. Worker-friendly labour market institutions appear to be the only force able to counteract these tendencies.

Keywords: Labour Share · Global Value Chains · Functional Specialization
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Introduction

In recent years, the investigation of labour share dynamics has regained attention in the economic debate, with evidence showing a sustained and widespread decline in the portion of value accrued by workers. Much of this research has focused on advanced countries, finding extensive support for the decline in wage share starting in 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; Riccio et al., 2022).

The souring interest in labour share dynamics is threefold. Firstly, the evidence of its fall surprised most economists, as most models assume labour share to be constant over time. For instance, marginalist economics solved the distributive conundrum linking wage growth to labour productivity. Hence, if output increases due to a rise in productivity, wages grow by the same amount, leaving the distribution of value between capital and labour unchanged. Secondly, Atkinson (2009) argues that functional income distribution is the "principal problem of political economy" due to its close relationship with income inequality, one of the plagues of modern economics. Indeed, the capital share is usually assumed to be more concentrated than wages, thus a decline in the latter would translate into an overall increase in inequality (Ranaldi and Milanovic, 2020; Piketty, 2014), which in turn hinders the probability of experiencing stable growth (Berg et al., 2012). Finally, following the post-Keynesian tradition, the decline in the wage share, and more generally, the increase in income concentration generates a shift in demand patterns which can ultimately lead to undesired structural changes and greater dependence on foreign, and more volatile, demand (Onaran and Galanis, 2013; Pasinetti, 1993)

This research investigates the effects of Global Value Chain (GVC) integration and associated functional specialization on the decline of the labour share of value added. We show that wage compression strategies ease GVCs' participation, increasing firms' international competitiveness especially in developing countries. Additionally, GVCs integration allows advanced countries to retain more remunerative tasks while pushing emerging markets to specialise in low-skill, low-wage occupations. Combined with the global dissemination of technology and a reduction of worker bargaining power, we identify these phenomena as major contributors to the decrease in the labour share. Our results show that Global Value Chains (GVCs) are structured hierarchically, with advanced countries - due to their greater market power and technological advantage - receiving higher value from global production networks. This favorable initial condition allows them to benefit from functional specialization in upstream tasks, which partially offset the decline in their labor share. Unfortunately, production workers are the biggest losers in this process, accounting for most of the drop in labor share. This is especially concerning, since production functions make up more than 50% of the workforce in both advanced and developing countries, leading to a rise in wage inequality globally.

Throughout this work, we use Timmer et al. (2015)'s methodology to track value added in global value chains, decomposing the final product into the value added in each stage of production. Following Chen et al. (2018) decomposition procedure, we combine input-output tables and wage flows in each stage to compute vertically integrated (GVCs) labour share. We employ world input-output tables that contain data on intermediate inputs which flow across industries as well as across countries. Additionally, we collect information on wages and employment levels from Socio-Economic accounts and on the occupation structure from

Timmer et al. (2019). This approach enables us to disentangle the impact of GVC penetration and international functional recombination on worldwide labour share dynamics.

The rest of the paper is organized as follow: section 1 revise the literature on drivers of labour share fall; section 2 describes the data and methodology employed; section 3 presents descriptive statistics on labour share dynamics; section 4 proposes a shift share analysis which decompose labour share drop in within and between sector contribution; section 5 investigates potential determinants by means of a parsimonious econometric analysis; section 6 concludes.

1 Literature Review: Determinants of Labour share drop

The factors contributing to the decline in labour share can be broadly divided into four groups: technological, structural, globalization, and welfare determinants[1]We leave aside the treatment of financialization and superstar firms that were alighted as potential determinants in the literature (Stockhammer, 2017; Autor et al., 2020; Barkai, 2020). The former channel is partially linked to structural factors and globalization. In fact, we can understand financialization as a progressive shift of resources toward the financial sector that is influenced by the international openness of the country and its ability to attract foreign investments. The superstar firms channel, on the other hand, relates to within-sector concentration patterns that would be hard to tackle in a multi-country industry-level study. (Stockhammer, 2013b). In this review, we do not aim to provide a comprehensive examination of the related literature, but rather to focus on the mechanisms and contributions that are most relevant to this research. Further, we highlight that most determinants are intimately related and that their interaction might boost the overall effects.

1.1 Technology Channel

The idea that technological change plays a significant role in shaping income distribution can be traced back to classical economics (Ricardo, 1819). The theory suggests that in a market where competition is perfect, employment is full, and production functions are well-behaved, the allocation of income is determined by technological progress. Although these assumptions are rarely satisfied in the real world, this mechanism is 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 has been found to augment the productivity of skilled labour while replacing the demand for unskilled labour. This shift towards skilled labour has contributed to the observed increase in personal income inequality (Autor et al., 2003; Card and DiNardo, 2002).

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 routine and complement tasks that require

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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 wage share in those industries where their use is extensive.

Eventually, the impact of technical change on the labour share is determined by the degree to which capital and labour are substitutable in production. If the elasticity of capital and labour is greater than one, which is often the case for low-skilled workers, then technological advancements may lead to a decline in the wage share. However, if the elasticity of substitution is less than one, as may be the case for high-skilled workers, technological change may lead to an increase in the wage share. If the negative effect for low-skilled workers exceeds the positive effect on the wage share for high-skilled workers, this process can result in a decline in the overall wage share.

There is a significant body of empirical research investigating the relationship between technological change and the evolution of labour share. Several researchers have argued that capital-augmenting technological progress has contributed to the declining labour share (Bentolila and Saint-Paul, 2003; Arpaia et al., 2009; Driver and Muñoz-Bugarin, 2010; Raurich et al., 2012). Karabarbounis and Neiman (2014) attribute the fall in labour share to the decline in the relative price of investment goods, which makes it more economical to substitute capital for labour. However, these findings crucially rely on the assumption that the elasticities of substitution between capital and labour are greater than one, which is at odds with several empirical studies (Kohler et al., 2018; Rowthorn, 1999). Other studies have suggested that the relationship between technology and the labour share may be more complex, with various contributions finding a little overall impact of technology on the labour share (EC, 2007; Tytell and Jaumotte, 2007; Guschanski and Onaran, 2021).

1.2 Bargaining Power & Institutional Channel

A competing explanation for the decline in labour share focuses on the bargaining power of workers. When considering markets that are not perfectly competitive, the distribution of income is the outcome of a negotiation process between firms and workers, represented by labour unions and mediated by overall labour market institutions. Workers who are protected by strong unions and pro-labour institutions are able to negotiate wage increases in line with productivity, helping to maintain a constant labour share.

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 (Kristal, 2010; Stockhammer, 2013b; Guschanski and Onaran, 2021; Bengtsson, 2014; 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 (Bengtsson, 2014; Stockhammer, 2013a, 2013b; Guschanski and Onaran, 2021). However, Osorio Buitron and Jaumotte (2015) suggest that high levels of collective bargaining coverage may lead to higher unemployment due to excessive wage demands by unions.

Interestingly, researchers Dimova (2019); Dao et al. (2020); Guschanski and Onaran (2021), suggest that unions may have different effects on the wage-setting process for different skill groups, protecting low-skilled workers, thus reducing wage inequality.

A related channel which impacts worker bargaining power is the overall 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 (Jayadev, 2007; Bloise et al., 2022; Ciminelli et al., 2018). However, although the reduction of the welfare state is widely acknowledged, several empirical difficulties arise in its measurements. The dimension of the welfare state is often measured using overall government spending, which however does not consider changes in government composition. Kristal (2010) used government civilian spending, but this still does not capture specific details of spending, such as the type of benefits and cash transfers, which are important for the social wage and bargaining power of labour. While Ciminelli et al. (2018) analyse the impact of employment protection deregulation on the labour share using a dataset of major reforms to employment protection laws finding substantial negative effects.

1.3 Structural Change Channel

Changes in the overall labour share can be partly attributed to structural changes towards industries traditionally characterised by lower-paid jobs or by greater use of material and immaterial capital, as pharmaceutical and chemical sectors (Chen et al., 2018). For instance, de Serres et al. (2002) found that sectoral changes accounted for most of the shifts in the labour share of advanced economies pointing to deindustrialization as a major determinant of the fall. The importance of the rise of services in wage share fall is confirmed by Arpaia et al. (2009) and Riccio et al. (2022) in the context of GVC integration. Rodrik (2016) emphasize manufacturing sector was historically characterised by a higher unionization level, thus strengthening the labour movement. In this sense, deindustrialization might pose a threat not only to workers but more in general to democracy (Rodrik, 2013).

In a similar vein, financialization (i.e. structural change towards the financial sector) exacerbates both deindustrialization Botta et al. (2021) and labour share decline as highlighted by a recently booming literature Lazonick, 2012; Stockhammer, 2017, Pariboni and Tridico, 2019 for a full account of possible channels). 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, participation in mergers and acquisitions and increasing involvement in financial activities. As a result, firms might perceive financial activities as more profitable than their core business leading them to move resources away from the industrial sector. This process leads to unemployment and a surplus of labour in the manufacturing sector, thus putting downward pressure on wages.

At the same time, and mostly related to this work, an increasing amount of evidence emphasizes the role of shifts in the occupational structure on wage share fall (Guschanski and Onaran, 2021, 2023; Reshef et al., 2019; Dao et al., 2020; Dimova, 2019). Empirical evidence shows heterogeneous impacts across occupations with elementary (routine intensive) occupations undergoing a major fall in their labour share. Considerations on shifts in the occupational structure are widely connected with the technological channel mentioned above and, even more, with the globalization channel that is the subject of the following paragraph.

1.4 Globalization Channel

The phenomenon of globalization has been widely studied in the economic literature and has had various impacts on income distribution. The Heckscher-Ohlin (H-O) model and the

Stolper-Samuelson (SS) theorem suggest that countries can increase efficiency by specializing in the production of goods that utilize their relatively abundant factors of production, resulting in a rise in the relative price of the goods produced and an increase in returns for the intensively-used factor. However, these results are based on strict assumptions such as perfect competition, constant returns to scale, and equal technologies.

Critics of the H-O model and SS theorem have argued that international specialization of production may not necessarily lead to benefits for workers in developing countries with a surplus of labour and for capital in developed countries. The Leontief Paradox challenges the principle of specialization at the core of the H-O model(Leontief, 1951), while several studies have pointed out the theoretical limitations of the SS theorem in explaining the distribution of returns to production factors and income (Vivarelli, 2014; Feenstra and Hanson, 1999; Wood, 1995).

Research has shown that globalization has not necessarily had a positive impact on those with lower education and skill levels in developing countries relative to those with higher levels. In fact, 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). Additionally, numerous studies have found significant negative impacts of globalization on functional income distribution at all levels of development (Harrison, 2005; Rodríguez and Rodrik, 1999; Jayadev, 2007).

1.5 Global Value Chain Channel & Functional Specialization

One potential reason for the failure of the SS theorem to accurately capture the distributional effects of globalization is the shift that occurred in the nature of trade in the 1990s with the emergence of global value chains (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 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 factors of production (Feenstra and Hanson, 1996; Grossman and Rossi-Hansberg, 2006).

The economic 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. 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 can provide advanced countries with access to a greater variety of cheaper inputs (Grossman and Rossi-Hansberg, 2006) 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 specialization (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 of social upgrading - improved 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 in countries with cheap labour, leading to lower unit labour costs (Keil, 2022; Gimet et al., 2015; da Silveira, 2014). 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) highlight that relying on low unit labour costs can be a low-road strategy for success in the global economy, while the high-road strategy involves specializing in innovative manufacturing sectors and upgrading towards knowledge-intensive activities, which requires a higher level of absorptive capabilities and effort. Pavlínek (2020) has highlighted 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 developing nations with cheaper labour costs. Furthermore, newer technologies often make it difficult to substitute factors of production, particularly in advanced firms that are integrated into GVCs due to the high precision and quality standards associated with these technologies (Rodrik, 2018). This increase in the stringency of production requirements boosts the demand for skilled labour in developing countries and reduces the demand for unskilled labour, which is abundant in low-income countries (Elsby et al., 2013; Vivarelli, 2014). For instance, 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 is 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 is similar to 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. In addition, research on the "smile curve" 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). GVC integration tends to favour task specialization, 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 (Timmer et al., 2019; Stöllinger, 2021; Mudambi, 2008). The inability to move up the value chain is particularly detrimental for developing countries, as a country's position in the GVC also affects the magnitude, composition, and wages of labour engaged in GVC activities (UNCTAD, 2013). Thus, the adoption of modern technologies can reduce the comparative advantage of low-income countries in standard manufacturing, while cost-cutting strategies can put downward pressure on the income share accruing to developing countries. Low-skilled workers in developing countries are likely to be the worst affected by these processes.

To conclude, the political economy approach to international trade emphasizes the changes in the bargaining positions of labour and capital due to their relative mobility (Rodríguez and Rodrik, 1999; Stockhammer, 2013b; Pariboni and Tridico, 2019). This perspective explains the concurrent decline in the labour share in both developed and developing countries and sug-

gests that, in contrast to 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. Harrison (2005); Jayadev (2007)).Rodríguez and Rodrik (1999) also shows, adapting the bargaining channel to a global context, that trade liberalization benefits capital. The shifts in income distribution occur due to the redistribution of rents, rather than the equalization of factor costs as proposed in the Stolper-Samuelson theorem. Interestingly, Epstein and Burke (2001) argue that redistribution can occur without changes in production locations due to threat effects. Therefore, following this perspective, we would expect globalization to have a negative effect on the wage share globally.

2 Data and Methodology

2.1 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 organization expenditure, government expenditure, gross fixed capital formation, and changes in inventories and valuables. Gross output data is also provided by the WIOD. All values are in US dollars at 2000 prices, using exchange rates from the WIOD website and price indexes from the SEA (2016) dataset for deflation. 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 A.

Occupation data comes 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 the period 1999-2011 for 41 out of 43 countries covered by WIOD. We use these data to obtain employment and wage figures disaggregate at the occupation level for each country-industry pair.

In this study, we limit the analysis to 23 manufacturing industries for 42 countries in the period 2000-2007. Our analysis focuses solely on the manufacturing sector due to the potential complexity arising from the subtle variety of occupations at the sectoral level that could confound our results. 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. Further, we decide to exclude the post-crisis (2008-2011) period for two reasons. Firstly, we acknowledge the counter-cyclical nature of the labour share that could potentially skew the results in the post-2008 results. Indeed,

the labour share literature shows that wages are stickier than profits and thus the period after a down-swing is generally characterised by a short-run rise in the labour share. We exclude the post-crisis period (2008-2011) from our analysis for two reasons. Firstly, we recognize the 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 conjunctural dynamic reverts 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 focussing our analysis on what the GVC literature considers the last upswing in GVC integration.

3 Methodology

In this section, we aim to construct our 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's (1936) methodology to compute the worldwide 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 Timmer et al. (2014); Chen et al. (2017) and Reshef et al. (2019). Chen et al. (2017) propose a disentanglement of value added in trade between income shares of labour, tangible and intangible assets. Reshef et al. (2019), closer to our approach, 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.

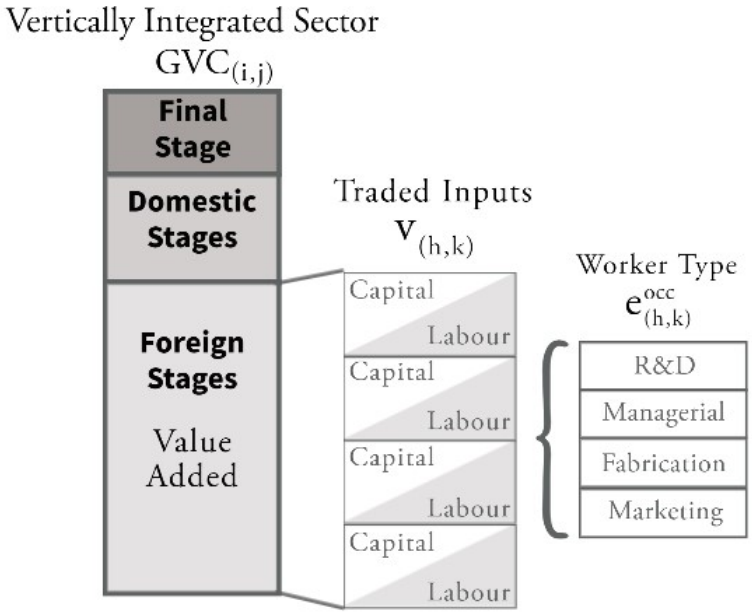

Fig. 1. Income decomposition in a vertically integrated sector

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

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 define global value chains based on the final stage of production. We also refer to this stage as direct contributions.
2. domestic stages of production (Dom): these comprise manufacturing inputs produced in the same country of the final stage and thus that do not cross the border. Also defined as indirect domestic contributions.
3. the foreign stages of production (For): which encompass traded intermediaries produced in foreign countries. Also defined indirect foreign contribution.

The sum of value added across these stages of production coincide 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 unit 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 Timmer et al. (2014); Chen et al. (2017), 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 i represents the number of countries and j 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. This second round is represented by $\boldsymbol{A}^2 z$. This process continues until we reach the basic materials (e.g., metal, rubber) required to start the production process. By summing over all stages, we can determine the total output of all industries (in all i countries and j industries) required to produce cars through $(\boldsymbol{I} - \boldsymbol{A})^{-1} z$, this geometric series represents the convergence of the sum over all rounds.

If instead, we are interested in measuring 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 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 Pasinetti (1973); Momigliano and Siniscalco (1982) and represent the value-added incorporated in intermediate production stages induced by the production of final goods.

In the final step, we use the $\boldsymbol{V}$ matrix as a weight to compute the labour share of vertically integrated sectors, 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. To do this, we create the weighting matrix $\boldsymbol{W}$, which consists of the elements of the matrix $\boldsymbol{V}$ divided by the corresponding column sum[2]. Once we have computed the weighting matrix, we introduce the labour shares information in an ij row vector l. Coming back to our example, one element of l contains the wages share of Chinese textile industry workers producing seat covers for the German automotive industry. Then, to obtain the income share of all labour that is directly and indirectly involved in the production of z, we multiply the row vector l by $\boldsymbol{W}z$. Following this procedure, we compute the average of the labour share in all stages of production, weighted by the value-added contribution of each input.

$$ls_z = l\,\boldsymbol{W}\,z \tag{4}$$

The ij vector ls represents the wages paid to labour employed in country i and industry j in the production of z. To calculate the labour share of a subset of the whole chain, we can set the corresponding elements in the matrix $\boldsymbol{V}$ to 1 while switching the others to 0. This procedure excludes their contribution from the calculation. This allows us to determine the labour share for say the foreign stages in developing countries. In this analysis, we focus on foreign manufacturing inputs and we distinguish between advanced and developing countries, as research suggests that these two groups may have different dynamics in terms of functional income distribution.

4 Descriptive Statistics

4.1 Labour Share Drop

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. Points lying above the bisectors are chains in which inputs' labour share has fallen while the opposite holds for points below the red line. The figure shows that overall, there was a decline in the labour share

[2] First, we multiply the matrix $\boldsymbol{V}$ by a column vector of ones (i) obtaining a row vector having the sum of each column of $\boldsymbol{V}$. Afterwards, we diagonalised this vector obtaining a diagonal matrix having the column sum of $\boldsymbol{V}$ on the diagonal and premultiply it by $\boldsymbol{V}$ itself. Formally:

$$\boldsymbol{W} = \boldsymbol{V}\,\widehat{(\boldsymbol{V}\,i)} \tag{3}$$

where i is an ij column vector and the $\widehat{\boldsymbol{V}i}$ refers to the diagonalised matrix.

for virtually all of the chains during this time period. Firstly, workers in advanced countries who were producing inputs were able to secure a significantly larger share of value compared to their counterparts in developing countries. This ranges from 0.55 to 0.75 for advanced countries, while developing countries only reached a maximum of 0.55. This trend is in line with previous research that has consistently found that advanced economies tend to have higher labour shares (Reshef et al., 2019; Chen et al., 2017; van Treeck, 2020; Riccio et al., 2022). Secondly, and perhaps more concerning, is the fact that the decline in labour share in developing countries was much more sustained and pronounced compared to developed countries. This indicates that workers in advanced countries are not only able to appropriate a larger share of value but that there is no sign of international convergence in labour share within GVCs.

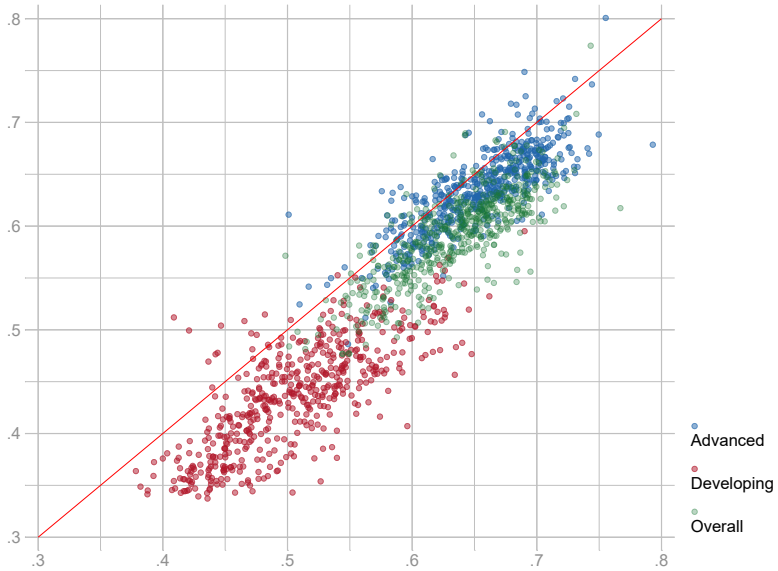

Fig. 2. Points represent the labour share shift between 2000 and 2007 in each $GVC_{(i,j)}$ foreign stages. Observations are grouped into Overall, Advanced and Developing inputs.

Figure 3 examines wage and productivity dynamics within global value chains to shed light on the heterogeneous decline in labour share across development levels. By applying a similar procedure to the one described in the previous section, we use the intersectoral value-added requirements matrix as a weight to compute the wage and productivity dynamics 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 divided between advanced and developing countries. Points above the red line indicate cases in which productivity gains have exceeded wage increases, resulting in a decline in the labour share. The figure supports the notion of a worldwide detachment between productivity and wages, as previously noted in the literature (Dosi et al., 2020; EC, 2007). However, it also reveals that while productivity growth is similar between advanced and developing economies, wage growth differs significantly. The larger decline in the labour share in developing countries is attributed to lower wage growth compared to productivity gains. This suggests that developing countries may be employing strategies such as wage compression (i.e. lowering unit labour costs) in order to increase their competitiveness and penetrate further into global value chains.

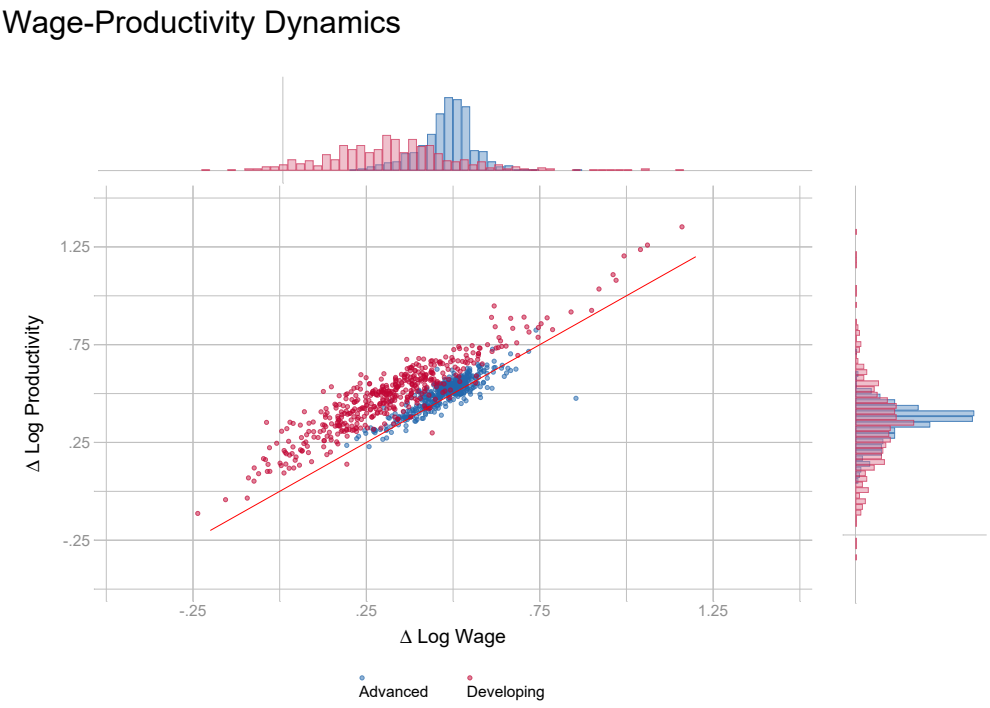

Fig. 3. Productivity-Wage dynamics in GVCs' foreign stages between 2000 and 2007 disaggregated by development level.

Next, let's examine occupation-level dynamics. 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. In other words, it represents the vertical labour share that would be obtained if the industry were to only employ workers in a specific occupation, such as fabrication workers. Our analysis reveals two key trends. Firstly, we have observed a decline in the labour share for every occupation in both advanced and developing countries. Secondly, while this trend is similar across occupations in advanced countries, upstream occupations such as R&D and managerial activities have experienced the largest declines in developing countries. It is worth noting that these activities were characterized by particularly high labour shares and, despite the decline, they remain far above those in downstream occupations. Interestingly, in contrast with the SS hp, wages in fabrication activities have fallen even in developing countries where they constitute the largest part of the

	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.

4.2 Functional Specialization Along GVCs

By tracking the employment levels at each stage of production, we can account for the functional specialization dynamics in the foreign stages of each global value chain (GVC). This allows us 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, for example. We can then use this information to investigate the revealed comparative advantage of inputs from advanced and developing countries.

Our findings align with those in the global value chain literature, demonstrating different specialization patterns across levels of development Timmer et al. (2019); Stöllinger (2021). When we divide the production process into pre-production (i.e. upstream) and post-production (i.e. downstream) activities, we see that developed countries tend to specialize in upstream activities, which are more knowledge-intensive and generate the most value-added. Figure 4, which compares the revealed comparative advantage (RCA) of foreign inputs from advanced and developing countries, supports the hypothesis that developed countries are more likely to specialize in R&D and managerial activities. These specialization patterns have become more pronounced over the last 7 years. Notice that overall specialization in fabrication activities is decreasing everywhere, regardless of the level of development. This suggests that technology is reducing the worldwide demand for fabrication workers, leading to a decline in their share in overall employment.

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

Finally, we examine the relationship between functional specialization and relative wage by occupation within the context of global value chains (GVCs). The Stolper-Samuelson (SS) theorem posits that as an occupation becomes more specialized, its relative wage should increase.

We aim to evaluate the validity of this theorem in a GVCs context by analysing the relationship between changes in backward linkages' RCA and their relative wage.

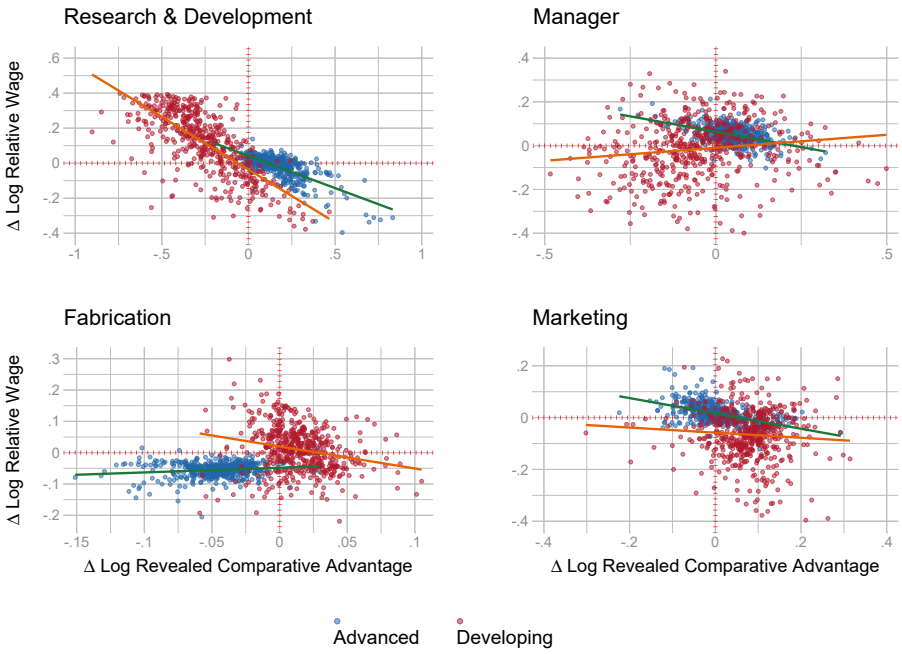

Fig. 5. Reltive wage and Specialization dynamics in the four broad occupation groups divide by development level.

The graph presented in Figure 5 illustrates the correlation between changes in relative wages and Revealed Comparative Advantage (RCA) across four broad occupation categories during the period under examination. Contrary to expectations, our analysis reveals signs of a negative relationship, if any, between the two variables. This negative correlation is particularly salient 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, developed countries exhibit a pattern where the occupation experiencing the most growth in relative wages is management, followed by marketing. In addition, by analysing the specialization patterns depicted in the last two figures, our research confirms the existence of a "smile curve," which highlights increasing specialization in marketing and fabrication activities in emerging economies and in upstream occupations, such as R&D and managers, in developed countries. This pattern suggests structural changes in the economy based on the level of development of a country. Overall, our findings challenge the conventional assumption that there is a positive relationship between changes in relative wages and specialization patterns, and provide valuable insights into the dynamic relationship between wages, comparative advantage, and the occupation structure of the economy.

5 Shift Share Analysis

In this section, we investigate how the reshuffling of inputs and task (occupations) along a supply chain impact the labour share in the foreign steps of each GVCs. Specifically, we're

examining data from the years 2000 to 2007. It's important to note that changes in vertical labour share can happen for different reasons. For instance, workers might not be able to obtain wage increases in line with productivity, and thus a decline in the labour share can take place even keeping constant the employment structure. On the other hand, a decline in the wage share might be due to a reshuffling of occupations towards workers able to appropriate a lower part of the value added. In the latter case, even keeping wages in line with productivity is not enough to keep labour share constant. Finally, even without changes in the occupation structure and in the labour share, a particular GVC might experience a decline in labour share if inputs with lower labour share increase their portion of value added in final production.

Too see this, in Eq. 5 we define the labour share in the foreign stages of the chain as the weighted average of the labour share in all the inputs using as weights value added. Further, the wage bill paid to workers in each industry (h,k) producing inputs can be divided into the wages paid to the four occupation groups. Thus, in eq. 5 we exactly decompose the overall variation in:

- between inputs component: tracks the impacts of the recombination of inputs along the chain keeping fixed country industry-specific labour share. It can be interpreted as a form of GVCs structural change.
- within inputs components: accounts for changes in occupation-specific labour share keeping fix GVCs' inputs composition and the occupational structure. Accounts for inputs-specific wage-productivity dynamics.
- (within inputs) between occupation: measure the effects of functional specialization on the labour share keeping fixed the structure of inputs and the wage-productivity relative changes.

$$\begin{aligned}
\Delta LS_{(i,j),t} = LS_{(i,j),t} - LS_{(i,j),t-1} = \Delta \sum_{(h,k,)\in(i,j)} \sum_{occ} \overbrace{\frac{v_{(h,k),t}}{\sum_{(h,k)} v_{(h,k),t}}}^{vash_{(h,k),t}} \underbrace{\frac{e^{occ}_{(h,k),t}}{e_{(h,k),t}}}_{empsh^{occ}_{(h,k),t}} \overbrace{\frac{w^{occ}_{(h,k),t}e_{(h,k),t}}{v_{(h,k),t}}}^{\frac{w^{occ}_{(h,k),t}}{\pi_{(h,k),t}} = ls^{occ}_{(h,k),t}} = \\
= \overbrace{\sum_{(h,k,)\in(i,j)} \sum_{occ} \Delta vash_{(h,k),t} \left(\widehat{empsh^{occ}_{(h,k),t}\, ls^{occ}_{(h,k),t}} \right)}^{BetweenInputs} + \\
+ \overbrace{\sum_{(h,k,)\in(i,j)} \sum_{occ} \Delta empsh^{occ}_{(h,k),t} \left(\widehat{vash_{(h,k),t} ls^{occ}_{(h,k),t}} \right)}^{BetweenOccupation} + \\
+ \overbrace{\sum_{(h,k,)\in(i,j)} \sum_{occ} \Delta ls^{occ}_{(h,k),t} \left(\widehat{vash_{(h,k),t} empsh^{occ}_{(h,k),t}} \right)}^{WithinInput}
\end{aligned} \tag{5}$$

Where the notation (i,j) refers to sector j in the country i 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 pi represent value-added, employment, real wages and productivity, respectively. While EMPsh and VAsh employment and value-added shares. The term Δvar refers to changes in this var between 2000 and 2007. While "$\widehat{var}$" is constructed using initial and final period averages. The decomposition procedure used in this study is fully described in Appendix B.

Figure 6 presents the results of the shift-share analysis presented 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 sum which coincide with the change in labour share. The bottom panels provide a more detailed breakdown of the data, broken down by occupation, allowing for a deeper understanding of the role of functional specialization. Our unit of analysis is individual GVCs which we divide into foreign inputs coming from advanced and developing countries respectively. Then, we aggregate results at the manufacturing level using GVCs value-added as weights.

Our findings align with previous exercises, showing that the decline in foreign inputs from developing countries is more than four times larger than the decline of intermediaries produced in advanced countries. It's important to note that during the same period, we analysed the penetration of developing countries' inputs in global value chains has risen consistently contributing to a greater worldwide decline in the labour share (Riccio et al., 2022). Furthermore, 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 is consistent across advanced and developing countries, despite their different specialization patterns. The most affected group are fabrication workers, which alone accounts for most of the labour share decline in both advanced and developing countries.

However, our analysis also shows that in advanced countries, the reshuffling of occupations and the specialization in upstream occupations has partially offset the decline in labour share within occupations. In contrast, in developing countries, while functional specialization patterns have a positive impact very similar to the one in advanced countries, those impacts are not enough to counteract the decline in the "within-component" labour share. Finally, The structural changes along GVCs have a negative impact on the labour income worldwide, as seen in the between inputs component of our analysis. This is due to a shift in production towards industries with lower labour shares, supporting the idea that wage/cost compression strategies are successful. Notably, R&D workers in advanced countries are the only group that benefits from these changes, while workers in the fabrication sector in developing countries are most negatively affected by this international structural change.

6 Econometric Framework

To assess the determinants of labour share decline along GVCs' foreign backward linkages, we perform a cross-country panel regression that relates changes in labour share to changes in potential drivers taken from the literature. Our goal is to disentangle the effect of functional specialization from other well-known determinants, such as technological change, worker bargaining power and GVCs participation.

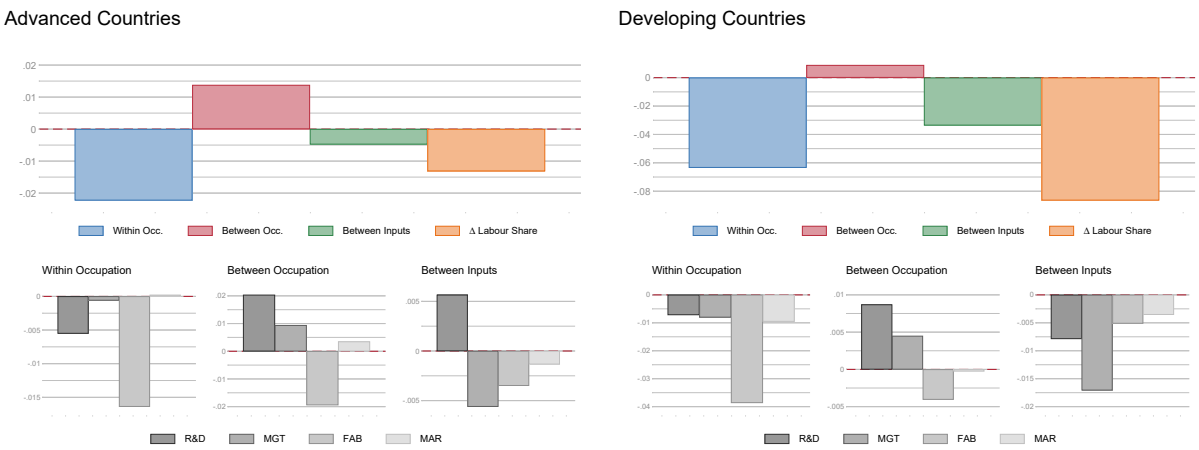

Fig. 6. Shift share analysis presented in eq 5 aggregated at manufacturing level using GVCs' value-added figures.

In the first empirical exercise, we analyse the labour share of backward linkages in 12 manufacturing industries across 41 countries from the year 2000 to 2007. We combine data from the World Input-Output Database (WIOD) and occupation data from Timmer et al. (2019) to create our sample. We exclude the years after the 2008 financial crisis as the labour share is known to be counter-cyclical and this might impact our results. Further, we also divide our sample into inputs from advanced and developing countries to examine any potential differences in dynamics.

Since we are interested in understanding the changes in wage 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 issues. 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 backward linkages of each chain. We use two estimation techniques: a cross-country panel 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 final equation to be estimated will be:

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

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 ears change in the variable 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. Thus, similarly to the growth literature, α_1 measures the convergence rate. A negative value means that labour shares are converging. To take into account technological change, we introduce the shift in capital per worker. The literature suggests heterogeneous effects across occupation types, capital is complementary to high skill- non-routinazable tasks while substituting low-skill workers.

Our main variable of interest is the Relative Downstream Specialization Index (RDSI) first introduced by Stöllinger (2021). It is thought to capture the role of functional specialization

along value chains and measures occupation's recombination across backward linkages. The main advantage of this variable is that it synthesizes the Revealed Comparative Advantage in the four broad occupations in a single number. RCA. Notice that, to take into account sectoral characteristics, RCA is computed as the deviation of industry-specific averages.

$$RCA^{occ}_{(h,k)} = \frac{e^{occ}_{(h,k)} / e_{(h,k)}}{\sum_h e^{occ}_{(h,k)} / e_{(h,k)}} \tag{7}$$

Where RCA are the Revealed Comparative advantage by occupation in each of the backward linkage of each GVC. Then, we compute the $RDSI$ for each inputs (h,k) contributing to (i,j) and aggregate using employment share: If functional specialization is the same then the average chain $RDSI$ takes value 1. An $RDSI$ equal to 1 means that the occupation structure of that chain is equal to the average chain. A positive value of $\Delta RFSI$ means that the chain is specializing in production tasks, as highlighted by the employment of more fabrication workers. Finally, we aggregate inputs' relative specialization using employment as weight. $RDSI$ gouge the impact of smile curve's trends on labour share dynamics.

$$RDSI_{(i,j)} = \sum_{(h,k,)\in(i,j)} \frac{e_{(h,k),t}}{\sum_{(h,k)} e_{(h,k),t}} \frac{RCA^{FAB}_{(h,k)} + RCA^{MAR}_{(h,k)}}{RCA^{R\&D}_{(h,k)} + RCA^{MGT}_{(h,k)}} \tag{8}$$

Another relevant variable in our inquiry is GVC penetration, as measured by the share of value-added coming from foreign inputs. The literature suggests that wage compression could drive GVC integration, thus we expect that greater penetration of foreign inputs might be linked with sustained labour share drop. On the political economy side, we also include a measure related to workers' bargaining power, namely the unionization rate along the chain. To do this, we use the information contained in the ICTWSS dataset (Visser, 2019), which gives information on unionization coverage across countries. We match this data with the employment foreign contribution to compute a measure of unionization 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 unionization density of the chain will be 25%. In line with the literature, we expect this variable to have a positive effect on labour share. Finally, we introduce a measure of GVC's performance, which is the change in final demand of the chain. Keeping the structure of inputs fixed, chains with increasing final demand will require a greater number of workers to produce inputs. Lower payment to labour either increases profit margins or allows for a decrease in final prices or both. Thus, this measure investigates if expansion in the world market is correlated with a decrease in the labour share in the inputs used. 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 variables employed in the regression analysis.

In the second empirical exercise, we delve deeper into the analysis of vertical labour share by investigating occupation-specific dynamics. We maintain the same econometric framework but substitute the implied labour share by occupation as the dependent variable. The implied labour share for occupation k is the labour share that would result if only workers of type k were employed in the industry. In this case, instead of using the RDSI index, which summarizes the whole functional specialization along backward linkages, we use occupation-specific RCA.

	Advanced				Developing			
	mean	σ	min	max	mean	σ	min	max
Labour Share	0.683	0.045	0.532	0.817	0.459	0.063	0.336	0.687
Kemp	144.811	54.387	66.738	601.382	19.052	8.190	3.051	188.590
GVCsh	0.102	0.067	0.013	0.313	0.021	.036	0.000	0.157
RDSI	0.601	0.093	0.387	1.207	1.018	0.360	0.423	3.695
UD	27.517	6.499	15.629	59.876	23.935	5.469	13.453	54.430
Final Demand	13893	39455	-1515	447616	13893	39455	-1515	447616

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

7 Results

7.1 Baseline Analysis

Table 7.1 presents the results of the regression analysis conducted using 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.

Our analysis reveals a general trend of convergence in labour share across different countries and development levels. This is indicated by the negative coefficient of the lagged variable in the regression analysis. This suggests that labour share tends to converge both between and within different levels of development. 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 estimates a positive relationship in advanced countries, indicating a complementarity between capital and labour. On the other hand, a negative impact is observed in developing countries, suggesting the potential for substitution between capital and labour. 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, as measured by the share of value-added coming from foreign stages, negatively impacts labour share. This is interpreted as a result of competitive dynamics within GVCs leading to wage compression. Notably, the estimation results show negative coefficients in both advanced and developing countries, but the impact is greater in the latter.

Functional specialization towards downstream occupations also has a negative impact on labour share in both advanced and developing countries. The impact of specializing in fabrication and marketing functions is more consistent 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 labour share. We interpret this as a consequence of increasing concentration in the final good markets. Chains that grow more are the ones in which labour share falls the most. Similarly, to GVC penetration, which measures competition within chain inputs, final demand measures competition between chains.

This result confirms that chains gaining market shares are the ones where labour is receiving a diminishing share of value added.

	(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. Column 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.

In order to further understand the dynamics of labour share, Table 4 presents the results of the same analysis, but with occupation-specific implied labour share as the dependent variable. Looking at the independent variable, the only difference is that we substitute the relative downstream specialization with occupation-specific revealed comparative advantage (RCA) calculated using equation 7. The results are presented with a breakdown by development level. It's worth noting that due to changes in inputs reshuffling and occupation structure, it's not trivial to directly compare these results with the previous ones.

7.2 Occupation-level analysis

When looking at the results by broad occupational categories, we do not observe any evidence of convergence dynamics in developing countries. The positive coefficient estimated for the initial period labour share suggests a widening gap across chains. In contrast, all occupational categories show a negative sign in advanced countries. The highest coefficients are for R&D, management, and marketing, while fabrication lags behind. Regarding our proxy for technology intensity, 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 not significant and positive. Interestingly, the coefficient for capital per worker in fabrication operations in developing countries

is positive, which suggests potential complementarity, which would be expected more in advanced than in developing countries. Increased GVC participation negatively affects all occupations in developing countries, while the impact on advanced countries' workers is mixed and not significant. Looking at the relationship between 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.

	(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.

The most interesting 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 this as evidence of increased protection for the most vulnerable workers, who manage to bargain for contract increases in line with productivity. At the same time, upstream occupations are penalized by increased union density. Overall, in line with the literature, unionization helps in lowering wage inequality. To conclude, final demand shows widespread negative coefficients in developing countries, while only for fabrication workers in advanced countries. We interpret this as an increased downward pressure on workers' share of value added due to increased competition in final good markets that stimulates cost/wage reduction strategies.

Concluding Remarks

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Appendix

A Deflation procedure

WIOD tables are provided in current prices and in previous year 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 (Junius and Oosterhaven, 2003; Lenzen et al., 2007; Temurshoev et al., 2013) 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 (`http://www.wiod.org/home`). Once 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 to a satisfactory deflation procedure.

B Shift Share Analysis

Commonly used shift share decomposition desaggregate overall shift in two components: a within components that accounts for the dynamics inside the unit of observation keeping fixed the composition, and a between components that tracks the role of changes in the composition assuming constant within sector variation. In the usual derivation, the variable to be decomposed is compute...

In this case, we aim to decompose the whole labour share shift in three components thus we need a slight revised decomposition. Our between inputs components accounts for changes in input composition while the other two components track within inputs dynamics. The first, is a within input- between occupation component which tracks the recombination of workers across occupations. The second, accounts for occupation specific labour share shifts.

In what follow, to lighten the exposition we will refer to value added share of inputs having as denominator the whole of each input as v, as employment occupation specific share e and their labour share as l. Further, we define the final period variable as '.

We do not aim at deriving the shift share but just to deliver the full formula.

$$
\begin{aligned}
&\Delta LS = LS' - LS = (v'\, e'\, l') - (v\, e\, l) = \\
&= (v' - v)\, \frac{1}{3}\Big[2(\frac{e' + e}{2}\frac{l' + l}{2}) + \frac{e'l' + el}{2}\Big] + \\
&+ (e' - e)\, \frac{1}{3}\Big[2(\frac{v' + v}{2}\frac{l' + l}{2}) + \frac{v'l' + vl}{2}\Big] + \\
&= (l' - l)\, \frac{1}{3}\Big[2(\frac{v' + v}{2}\frac{e' + e}{2}) + \frac{v'e' + ve}{2}\Big]
\end{aligned}
\tag{9}
$$