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"THE GREAT FALL OF LABOR SHARE: MICRO DETERMINANTS FOR EU COUNTRIES OVER 2011-2019"

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The Great Fall of Labor Share:
Micro Determinants for EU Countries Over 2011-2019[1]

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Abstract

The worldwide fall of labor shares in recent decades is well documented, but its underlying sources remain still unclear. Most of the recent empirical analysis rely on industry or aggregate macro data, downplaying the importance of heterogeneity among firms. In this paper we analyze micro panel data from Amadeus and seek to understand the dynamics of labor share in 19 sectors of the EU28. In our model firms are heterogeneous in capital stock, market power and technology. Labor share's changes turn out to be driven by the complex interplay among these factors. We show that its slowdown in recent years reflects changes in capital deepening, technology progress and capital-labor substitution. Although institutional factors play a significant role in specific industries, they appear to be less relevant, than is usually believed, for the aggregate economy. Specifically, non-linear terms for the capital-output ratio make the effect of capital accumulation on the labor share no longer trivial, explaining the observed heterogeneous behavior within industries.

JEL codes: E24, E25, C33

Keywords: Labor Shares, Capital-Output ratios, Elasticity of Substitution, Technological Change, Markups.

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1. Introduction

Labor share measures the amount of net national income paid out of wages, including benefits and employer's social contributions. This ratio has been on a downward trend in many advanced economies over the last decades (Blanchard, 1997; Bentolila and SaintPaul, 2003; Rodríguez and Jayadev, 2010; Elsby et al., 2013; Karabarbounis and Neiman, 2014; Piketty, 2014). Interestingly, real wages have grown faster than productivity in several industries and less than productivity in others. However, the aggregate labor share has declined because productivity grew faster than wages in the most productive industries, thereby shifting a growing fraction of productivity gains from labor to capital (OECD, 2015). Although there is still a dispute over the extent of this phenomenon because of technical problems, such as the treatment of capital depreciation and indirect taxes (Rognlie, 2016; Bridgman, 2018), the apportionment of mixed income (Cette et al., 2019) and intangible capital (Koh et al., 2019), the consensus is that the fall has been strong and significant. This is very relevant for economic analysis since varying factor shares contrasts with the famous stylized facts of Kaldor (1961) and the properties of the Cobb-Douglas production function. Many elements of this puzzle have recently been pieced together, but some of the sources behind these secular changes, and the variety of industry experiences, are still not fully understood. The empirical literature has proposed numerous explanations for the observed aggregate decline, most of which must be sought at the firm level. Recently, an emerging strand of the labor share literature leaded by the pioneering work of Autor et al., 2020 emphasized the role of rising concentration and markups. They found industry- and establishment-level evidence on firm concentration shares which is consistent with a small fraction of "superstar firms" responsible for the decline, thus giving a major role to structural change and the relocation of added value among companies. However, very little is known about withing-firm dynamics and the shocks that drive the distribution of value added at the lower level of aggregation. Our paper fills this gap and attempt to explain an important part of the shifts. We employ data from Amadeus to study the firm-level evolution of the labor share in 28 EU countries and 19 sectors over the period 2011-2019. Further, we extend the current literature by focusing on a large group of European countries, contributing to a debate that has been dominated by evidence from the United States. We show that the decline of labor share strongly depends on the individual characteristics of firms, with a strong heterogeneity even within industries, as well as within firms over time. We focus on the crucial role played by the capital-output ratio. We find that the main factor decreasing the labor share are connected to capital deepening (a 1% increase in the capital-output ratio reduces the labor share by 0.03

percentage points) in conjunction with capital-augmenting technical progress and labor substitution (-0.15). Although institutional factors play a significant role in specific industries, they are less important for the aggregate economy. However, our most important result is to show that when non-linear terms for capital-output are included in the model the effect of capital accumulation on the labor share gives rise to complex and heterogeneous dynamics. The non-linear relationship between k and the LS is the most important result of the paper, since potentially able to reconcile the conflicting findings in the literature for estimating the elasticity of substitution. The paper is organized as follows. Section 2 reviews the relevant literature. In Section 3, we present some stylized facts on the evolution of the labor share following a top-down approach. A simple theoretical model is presented in Section 4 and the resulting empirical relationships are tested in Section 5. Section 6 conclude.

2. Literature review

The functional distribution of income was defined by Ricardo as "the principal problem of political economy" (Ricardo, 1891). In the early 20th century, as well as the 50s and the 60s the topic was frequently debated (Giovannoni, 2014). This relevance lasted at least until the pioneering work of Kaldor's (1961) with its "stylized facts" of economic growth that became widely accepted among economists. Factor shares have been stable until 40 years ago and this relative constancy was alternatively considered a "bit of a miracle" by Keynes (1939) and a law by Bowley (Samuelson, 1964). Times of large-scale shared economic gains and widespread prosperity shifted the focus of economists from distribution to growth. For at least 20 years, the labor share in industrialized countries remained relatively stable through expansions, recessions, periods of high and low inflation, as well as the long transition from an economy of manufacturing to one centered on services. However, the recent striking and worldwide decline in labor income shares as well as rising inequalities on the personal side of the distribution brought new and fresh blood to this research field. Finally, the interest in the field has risen again after the crisis of 2008, following a worldwide dissipation of wealth along with a decline in aggregate demand. If, according to Gordon (2012), the economic growth rates of the past century in developed countries are over because their drivers have been fully exploited, the distribution of income will become even more contested.

A flourishing literature has provided several explanations for the decline in the labor share. These involves: (i) rapid technological progress (Bentolila and Saint-Paul, 2003;

Karabarbounis and Neiman, 2014); (ii) the globalization of trade and capital (Guscina, 2006; Doan and Wan, 2017); (iii) product, labor market institutions (Blanchard and Giavazzi, 2003) and market concentration (Autor et al., 2020); (iv) the bargaining power of labor and unemployment (Bental and Demougin, 2010). There is a wide diversity of results on the relative importance of these factors obtained using several econometric techniques on either country, industry- and firm-level data. The consensus is that, despite some costs for specific groups of workers, all trends have contributed to global economic growth and convergence of incomes between developing and developed economies.[5] The benefits of extended trade and financial integration for emerging and developing economies are well documented within the European Union (Jena and Barua, 2020). On the other hand, empirical analysis has also shown that, in some advanced countries, the automation of "routine" jobs, along with offshoring and an increasing competition on import, led to a consistent loss of jobs for lower or middle-skilled occupations (Autor and Dorn 2013; Goos et al., 2014).[6]

Technological progress is often presented as the main responsible for labor share movements, with authors focusing on the role of capital accumulation and capital-augmenting technological change (e.g., Bentolila and Saint-Paul, 2003; Arpaia et al., 2009; Driver and Muñoz-Bugarin, 2010; Karabarbounis and Neiman, 2014; Piketty and Zucman, 2014). Embodied technological change affects factor shares through a reduction in the relative price of capital goods. This lowers the user cost of capital for firms providing them an incentive to replace one factor by another (Karabarbounis and Neiman 2014).[7] More recently Acemoglu and Restrepo (2018) extended this theory by focusing on the role of ICT capital, AI and robots. Automation displaces labor demand and wages as it replaces labor in the tasks it used to perform. This is compensated by a relative productivity effect which increases the demand for labor in non-automated tasks but is not sufficient to preserve the labor share of income.[8] Autor and

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[5] An exhaustive review can be found in Baldwin (2018). Other studies on the subject include Costinot and Rodriguez-Clare (2014), Donaldson (2015) and Fajgelbaum and Khandelwal (2016). They all document that capital inflows are accompanied by higher per capita growth in both emerging and developing economies.

[6] Autor and Dorn (2013) found a strong link between the adoption of ICT and the polarization of employment and wages in the United States, while Goos et al. (2014) provide evidence that routine-biased technological change and the offshoring of production can explain job polarization in Europe.

[7] Following the development of automation and the spread of ICT, new vintages of capital goods became cheaper and increasingly capable of replacing workers in their routine tasks. The user cost of capital increases with the price of capital, the interest rate, the depreciation rate, and the (expected future) decline in the price of capital. Thus, firms have an incentive to invest in creating a technology which is biased towards one input if the relative price of this input is much lower (Acemoglu, 2002).

[8] Similarly, Koh et al. (2019) emphasized the increasing importance of intangible capital, such as intellectual property products, R&D and knowledge in the production functions of developed economies.

Acemoglu (2011) showed that the standard model cannot account for the relationships between skills, tasks and technology and proposed an alternative task-based framework where the richer possibilities for substitution among skill sets results in technical change that benefit some workers and is detrimental to others.

A common element in the argument of these papers is that the elasticity of substitution between equipment or intangible capital and labor is assumed to be greater than unity. However, recent empirical works by Oberfield and Raval (2014) and Chirinko and Mallick (2017) cast some doubt on this hypothesis. The value of the elasticity is a matter of first-order importance for analyzing long-rung movements of income distribution. Even if capital and labor are gross complements, Grossman et al. (2017) show that a slowdown in the growth of labor productivity or capital-augmenting technological progress can eventually lead to declining labor shares. Finally, Alvarez-Cuadrado et al. (2018) stress the importance of industry-level specificities in technological progress and the elasticity of substitution between labor and capital in determining the dynamics of factor shares within industries.

Studies find negative (but small) effects of globalization on the labor share in developed countries (Schwellnus et al., 2018). World trade and financial integration of national markets have increased tremendously over the past 40 years. These processes have been driven by the progressive reduction of restrictions, barriers and tariffs on international trade and capital mobility, which, together with the decrease in transport and communication costs have pushed companies towards a global reallocation of factors. A growing competition on imports encouraged the relocation of lower-skill and labor-intensive stages of production to cheaper labor abundant countries (Dao et al., 2017). This occurred with or without an actual change in production locations, i.e., "threat effects" (Burke and Epstein, 2001). Elsby et al. (2013) and Ebenstein et al. (2015) emphasized the importance of international trade and outsourcing with China and found in offshoring an important driver of the labor share in the United States.[9] This has been confirmed by Boehm et al. (2020) which employed plant-wide data, founding that offshoring was a major cause of employment cuts in U.S. manufacturing, while it increased profits in the remaining production plants. However, more recently, Autor et al. (2020) showed

Bridgman (2018) claims that the rise of less durable capital (i.e., computers, software, etc.) mean that a larger share of VA must be allocated to replace depreciated capital. Once the items that do not add to capital, depreciation and production taxes are removed the labor share is virtually stable.

[9] Bockerman and Maliranta (2012) present similar evidence for Finland. Perugini et al., 2017 for Austria, France, Germany, Hungary, Italy and Spain.

that the decline in the labor share involved both tradable and non-tradable sectors, thus weakening the hypothesis that globalization was a key factor in explaining its negative trend.

The role of financial markets has also been stressed. The pressure on firms leads to increased shareholder value by making them focus on their core businesses, exporting low-value, labor-intensive stages of production (Dünhaupt, 2013). Even if some groups of workers may have benefited from this process - by relying on other forms of compensation (i.e., pension funds or capital gain) - there is strong evidence which indicates that for the average worker the extent and magnitude of such gains is circumscribed (Bell and Van Reenen, 2013). This tendency of top labor income to "pass-through" business profit, especially in skill-intensive industries also led to some problems in measuring labor share (Smith et al., 2019). In this perspective, authors questioned whether the decline may be due to measurement issues and redefinitions of income.

Finally, institutional factors have been explored. Although the technological conditions determine factor substitutability, the speed at which firms replace capital with labor depends on frictions in the labor market, which are ultimately determined by the institutional setting. Labor market institutions, product market regulations, bargaining power of workers and the structure of the welfare state are all variables that have been discussed as potentially able to influence the labor share. Special attention has been paid to factors and institutions such as union density, minimum wage, unemployment benefits and compensation for dismissal. The decline in union density in many developed economies has been linked to a reduction in the bargaining power of workers, with a negative effect in their ability to negotiate a larger share of productivity gains in compensation for their labor activities (Fichtenbaum, 2011; Young et al., 2018).[10] Similarly, the level of minimum wage (Harasztosi and Lindner, 2019), including the employment protection legislation (Ciminelli et al, 2018), the use of temporary contracts (Damiani et al., 2020), the generosity of unemployment benefit, as well as the role of social norms and other labor market institution, have been extensively analyzed (Pak and Schwellnus, 2019).[11] A high unemployment rate can exert a downward pressure on the wage demand curve and hence on the labor share, while the level of unemployment benefits can have an impact on the latter by affecting the "reservation wages" of workers. Blanchard and Giavazzi (2003) argue that weakening employment protection policies has contributed consistently to the decline of the labor share in OECD countries. Other studies have attributed to labor market deregulation

[10] The positive effect on labor share is consistent with a "right-to-manage" or "efficiency bargain" model.

[11] However, one could argue that the common experience of a general decline in labor shares in countries with varying degrees of unionization and other labor market institutions, as present in the data, vitiates this argument (Autor et al., 2020).

most of the decline. Azmat et al. (2012) show that a reduction in product market competition and declining employment protection policies have depressed labor shares in European industries but did not find any evidence of this latter effect. Bassanini and Manfredi (2014) associated increasing competitiveness of the markets with increasing labor shares, as the fall in barriers to entry decreases rents of firms and increases the value accruing to workers. The importance of institutional variables is clear, but the evidence is - once again - mixed.

The main objective of this paper is to provide a novel contribution to the debate with new evidence on the role of technology and institutional factors at the firm level. Although previous research has recognized the importance of technological change, we extend the current literature by focusing on a large group of European countries. The role of institutional factors is typically one of the most challenging to be assessed, because of the difficulty in finding reliable proxies to measure their impact. Little time and cross-sectional variation generally characterize index of market regulations, especially at low levels of aggregation. For this reason, to our knowledge, all these explanations have been largely tested only at the country and industry level, even though the aggregate labor share is the result of production decisions and wage-setting processes occurring in large part in individual, heterogeneous firms. A firm level analysis is eventually crucial to reduce measurement problems and control for potential composition bias.[12] The recent results of Autor et al. (2020) showed that increasing market concentration, favored by the employment of new technologies, is likely to drive the decline of the labor share in the United States. For this reason, the role of market regulation is now in the front line in different explanations and deserves further investigation, especially in the European context where the within-industry component is particularly relevant.[13]

We employ Amadeus data and propose a methodology for calculating the labor share of value added and capital-output ratios at the firm level in 28 European Countries. For these

[12] A firm-focused analysis overcomes several measurement issues regarding the accounting for employee and self-employment incomes (Gollin 2002). Further, it allows us to control for composition bias due to changes in the sectoral composition of the economy or firms (De Serres et al. 2002).

[13] De Loecker et al. (2020) employed firm-level data for the U.S. and showed that markups have grown within industry over time, lowering the labor and capital shares. Adrjan (2018) with U.K. longitudinal firm-level data found that firms with greater market power and a higher capital-to-labor ratio allocate a smaller proportion of their VA to workers. Bauer and Boussard (2020) with a database of French firms documented that reallocation of VA contributed negatively, and firm level markups contributed positively to the decline of the labor share, while the contribution of technology was negligible. Dall'Aglio et al. (2015) analyzed labor share dynamics in Italian firms and found that the capital-output ratio plays a key role in either the short and medium run. While increases in the markup and technological progress have positive effects on the labor share in the short run, they eventually became negative in the medium run.

countries we provide microeconomic evidence on the evolution of labor shares in 19 major sectors of the economy. We show that the labor share varies significantly across firms, even within narrowly defined industries, as well as within firms over time. Then we investigate what determines the labor share of individual firms and focus on the crucial role played by the capital-output ratio. To guide our empirical analysis, we build on the theoretical insights of Bentolila and Saint-Paul (2003) and express the labor share of output (value added) as a function of a set of technological factors. We show how distribution in firm-level characteristics can drive and explain observed firm-level differences in labor shares and, in turn, influence its aggregate pattern over time. We allow firms to differ by the capital intensity of their production processes, their market power, productivity and consider potential non-linearities in these relationships. To this extent, we believe that the model presented in this paper can contribute to shed some more light on the channel through which an increase in capital intensity can influence the firm's payments to labor as a share of value added.

3. Some stylized facts

Labor income shares in the European Union began trending down in the 1980s, they reached their lowest level of the past half century before the financial crisis of 2008-09 and have not recovered since then. During the heaviest years of the global economic crisis, the long-term downward trend stopped to collapse again after 2009. This reflects the fact that wages tend to be less volatile than profits during economic recessions. The countercyclical behavior of labor shares in advanced economies has been well documented by business cycle research (Schwellnus et al., 2018) and is explained by the presence of insurance mechanisms for both households and firms in the wage bargaining process which are particularly relevant for European countries (Charpe et al., 2019).[14]

At the same time, the extent of the decline has been very different around Europe. The downward trend can be observed either in recession-hit advanced economies like Ireland, Italy, Portugal and Spain as well as in economically prosperous ones such as Austria, Belgium,

[14] Wage trends in Europe are largely determined by collective agreements at industry level, which continue to apply for long periods of time and are negotiated on inflation expectations which slowly adjust to actual price dynamics. This generates an inertia and rigidities in the behavior of wages, preventing labor cost from adjusting rapidly to changes in labor market conditions. On the other hand, there are substantial changes in employment over the business cycle (Schneider, 2011; Cournède et al., 2016). Labor adjustments costs and labor hoarding may explain part of the recent rise in the labor share (Torrini, 2016).

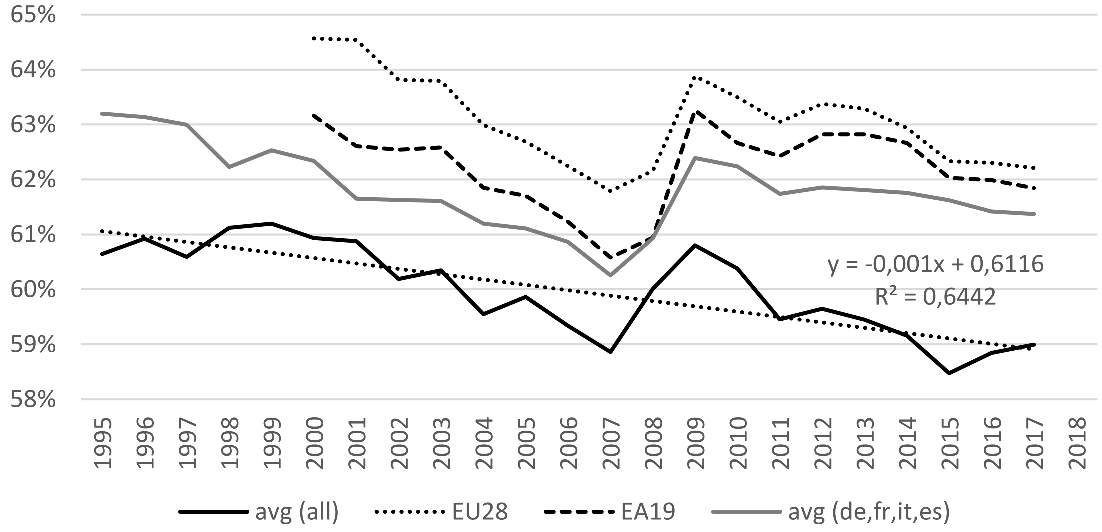
Germany and the Netherlands. New member states of eastern Europe like Croatia, Estonia, Hungary, Malta, Poland, Romania and Slovenia experienced a decline as well, and a few of them (Estonia and Bulgaria) are now on the rebound. Overall, several emerging economies have increased their labor share. Remarkable is the case of Bulgaria, whose labor share in national income was the lowest in 1995 and is now the second highest in the sample. From a cross-country perspective, it is striking to see that large differences exist even across countries that are relatively similar from a technological point of view and even more so that the labor shares of a highly economically integrated area do not converge with each other. During the period of observation, the standard deviation in the growth rates has not changed and since the initial situations in levels were very different these differences have persisted over time. There was a sort of convergence until 2008 when the labor shares began again to diverge quite sharply. Nowadays, some countries like Belgium, France and the United Kingdom have labor shares around 65% of their GDP, while others like Italy, Greece and Sweden have more modest values around 56%. Finally, the labor share of Ireland is as low as 38%.

Figures 1 and 2 are the figures of concern. They illustrate the general decline in 28 European countries.[15] The (adjusted) labor share fell from an average of about 65 per cent to about 60 per cent of income in the most advanced countries of the E.U., and from 57 per cent to 54 per cent in Eastern and developing European countries between 2000 and 2019.[16] None of them - with notable exceptions of Bulgaria and Latvia - experienced any significant increase. The implication is that, in these countries, labor is obtaining an increasingly smaller share of the private-sector's pre-tax revenue.

[15] We compute an adjusted version of the labor share by employing the Gollin (2002) method, i.e., by assuming Identical wage rates. We assign the same average wage to each worker regardless his status (employee or self-employed). This means that the resulting labor share can be considered as a lower bound, since self-employment covers professions such as doctors, lawyers, accountants, consultants and business owners whose income is likely to be above the market average. The labor share is computed for the whole EU28 and the EA19.

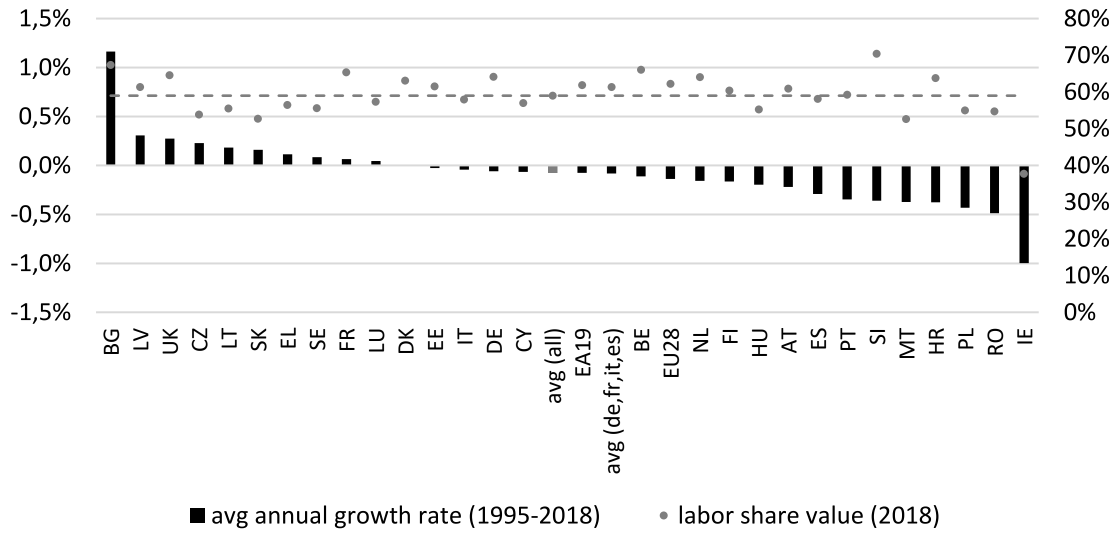
[16] Very large falls in the aggregate labor shares were observed in Ireland (-0.81%), Romania (-0.63%), Croatia (-0.34%), Malta (-0.31%), Portugal (-0.29%), Slovenia (-0.27%), Poland (-0.27%), Hungary (-0.25%), Spain (-0.25%) and Austria (-0.21%), where the cumulative decline for the whole economy exceeded 5 percentage points and is even more pronounced if we consider the private sector alone.

Figure 1 - Labor share of income (whole economy) at current factor cost in European countries (1995-2018).



Note: The figure shows average values weighted by nominal GDP in current euro.
Source: Author's calculation on Eurostat data.

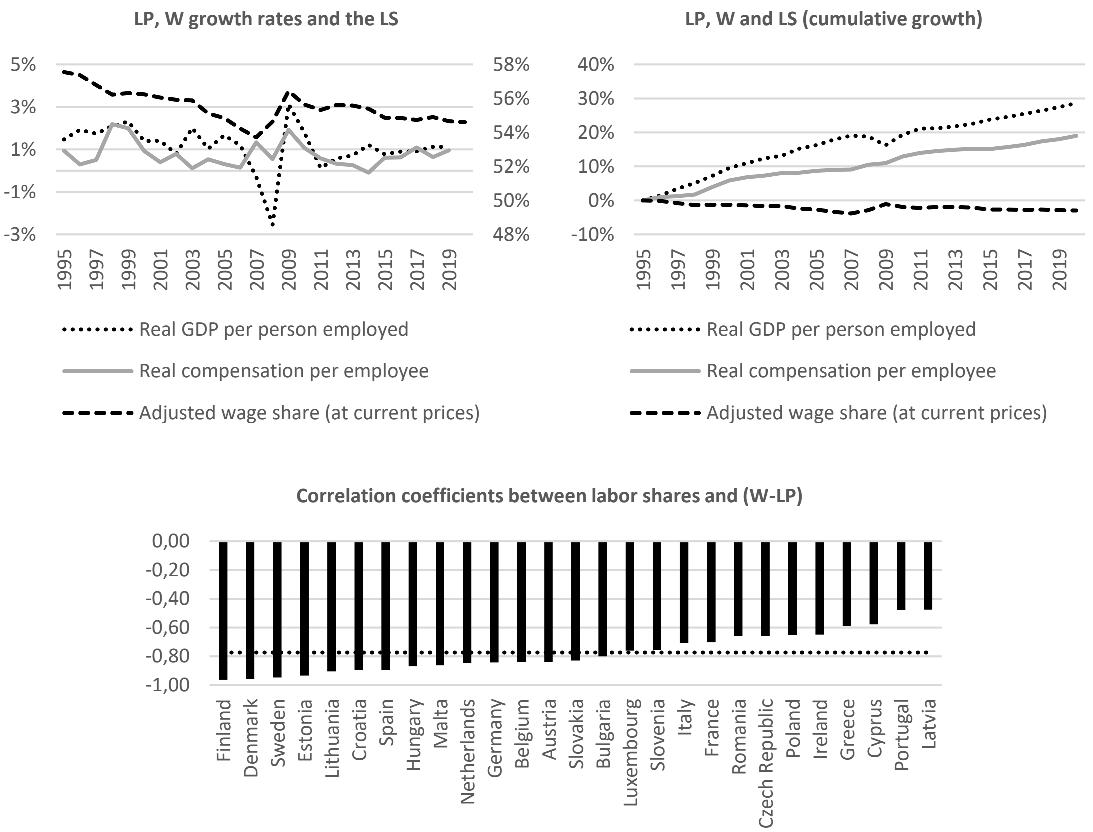
Figure 2 - Labor share of income (total % change 1995-2018 and levels) in European countries.



Note: Bars indicate the % change and the points stand for the levels in 2018.
Source: Author's calculation on Eurostat data.

A falling labor share implies that real wages grow more slowly than productivity (Figure 3).[17] If labor productivity increases rapidly due to technological progress, and this goes hand in hand with a steady increase in labor income, a declining labor share is a byproduct of positive economic development (IMF, 2017). However, in several economies, the decline in labor shares occurred because wage growth failed to keep pace with a weak productivity growth.[18] When this is the case, the decline of the labor share is accompanied by an increase in income inequality (Piketty and Zucman, 2014; Wolff, 2017; Manyika et al., 2019). The relationship between wages and labor productivity can become more complex if the share of wages in total compensation changes over the period of observation, or if different measures are used to deflate wages and output per worker. However, the ILO (2014) shown that in several countries where labor shares declined, wage growth lagged productivity growth even when different deflators are employed.

Figure 3 - Labor productivity, real compensation and the labor share in the EU28.



Source: Author's calculation on Eurostat data.

[17] Recall that the labor share of income can be written as: $(WL)/(PY) = (w/P)/(Y/L) = (w/y)$, where: W is the nominal money wage (including benefits); L is the level of employment; Y is real output and P the GDP deflator. Therefore, Y/L is labor productivity (y), while W/P is the real wage.

[18] On the links between real wages and labor productivity, see Mendieta-Muñoz et al. (2020). For the productivity slowdown, see also Saltari & Travaglini (2009), Ollivaud et al. (2016), Giombini et al. (2017).

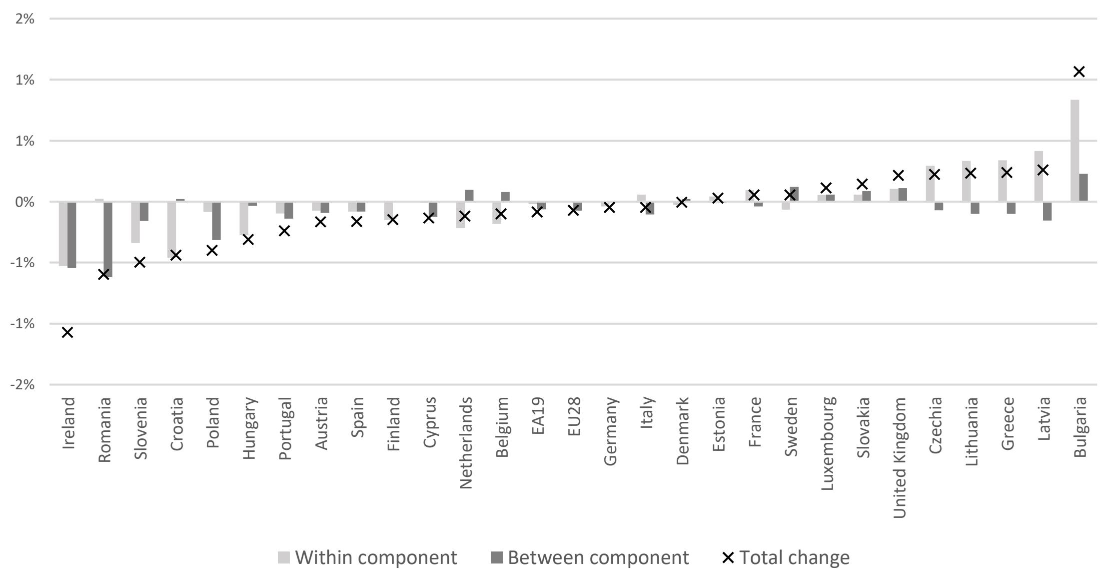
As many large EU economies, including Germany, Italy and Spain, have seen wage growth lagging behind productivity growth, labor productivity has outpaced real average wage growth in a group of 28 European economies for which data is available since 1995.

The trend of stagnating or declining labor shares across the EU reflects considerable heterogeneity not only across countries, but also across sectors, firms and notably skill sets Dimova (2019). In most economies, the erosion is skewed toward low- and medium-skilled workers. Automation raised productivity of specialized workers in several fields such as agriculture, construction and specialized professional services. Gains in service sectors are driven by high-skilled professionals, and their labor share has grown in advanced EU economies. These increases have been driven mainly by productivity. At the other end of the employment spectrum are low and medium-skilled workers, whose share of employment has shrunk because of globalization along with a reduction in unemployment benefits and job protection. Their situation was then made worse by stagnant productivity.

In many countries, real wages have grown faster than productivity in several industries and less than productivity in others. Yet, in these countries, the labor share still decreased on average within industries because labor productivity used to grow faster in high-productivity industries, thus raising the average growth of labor productivity at a level above that of real wages. Several studies have suggested that the observed trends in Europe and the United States could potentially hide important compositional factors (see De Serres et al., 2002; Arpaia et al., 2009; Dao et al., 2017 and Dimova, 2019).[19] Since the early 90s, a number of industries characterized by low labor shares, in particular services such as financial intermediation and insurance activities or the real estates, have gained importance in most countries of the EU while other traditionally labor-intensive industries, such as part of the manufacturing like textiles, have shrunk, thus depressing the aggregate labor share. In Figure 4 we decompose the aggregate change in the labor share into a within-sector and composition effects by means of a standard shift-share analysis for the period 1995-2018 (refer to Appendix B for further details on the methodology employed and Table A1 in Appendix A for individual country results).

[19] De Serres et al. (2002) found that from the mid-1970 to the mid-1990s most of the variation in the labor share in Belgium, France, Italy, and the United States related to the within-sector component, while in Germany the downward trend in the labor share of the business sector was fully explained by a compositional shift towards industries with lower labor shares. This was due to structural change with service activities gaining importance in aggregate value-added at the expenses of manufacturing. Garrido Ruiz (2005) and Arpaia et al. (2009) confirm this result for Spain and the EU15 over specific periods.

Figure 4 - Within and between-industry changes in the business sector's labor share, 1995-2018



Note: Shift-share decomposition of variations in the labor share of the whole economy, partitioned in 11 industries. The wage of the self-employed is imputed assuming that in each industry their hourly wage is the same as for the average employee of the industry. Estimates are based on average hours worked per employee. Average annual contributions of each component in % points. Source: Author's calculation on Eurostat data.

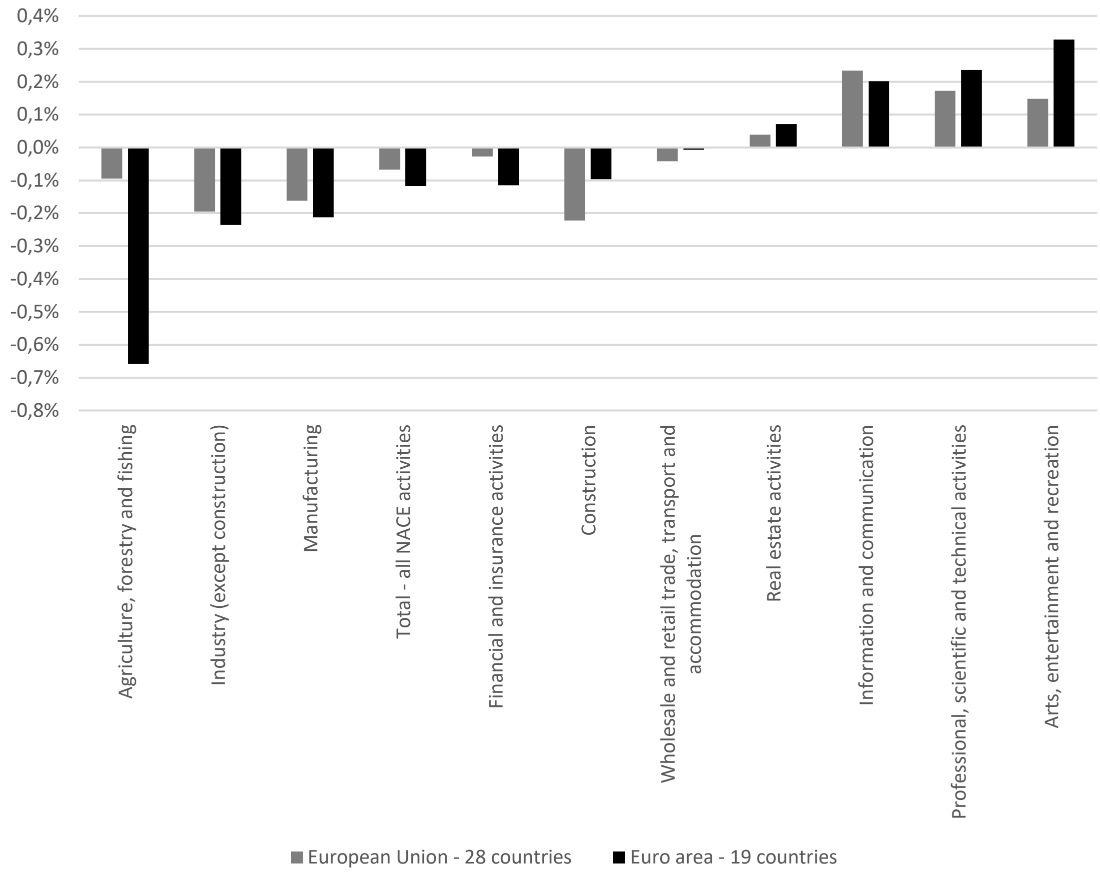
The evolution of the within labor share replicates very closely the evolution of the observed labor share, suggesting that the between-industry component - capturing structural change - has been relatively unimportant in explaining the evolution of the labor share in Europe.[20] More than 70 percent of variation in labor share trends across countries is explained by within one-digit sector variation (see Figure A1 in Appendix A). The role of between-sector reallocation is small on average but plays a dominant role in Romania, Ireland, Poland, Slovenia, Latvia and Portugal - where structural reallocation across industries accounted for a decrease of the aggregate labor share greater than 0.15 percentage points per year. By contrast, in a few other countries, and notably Belgium and Sweden, reallocation to high-wage share industries limited somehow the aggregate consequences of sizeable within-industry falls in the labor share. Finally, in Slovakia, a similar shift in industry composition is responsible for a major part of the

[20] These results are robust to the exclusion of industries for which the labor share is estimated with high uncertainty: (i) real-estate services, whose value added is in great part reported as capital income since results from the imputation of owner-occupied housing in National Accounts; and (ii) public administration and social services, which are provided by the public sector and whose value added is almost equal to the sum of labor costs. Results remain available upon request. Moreover, we reach the same conclusion for the Euro Area (Figure A2 in Appendix A).

significant increase in the labor share in that country. In all other countries that experienced a consistent reduction in the labor share, reallocation of value added across industries played a minor role. In the few cases where this happened, most of the reallocation took place from agriculture, manufacturing, accommodation, food and other service activities towards construction, transportation and professional/technical activities. These results can be explained by a relatively stable industrial structure for developed economies, together with the fact that the reallocation of resources has taken place not between sectors with higher and lower labor shares but rather among sectors with a relatively high labor share of income.

A key question is whether the decline in the labor share has been homogeneous across sectors or whether such a phenomenon has been more important in some specific industries.

Figure 5 - Cross-country average of within-industry changes in the labor share, 1995-2019.



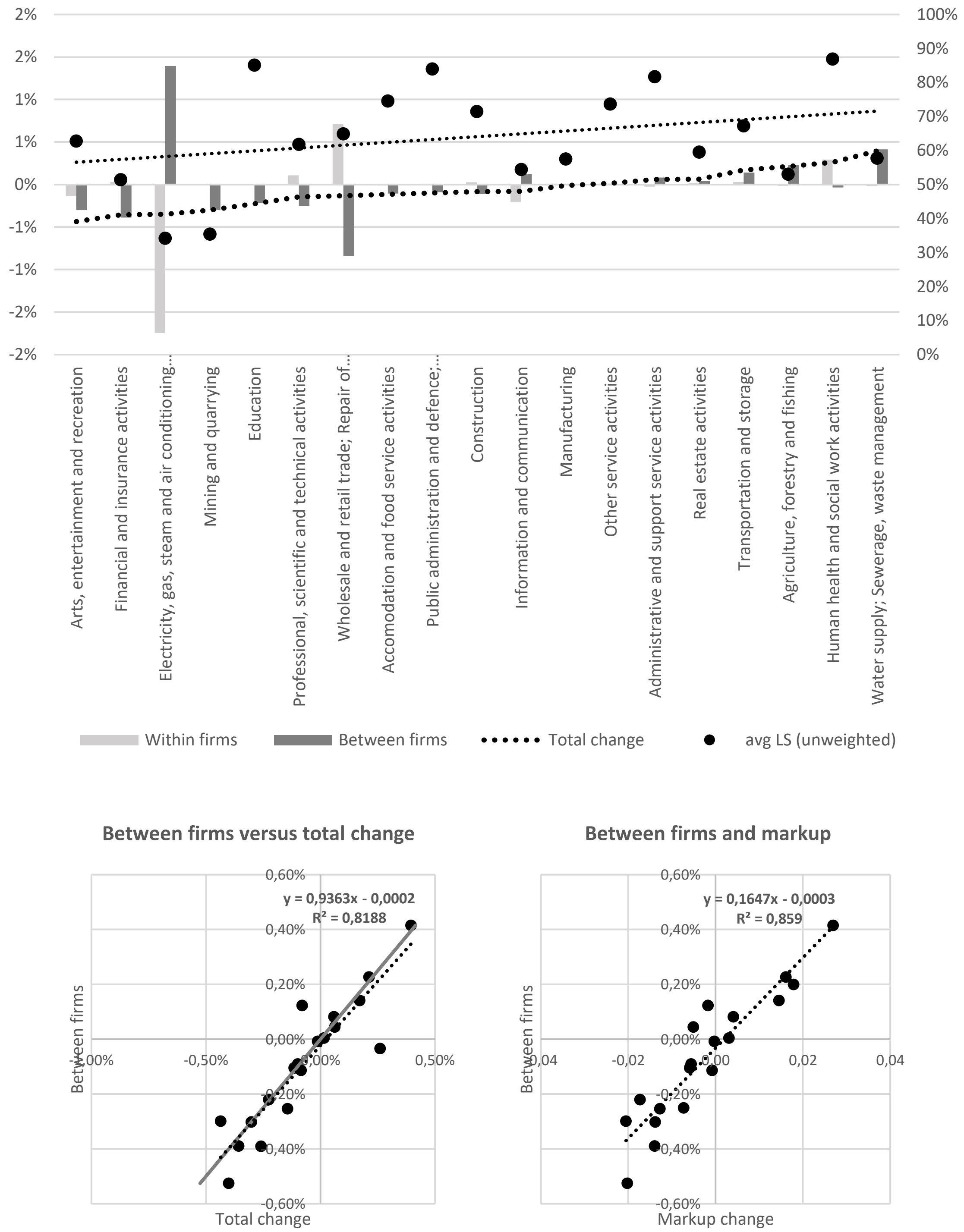
Note: average of within-industry annual percentage-point variations.
Source: Authors' calculations on Eurostat data.

Figure 5 shows that on average across European countries, within-industry changes in the labor share declined or remained rather stable in all business-sector's industries with the exceptions of (M) Professional, scientific and technical activities; (J) Information and communication (ICT); and notably (R) Arts, entertainment and recreation where the labor shares rose substantially by almost 0.54 percentage points per year (0.64 if we consider the EU19). However, these sectors together account for less than 35% of the total value added generated in Europe. By contrast, large contractions in the labor share (above 0.34 percentage points per year on average in the EU28 and 0.26 in the EU19) occurred in the Construction industry as well as in high technology manufacturing, while declines were typically small in other service activities and the low-tech part of manufacturing.

We conclude our top-down analysis with a decomposition of changes in the labor share into between- and within-firms. At the purpose we employ micro data from Amadeus to explore the role of between-firms reallocation of value-added in falling labor shares (Figure 6). In twelve of the nineteen industries considered we observe a decline of the aggregate labor share of value-added over the period 2011-2019. Along with Autor et al. (2020)[21] we find that the unweighted mean labor share across firms has not decreased much in most of sectors of the economy (see Table A2 in Appendix A). Thus, the average firm shows little decline in its labor share and consequently to explain the decline in the aggregate labor share, one must study the reallocation of activity among heterogeneous firms toward firms with low and declining labor shares. Across most European economies, there has been a fall in the labor share and a rise in concentration (here measured thought an increase in markups) with the fall in labor share being greatest in industries where concentration has increased the most. However, withing firm decline is not negligible - accounting for **30%** of the observed decline - and still important in some sectors, in particular (G) Wholesale and retail trade; Repair of motor vehicles (D) Electricity, gas, steam and air conditioning supply (J) Information and communication (Q) Human health and social work activities. Further it contributed significantly to the decline in 9 out of 19 of the industries analyzed. It is exactly this mechanism we want to investigate with the paper, thus resolving the remaining part of the puzzle by focusing on the decline of the labor share within individual companies.

[21] Autor et al. (2020) proposed a "superstar firm" model that emphasizes the role of firm heterogeneity in the dynamics of the aggregate labor share. Modern industries are increasingly characterized by "winner take most" features where a small number of firms can gain very large shares of the market. Large firms have lower labor shares if production requires a fixed amount of overhead labor in addition to a size-dependent variable labor input, or if markups in the product market is positively correlated with firm size.

Figure 6 - Within and between-firms decompositions of business sector's labor share, 2011-2019



Note: Shift-share decomposition of changes in the labor share for the whole economy, partitioned in 19 industries. Between-firm refers to the reallocation component occurring between incumbent firms, while within-firm refers to the unweighted average change in the labor share. Labor share is payroll divided by value-added. Source: Author's calculation on Amadeus.

4. The model

In this section we present a microeconomic model to show why the labor share may vary across firms even within strictly defined sectors and under the assumption that production technologies are identical across firms. To analyze the potential determinants of the labor share, we use as a starting point the model proposed by Bentolila and Saint-Paul (2003). Labor share LS_i on value added of a firm i can be defined as $LS_i = W_i L_i / P_i Y_i$, where W_i is the compensation paid to labor L_i and $P_i Y_i$ is the value added in monetary terms. It is possible to show that under the assumption of Constant returns to scale (CRS), competitive markets and labor-augmenting technical progress - i.e. $Y_i = F(K_i, B_i L_i)$ - there is a one-to-one relationship between LS_i and the capital-output ratio ($k_i = K_i / Y_i$), the so-called $LS - k$ curve (the "share-capital schedule" in Bentolila and Saint-Paul's words):

$$LS_i = f(k_i) \tag{1}$$

Thus, there exists a unique function $f(\cdot)$ to explain the LS_i of a firm based on its capital-output ratio, which in turn depends on factor prices and labor-augmenting technical progress. This implies that variations of the labor share across firms, sectors and countries may be due to different values of the capital-output ratios and different elasticities of substitution between factors. From a theoretical point of view, the response of the labor share to the capital-output ratio is related to the elasticity of substitution in the production function between capital and labor (indicated by σ) and the elasticity of labor demand to wages (η):

$$\frac{dLS_i}{dk_i} = -\frac{1 + \sigma_i}{k_i \eta_i} \tag{2}$$

In this way, as k_i is always positive and the labor demand elasticity with respect to wages is negative, a positive slope of the schedule (i.e. a positive coefficient in a regression of LS_i on k_i) means that the absolute value of the elasticity of substitution between factors (σ_i) is lower than one (factor complementarity); vice-versa, for $\sigma_i \geq 1$, firms substitute capital for labor and the LS curve in the (k, LS) plane is downward-sloping. In the special case in which $\sigma_i = 1$ (i.e., the Cobb-Douglas case), changes in relative factor intensities are exactly offset by changes in their relative prices and the labor share is independent of capital intensity.

From an empirical point of view at the country level, consistently with the canonical model of skill differentials, the first situation has been often associated with developed economies, because of the large share of skilled workers makes them relatively more complementary to capital. On the other hand, the second scenario is more likely to reflect what are experiencing developing economies, where the large share of low-skilled workers makes capital and labor relatively more substitutes (Paul, 2019). Bentolila and Saint-Paul (2003) and Bassanini and Manfredi (2012) obtain both a significant and negative effects of capital intensity as well as TFP - as a proxy for capital augmenting technological progress - in a sample of OECD countries. Similarly, Karabarbounis and Neiman (2014) provide evidence for a negative effect of technological change on the labor share and increasing capital intensity worldwide. Finally, an elasticity of substitution greater than one is also the result of Piketty and Zucman (2014) using data from 1970-2010 in the top eight developed economies of the world. In contrast, there is an equally thriving literature on the labor share that find none or a positive effect of capital intensity, implying an elasticity of substitution that is below or equal to one (Grossman et al., 2017). This is also the result of many studies that tried to estimate the value of this parameter as accurately as possible (Chirinko and Mallick, 2017).[22] Raurich et al. (2013) show that the elasticity of substitution is larger than one in Spain and smaller than one in the U.S. In Spain, the labor income share has decreased while the ratio of capital to GDP has increased, while both the ratio of capital to GDP and the labor income share have decreased in the U.S.[23] This mixed evidence raised our concerns about the possible existence of non-linearities in the impact of the capital-output ratio on the labor share. From an operational point of view, nonlinearities at the firm level could originate from a task-based framework *a là* Autor and Acemoglu (2011). This possibility - which we prove to be supported by the data - allow to reconcile the contrasting results obtained over the years by the literature on the labor share.

Equation (1) of the model tells us that we can observe a negative relation between capital intensity and the labor share of a firm which is not connected with the substitution of capital for labor. More specifically three types of variables are responsible for shifts and movements of the curve. First and foremost, the $LS - k$ curve is stable only if the pattern of technical progress is labor augmenting. Conversely, for capital-augmenting technical progress - $Y_i = f(A_i K_i, B_i L_i)$ - changes in A_i shift the curve, in a way that the effect of A_i and k_i on LS_i

[22] The mean value found by these studies falls in the range of 0.4 to 0.7.

[23] This is closely related to the sectoral composition of the economy. For instance, the IMF (2017) found no significant effect of the relative price of investment on the labor share in tradable sectors, while they found significant evidence for a negative effect in non-tradable sectors, those with a high exposure to routinization of activities.

should always have the same sign.[24] Only in the special case of a CES production function where the LS is given by $LS_i = 1 - \alpha(A_i k_i)^{\gamma}$, the LS_i is monotonic in k_i and the relation between the two variables is either increasing or decreasing depending on the sign of γ, with technological changes A_i which always reinforce the effects of capital intensity k_i. For more general production functions, the relationship does not need to be monotonic, so that the labor share can go up and then down as some variable driving changes in k_i varies. Finally, movements of the $f(k)$ function are also possible. In an environment featuring product and labor market imperfections, there is a gap between the real wage rate and labor productivity. Therefore, all institutional variables that influence this gap are potentially able to cause changes of the LS_i and departures from the curve.

Under *imperfect competition in the product market*, profit-maximizing firms charge their price of a mark-up (μ_i) and their production is sold at a price above marginal costs to achieve a certain profit target. Therefore, the LS_i is conditioned by firms' market power. A rise in the mark-up exerts downward pressure on LS_i and counter-cyclical variation in the price mark-up causes pro-cyclical shifts in the LS_i (Rotemberg and Woodford, 1999 and Nekarda and Ramey, 2020).

$$LS_i = \mu^{-1} f(k_i) \tag{3}$$

Very often in empirical analyses markups are used as a measure of product market regulation, with the idea that a reduction in their strictness causes a reduction of monopolistic positions and a consequent increase in the LS. Note that decreasing entry barriers, consistent with the hypothesis of product markets with homogenous firms and workers, would result in a higher firm competition, a rise in labor demand, and an upwards shift of the $LS - k$ schedule (Blanchard and Giavazzi, 2003). From this perspective, an interesting micro channel for the decline of the labor share is the one highlighted by Autor et al. (2020), which propose and empirically explore an alternative hypothesis for labor share decline based on the rise of "superstar firms". They show that a large class of models of imperfect competition may end up generating large price-cost markups for firms with a high market share. The reason lies in the Marshall's "Second Law of Demand", according to which consumers will be relatively more price-inelastic at higher levels of consumption and lower levels of price.[25] Therefore, an exogenous

[24] As shown by Bentolila and Saint Paul (2003), this means that if A_i shifts the $LS - k$ curve but violates that condition, it is neither labor nor capital-augmenting technological progress.

[25] As shown by Autor et al. (2020), most utility functions deliver this implication, e.g., a quadratic utility function which generates a linear demand curve, but also the CES when there are fixed costs of overhead

shock that reallocates market share towards these firms tends to depress the aggregate labor share. However, it is worth pointing out the results of Kaplan and Zoch (2020) who show that equation (3) is not always valid and whether an increase in the markup leads to an increase or a decrease in the labor share depends on the share of expansionary labor in the economy.[26]

A second source of departures from the $LS - k$ curve relates to *collective bargaining*. If the labor markets are not fully competitive, the bargaining relationships between capital and labor may determine a functional distribution of income more in favor of capital, no matter capital intensity. In models of bargaining power, capital and labor bargain for wages and in some cases employment levels with the consequence that the division of value added depends on their respective backstop options. The bargaining practices of European countries are either described by a "right to manage" or a "efficient bargaining" (Fanti, 2015). Under the former regime, firms and unions bargain over wages and then firms set employment, taking wages as given. Labor demand, obtained from the profit maximization condition, requires equality between the marginal revenue product of labor and the real wage. The outcome is a point on the labor demand curve with the consequence that wage pushes cause changes in the capital-output ratio and movement along the $LS - k$ curve.[27] In contrast, in the efficient bargaining model of McDonald and Solow (1981) trade unions cause departures from the $LS - k$ schedule whenever they negotiate with firms over both wages and employment. In this case the wage rate differs from the marginal product of labor and unions create a gap between these two variables. Wages and employment, obtained as solutions of a Nash bargaining game, result in a "contract curve" where the union iso-utility and employer iso-profit curves are tangent. Depending on the shape of union preferences, the contract curve can be sloped upward or downward in wage-employment space and the relationship between LS and the capital-output ratio is off the one implied by the $LS - k$ schedule[28] (Bentolila and Saint-Paul, 2003). Therefore, in this framework, a rise in union bargaining power raises both real wage, employment and the LS_i of the firm. Empirical evidence on the appropriate model of union behavior is inconclusive.

labor that do not rise proportionally with firm size. For more details see Mrazova and Neary (2017) which discuss the implications of a wide class of utility functions which may generate "demand manifolds".

[26] Expansionary labor activities include a wide range of business activities such as overheads, product design, R&D, logistics and marketing. Incorporating this particular and very specific use of labor has important implications for aggregate labor income dynamics and income inequality.

[27] For a given wage, employment in the *right-to-manage* firm will be the same as in a competitive firm. When unions raise wages above the competitive level, employment decreases.

[28] For a given wage, employment is higher in the *efficient-bargaining* models if unions care about employment. If unions do not care about employment (the "seniority" *a la* Oswald, 1993) the RTM and EB models are indistinguishable.

For what concerns *labor hoarding*[29], the literature on LS has investigated the effects of labor adjustment costs - such as firing and hiring restrictions, search and training costs of employees. Specific indicators for labor market reforms were developed and employed by the literature, usually based on "hiring and firing legislations" or "business regulations". Firing (hiring) costs for instance force firms to fire (hire) less in recessions and hire (fire) less in booms causing wage costs to fluctuate less cyclically than output, thus reducing volatility and inducing the observed countercyclicality in the labor share. This is a matter of particular interest for European countries, whose regulation imposes high hiring and firing costs. In this context, changes in the employment legislation are responsible for movements off the $LS - k$ curve which take place in the short run during the transition between two different equilibria (EC, 2018 and Torrini, 2016 for Italy). Bentolila and Saint-Paul (2003) argued that enhancing labor adjustment would boost the wedge between the real wage and the marginal revenue product of labor. An increase in the marginal adjustment cost generated by an extra unit of labor will push the marginal cost of labor above the wage when the firm is hiring and below it when it is firing. If adjustment costs are convex in the change in employment $AC(\Delta L)$,[30] they translate into a gradual distribution over time, no matter the magnitude of the change in employment, which rationalizes a delayed response of employment to changes in production. Adjustment costs have two effects on the labor share. (i) They influence the demand for labor of firms and the equilibrium real wage. In this sense, for a given average employment level, the firm's marginal costs are higher when employment adjustment is costly, which implies a lower wage share. (ii) On the other hand, since labor income is made up of work and a monetary transfer corresponding to the value of the insurance against unstable employment provided by the adjustment costs, adjustment costs raise the labor share if they translate in additional compensation to workers.[31] The overall effect on the curve is unclear.

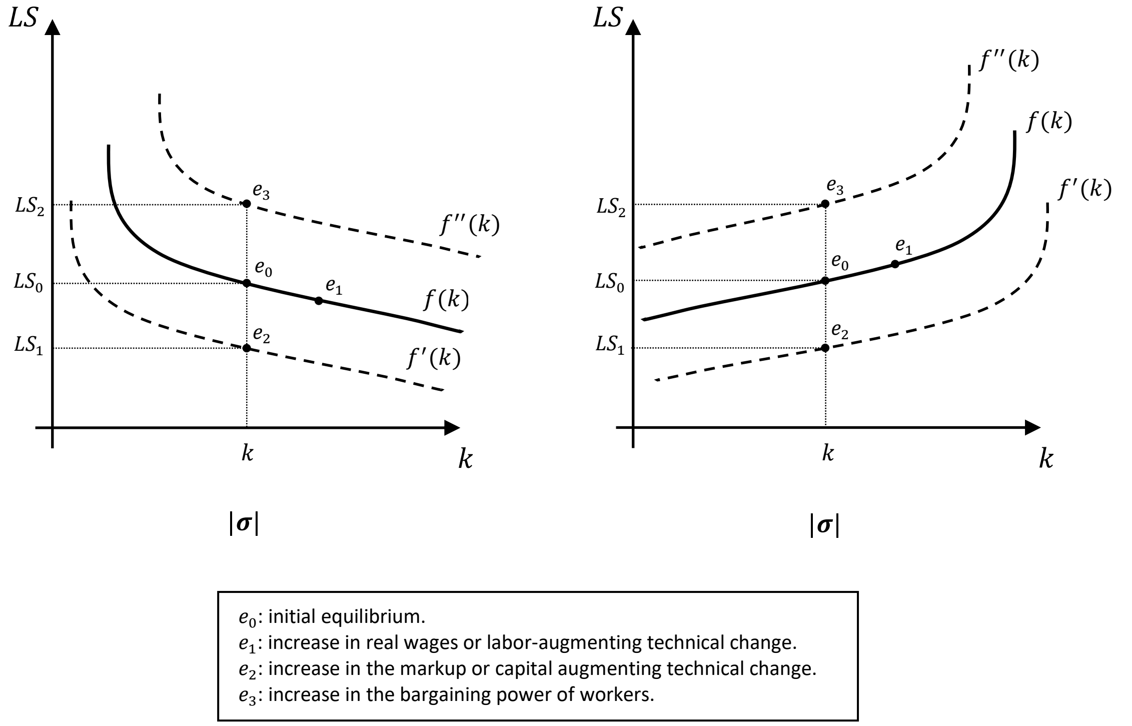
The discussions made so far on the $LS - k$ curve, including movements along it for different values of the elasticity of substitution and shifting factors are summarized in Figure 7.

[29] Under-utilization of labor can take various forms, such as reducing effort or working hours, and shifting labor to other uses (e.g., training). From a company perspective, some labor hoarding may be optimal given the fixed costs associated with staff adjustment. These costs include the costs of recruiting, selecting and training new workers, as well as costs related to the end of contracts (like for instance severance pay).

[30] Adjustment costs have most often been represented using a convex symmetric function, even if a growing body of empirical literature has rejected the hypothesis of "symmetric adjustments" in favor of some forms of asymmetry (see a comprehensive review of the literature in Hamermesh and Pfann, 1996).

[31] It is possible to distinguish between adjustment costs that take the form of payments from a firm to the worker (e.g., severance pay, training costs, or recruitment services from recruitment agencies) and costs that are not directly or indirectly related to employment.

Figure 7 - $LS - k$ curve for respectively an elasticity of substitution > or < 1.



Note: an increase in the real wage (or a decrease in the user cost of capital) results in movements along the curve and variations in the labor share which depend on the elasticity of the substitution between labor and capital. A high elasticity of substitution (i.e., $\sigma \geq 1$) provides firms with a strong incentive to replace labor with capital thus decreasing the labor share, since higher wages are largely offset by a decrease in employment, for a constant level of production (panel A). On the other hand, the complementarity between labor and capital (i.e., a $\sigma < 1$) leads the same increase in wages (or a decrease in the user cost of capital) to raise the labor share, due to the very strong increase in employment (since in this latter case labor is a complement to capital) (panel B).

An important lesson we draw from the literature review in Section 2 refers to the possibility of non-linear relationships between the labor share and some of its driving forces. This should be a strong reason to move beyond the notion of a constant, immutable, and exogenous elasticity of substitutions (Palivos, 2008). Indeed, the diversity of findings on the matter is remarkable and explains the difficulty of obtaining agreement on an empirically supported consensus value for σ (Knoblach et al., 2020). Raval (2019) estimates it to be in the order of 0.3/0.5 using American plant-level data, with similar results across industries. Production technology determines the characteristics of σ and the relationship between the allocative efficiency of factors.[32] The "accumulation view" is not always supported. For instance, Paul (2019) shows how both capital-output ratio and the labor share of income increased simultaneously in most Japanese industries

[32] Since the elasticity of substitution is "a measure of the efficiency of the productive system" (De La Grandville, 1989), it makes more sense to assume that this parameter it is firm- rather than sector-specific and expect wide variations also across different firms within a given sector.

between 1970 and 2012, while estimates of σ obtained with a standard CES framework are predominantly greater than unity across sectors. All these findings point to an apparent puzzle.

Here we attempt to resolve this puzzle and show how the assumption of a non-unitary σ along the isoquants of firms can potentially explain the observed movements in capital-output ratio and the labor income share over time. The labor income share moves along a stable and non-linear curve with certain factors - either institutional technological - that shift it upward or downward as also noted by the previous literature. Capital-output depresses labor income share at low levels of the capital accumulation curve but enhances labor income share when a moderate level of capital stock has already been attained. In what follows, we augment in qualitative terms the model formulated by Bentolila and Saint-Paul (2003) by adding our own working hypotheses, which rely on the large empirical evidence about the possibility that the elasticity of substitution for firms changes with capital accumulation along their isoquants. We abstain from any consideration concerning the functional forms and rely on a general production function as the one expressed in Equation 1.

5. Empirical results

The $LS - k$ curve is a technological relationship, and hence it is more appropriate to investigate it at the firm rather than at the country level. Therefore, we verify the hypotheses discussed above by estimating the relationship between the capital-output ratio (k_{it}) and the labor share LS_{it} for firm *i* and year t, capital-augmenting technological progress proxied by firm-level TFP (A_{it}), market competition proxied by firm-level markups (μ_{it}) and labor adjustment costs proxied as in Bentolila and Saint-Paul (2003) by changes in employment at the industry level (ΔlnE_{jt}).[33] To this purpose we do not restrict the functional form of the labor share to the one derived for a specific production function and start from a general form representing an augmented $LS - k$ curve:

$$LS_{it} = f\left(k_{it}, A_{it}, \mu_{it}, \Delta lnE_{jt}\right) \tag{4}$$

[33] TFP and markups are estimated using the generalized cost-minimizing producers procedure and a translog value added production function following De Loecker and Warzynski (2012) (see Appendix B for a detailed description of the procedure employed).

Equation 4 is estimated on our unbalanced panel of 716.094 firms belonging to 19 1-digit NACE rev. 2 sectors, 28 EU countries and for the period 2011-2019. We take the log and estimate the following linear model:

$$\log(LS_{it}) = \alpha_i + \beta \log k_{it} + \psi \log TFP_{it} + \delta \log \mu_{it} + \theta \Delta \log E_{jt} + \tau_t + u_{it} \qquad (5)$$

where α_i is the firm fixed effect to account for all time-invariant firm-specific unobservables and τ_t is a series of year dummies accounting for common trends in our variables.

Modeling the drivers of the labor share poses some identification issues. A relevant one relates to potential sources of endogeneity. To cope with it we treat right-hand side variables (in particular the capital-output) as potentially endogenous. In line with Bentolila and Saint-Paul (2003) we use as instrumental variables for the levels of capital-output ratio, TFP, markup and changes in industry-level employment the lagged first difference of the same variables, thus limiting endogeneity coming from simultaneity. As a robustness check, in Appendix A - Tables A4 and A5, we also report results in which we do not account for this endogeneity.

In Section 3, we argued that the relationship between the labor share and the elasticity of substitution between capital and labor may not be so easy to interpret because of the (potential) dependencies across the variables involved which could indeed turn out to be very strong. Consequently, the estimation of a standard linear additive models with all the explanatory variables considered as independent (as in Equation 5) may be inferior to the alternative of estimating a multiplicative model with interactions, where the effect of each independent variable depends on the value of other independent variables. Indeed, this is the appropriate way of modelling whenever the hypothesis being tested is conditional in nature (Brambor et al. 2006). Therefore, we also decided to estimate a modified version of the standard model by including multiplicative interaction terms between firm-level independent variables.[34] In turn, the corresponding multiplicative interaction model takes the following form:

$$\begin{aligned} LS_{it} = \alpha_i + \; & \boldsymbol{\beta_1 \log k_{it}} + \boldsymbol{\beta_2 (\log k_{it})^2} + \boldsymbol{\beta_2 (\log k_{it})^{\cdot}} + \pi_1 \log(TFP_{it}) \\ & + \pi_2 log(\mu_{it}) + \pi_3 \Delta\log(E_{jt}) + \pi_4 \log(TFP_{it})\, log(\mu_{it}) \\ & + \pi_5 \log(TFP_{it})\, \Delta\log(E_{jt}) + \pi_6 log(\mu_{it}) \Delta\log(E_{jt}) \\ & + \pi_7 \log(TFP_{it})\, log(\mu_{it}) \Delta\log(E_{jt}) + \tau_t + u_{it} \end{aligned} \qquad (6)$$

[34] Several authors in recent years have offered valuable advice on how to estimate and interpret models that postulate interaction by correctly specifying expected conditionality and effectively interpreting results. To further explore the role of interactions, see the works of Braumoeller (2004), Franzese and Kam (2009), Berry et al. (2012) and Hainmueller et al. (2019).

The main purpose of Equation 6 is to estimate the exact shape of the conditional relationship between capital-output ratio and labor share. Such model with saturated interaction terms of our control variables allows to partial out observable confounding effects in a flexible way.[35]

5.1 Descriptive evidence

We consider the factors driving the evolution of the labor share at the firm level in 28 EU countries and 19 sectors over the period 2011-2019. We use balance sheet and income statement data from Amadeus (Bureau van Dijk) for 716.094 public and private companies in 28 European countries.[36] Appendix C provides further details on the database, variables, data construction, the number of unique firms and the number of observations. The covered firms in these 19 1-digit NACE rev. 2 sectors comprise approximately 60-85 percent of both total employment and value-added in the country.[37] Total compensation in AMADEUS includes all forms of paid compensation, such as wages and salaries, paid in cash or in kind, as well as employer contributions to pensions, healthcare, and social insurance. The gross value added is estimated as sales minus the cost of intermediate inputs different from employee compensation (calculated from the income statements as earnings before interest, tax, depreciation, amortization plus the expense for employee compensation). The stock of capital is calculated as the sum of tangible and intangible assets net of accumulated depreciation. Monetary variables are deflated by means of sector- and variable-specific deflators from the National Accounts by 64 branches of Eurostat.

Standard descriptive statistics are reported in Appendix C. Let us focus our discussion on our two focal variables. The distributions of the aggregate labor share and that of the capital-

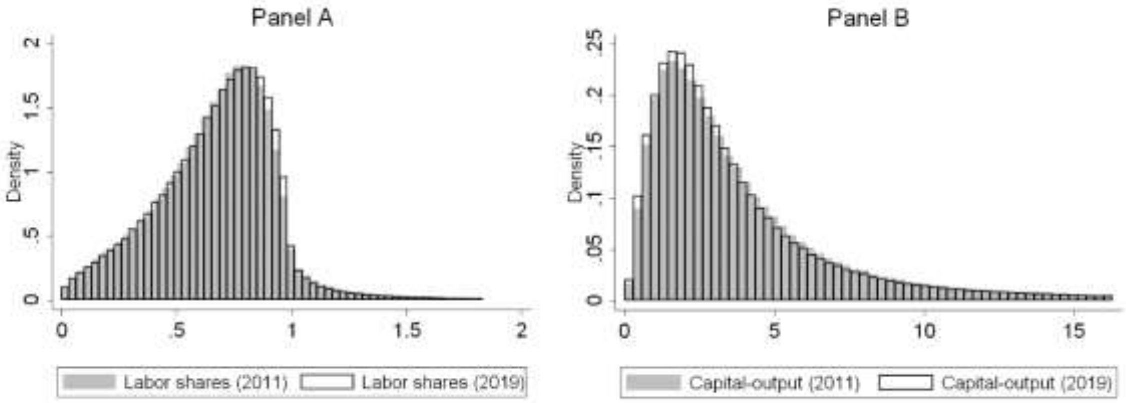
[35] As we have several possible endogenous interaction terms, it is not straightforward to employ lagged first differences as instrumental variables. Due to the descriptive nature of this second step of our empirical analysis, we estimate Equation 5 by means of a simple linear fixed effect model, assuming that all variables are exogenous. The presence of many interaction terms alters the interpretation of the estimated parameters directly. To sum up, our empirical model assesses the cross-dependencies among capital-output ratio, total factor productivity (TFP_{it}), the markup (μ_{it}) and labor adjustment costs (ΔE_{jt}).

[36] The Dataset only enumerates employer firms with more than €1 million in total operating revenue and does not include self-employed income. Therefore, remains an issue of how business owners allocate income. However, Smith et al. (2019) show that this account for a negligible part of the labor share decline.

[37] Cross-country comparability is possible, keeping in mind that different countries use different reporting thresholds in the definition of their sampling frames. Coverage of the small and medium enterprise segment (SMEs) is particularly good in Italy, Portugal, and Spain. Although the latter is considerably smaller in Germany, Amadeus still captures two-thirds of corporate sector assets.

output ratios have remained rather stable between 2011 and 2019 (Figure 8), even though the distribution of the capital to output ratio has become less skewed.

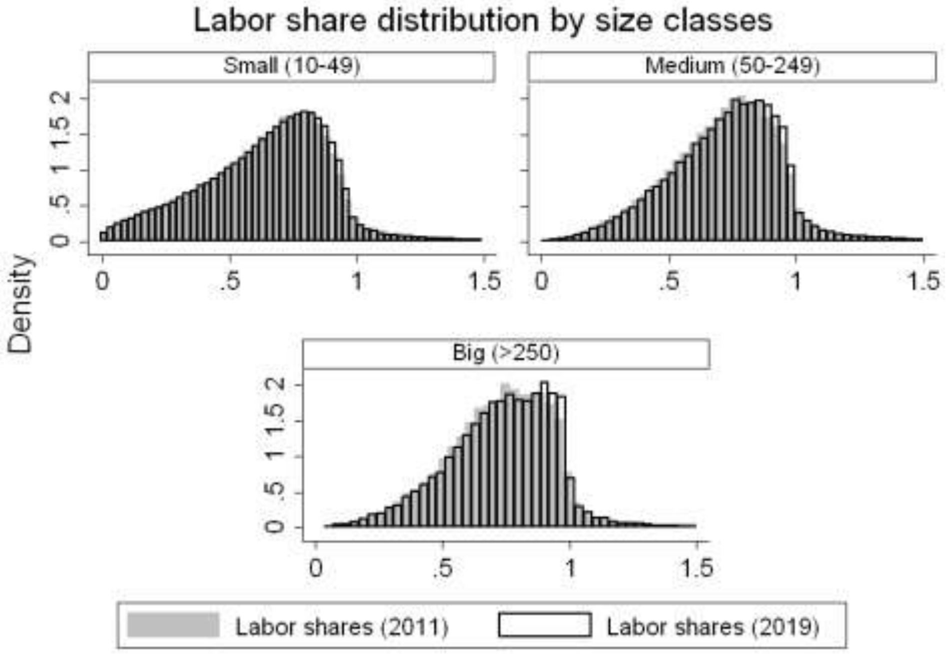
Figure 8 - Distribution of labor shares (LS) and capital-output ratios (k) (2011 and 2019).



Note: The grey area reflects the weighted raw distribution of respectively labor shares (panel a) and capital-output ratios (panel b) in 2011, while the red shaped overlay area that in 2019. Source: Authors' elaboration on Amadeus.

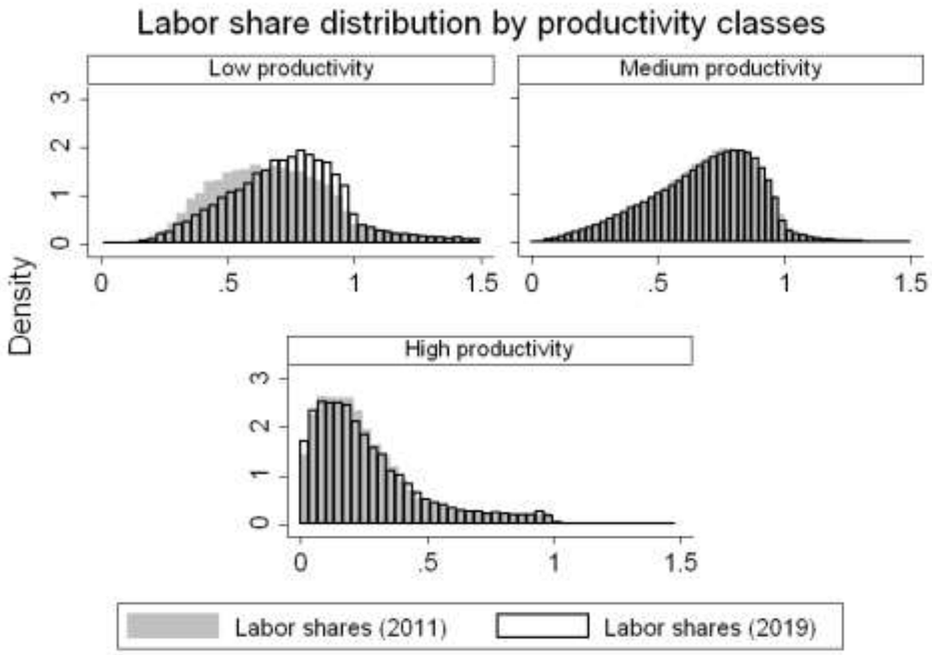
This latter hide contrasting movements at the micro level between different groups of firms. Indeed, alongside the aggregate stability in the mean value of the labor share and its distribution - meaning that the median firm did not experience any substantial change in its labor share - there has been a substantial redistribution between groups. If we look at firms in terms of their size, we find that the relatively contained decline of the (weighted) aggregate labor share has been entirely driven by a reallocation of value added toward the small and medium-sized enterprises of the sample which nevertheless have decreased both their average and median labor shares (see Figure 9). In these groups (defined as those with respectively less than 250 and 500 employees) the labor share in 2011 was 1.35 and 1.79 percentage points higher than the level registered in 2019. On the other hand, companies with more than 500 employees seem to have withstood the impact better even if they have lost ground in terms of value-added. The average labor share of firms in different size classes is relatively homogeneous (for instance, the average of small and big firms is in both cases roughly 61%). This result should not surprise us too much because our model clearly states that the size of the company is not in itself a feature that can influence its labor share. What influences the firm's labor share are instead its underlying characteristics in terms of the variables that we have identified to be relevant in affecting its behavior.

Figure 9 - The changing distribution in the labor share by size class, 2011 and 2019.



Source: Authors' elaboration on Amadeus data.

Figure 10 - The changing distribution in the labor share by labor productivity class, 2011 and 2019.



Note: Productivity classes are derived by referring to labor productivity distribution. More precisely we consider as high-productivity those firms that belong to the highest decile of the distribution, while low-productivity all those that belong to the lowest decile. Source: Authors' elaboration on Amadeus data.

5.2 Results

Autor et al. (2020) show that, if globalization or technological change imply a relocation of production towards the most productive firms within each industry of the economy, market concentration will rise as industries become dominated by the so-called "superstar firms". Since these latter are characterized by systematically higher markups and a lower labor share of value-added, such a framework implies that the reallocation of output may be crucial to understand movements in the aggregate labor share. The labor share of the most productive firms (top 10%) is 35 percentage points lower than that of medium productive ones and up to 48 percentage points lower than that of the low productive (see Figure 10). This means that the observed fall in the labor share over the long run may be ascribable to the reallocation of value-added between heterogeneous firms rather than a general fall within incumbent firms.

Estimates of Equation 5 for the whole economy lead to the following results (t-ratios).

$$\begin{aligned} log\ (LS_{it}) = \underbrace{-0.0301}_{(-4.21)} \log(k_{it}) \underbrace{-0.152}_{(-8.73)} \log(TFP_{it}) \\ + \underbrace{0.000598}_{(1.21)} \log(\mu_{it}) \underbrace{-0.00102}_{(1.21)} \Delta \log(E_{jt}) \end{aligned} \tag{7}$$

The coefficient for the capital-output ratio (-0.030) implies, for a value of $\eta = -0.51$ an average capital-labor elasticity of 1.01, which is not far from the Cobb-Douglas value of 1 at the 1% level. This result lies between those found by other researchers. Table 1 reports the estimates of our basic specification, Equation (5), broken down by sector.[38] The effect of firm's capital-output ratio on the labor share turns out to be either positive or negative, suggesting that labor and capital can be either complements or substitutes depending on the industry (t-ratios indicate that industry coefficients are statistically significant, except for Real estate activities, Public administration and Education). It could be argued that this result may ultimately relate to the shares of skilled labor and the shares (but also the role) of tangible and intangible capital in different firms and industries (O'Mahony et al., 2019).

As a check of the results, in the spirit of Bentolila and Saint-Paul (2003) we employ the estimated coefficients to compute industry-specific measures of the elasticity of substitution between K and L, σ_{KL}. Following their methodology, from Equation (5), we compute it as: $\sigma_{KL} = -\left(1 + \frac{\partial \ln LS}{\partial lnk} \overline{LS} \eta\right)$. To this aim, we need an estimate of η, i.e., the elasticity of the labor demand with respect to the wage. There are several estimates of wage elasticity in the

[38] The same estimates for the manufacturing subsectors are shown in Table A3 - Appendix A.

literature, but they are heavily dependent on the specifications employed. For this reason, we rely on all previous research and in particular the work of Lichter et al. (2014) which building on 942 elasticity estimates from 105 different studies find an overall mean (median) own-wage elasticity of labor demand of -0.508 (-0.386), with a standard deviation of 0.774. Table 1 shows our estimates for σ_{KL}. Using these values for η, we obtain elasticities above 1 in 10 out of 19 cases, varying across sectors from 0.77 to 1.35. For comparison purposes, in the column immediately to the left we also report the value obtained using an elasticity of labor demand with respect to wages of (-0.39) as in the original article by Bentolila and Saint Paul. However, it is worth noting that we do not get any major changes in our results, except for Real estate activities that had an elasticity greater than unity and exactly equal to 1 after the change in the elasticity of labor demand.

Firm-level TFP is meant to capture the effect of capital-augmenting, or more generally "not labor-augmenting", technological progress on the labor share. The estimated coefficient for the full sample is negative and significant. On average, an increase in the TFP by one percent lead to a decrease of the labor share by 0.15 percentage points. Therefore, capital biased technological progress decreases the labor share of income in European Countries. This finding confirms that of other studies also at higher levels of aggregation such as Guscina (2006) which, using labor productivity as a proxy for technological progress, analyzes the impacts of the evolution in technology on the labor share of income for 18 industrialized countries between 1960 to 2000. However, when considering cross-sectoral heterogeneity, we find a negative and significant relationship for six industries but a positive and significant relationship for nine industries. As pointed out above, if total factor productivity is strictly capital augmenting, its relationship with the labor share should have the same sign of the capital-output ratio. Indeed, this is the case for most sectors, but not all, suggesting that a more complex effect of productivity on the production function may be at stake.[39] We will consider this fact in estimating the model with interactions afterwards.

[39] TFP has a different sign with respect to the capital-output ratio in four industries: Agriculture (A), Mining (B), Accomodation and food (I) and Administrative and support service activities (N).

Table 1 - Estimation of labor share equation Dependent variable: $lnLS_{it}$

Code	Sector name	log(k)	- σ_{KL} η=(-0.39)	- σ_{KL} η=(-0.51)	log(TFP)	Markup	ΔE	F test excl IV	N obs
A	Agriculture, forestry and fishing	0.310*** (9.54)	-1.070	-1.080	-0.080*** (-2.63)	-0.090*** (-6.39)	-0.020** (-1.81)	1575.45	73,941
B	Mining and quarrying	-1.650*** (-3.43)	-0.730	-0.660	0.370*** (4.77)	-0.320*** (-5.27)	0.010 (0.42)	158.57	9,925
C	Manufacturing	0.080*** (4.86)	-1.020	-1.020	0.050*** (3.02)	-0.480*** (-3.72)	-0.010** (-2.16)	7013.92	662,015
D	Electricity, gas, steam and air conditioning supply	-0.070 (-0.44)	-0.990	-0.990	-0.320 (-0.402)	0.030 (0.144)	-0.010 (-0.17)	75.99	18,276
E	Water supply; Sewerage, waste management	0.750*** (3.55)	-1.180	-1.230	0.970*** (3.19)	-0.570 (-1.08)	-0.010 (-0.41)	511.18	29,365
F	Construction	-0.170 (-1.31)	-0.950	-0.940	2.060** (2.16)	-0.700*** (-2.64)	0.010*** (3.19)	4020.92	238,267
G	Wholesale and retail trade; Repair of motor vehicles	-0.350*** (-9.08)	-0.910	-0.880	-0.090** (-1.97)	-0.340** (-2.48)	0.010*** (4.13)	5085.72	719,367
H	Transportation and storage	0.030 (0.52)	-1.010	-1.010	0.150** (2.15)	-0.240** (-2.03)	0.020*** (3.57)	2456.48	146,307
I	Accomodation and food service activities	-0.490*** (-5.05)	-0.860	-0.820	1.530*** (7.98)	-0.810*** (-3.46)	-0.020 (-0.69)	2100.85	105,435
J	Information and communication	-0.190*** (-5.24)	-0.960	-0.950	-0.320*** (-4.96)	-0.180*** (-3.65)	-0.010 (-0.99)	597.56	74,619
K	Financial and insurance activities	-0.080 (-0.68)	-0.980	-0.980	0.750 (0.401)	0.010 (1.64)	0.020 (1.08)	674.60	112,630
L	Real estate activities	0.020 (0.02)	-1.000	-1.010	1.470 (0.55)	-0.390* (-1.88)	0.010 (1.12)	619.15	56,387
M	Professional, scientific and technical activities	-0.160*** (-3.08)	-0.960	-0.950	-0.560*** (-4.66)	0.090 (0.22)	0.020** (2.22)	388.88	83,428
N	Administrative and support service activities	-0.470*** (-5.04)	-0.850	-0.810	1.020*** (3.61)	-0.420** (-1.98)	0.010 (0.93)	1257.51	81,066
O	Public admin & defence; Compulsory social security	0.240 (1.53)	-1.080	-1.100	1.820 (0.48)	-1.070 (-0.63)	-0.010 (-0.72)	262.95	14,317
P	Education	-0.050 (-0.74)	-0.980	-0.980	2.220*** (8.94)	-1.540** (-2.16)	0.010 (0.44)	897.84	37,125
Q	Human health & social work activities	0.330*** (8.77)	-1.110	-1.140	0.450** (2.43)	-0.820*** (-3.78)	0.010 (0.9)	730.90	27,145
R	Arts, entertainment and recreation	0.170*** (2.88)	-1.040	-1.060	-0.040 (-0.31)	-0.500*** (-3.04)	-0.020* (-1.73)	342.65	23,606
S	Other service activities	0.310*** (2.65)	-1.090	-1.120	0.260 (1.124)	-0.690** (-2.13)	0.010 (0.57)	303.92	15,179
ALL	Whole economy	-0.030*** (-4.21)	-0.990	-1.010	-0.152*** (-3.293)	0.0005** (2.09)	-0.001 (0.92)	14078.88	2,528,400

Note: IV fixed effect model. Instruments for levels of log(k), log(TFP), markup, ΔE: lagged first differences. t-statistics based on standard errors clustered by firm in parenthesis. Additional controls: year dummies. Period: 2011-2019.

Turning to movements off the equilibrium (i.e., off the established $LS - k$ curve), in Table 1 the variable capturing the effects of labor adjustment costs, namely the sector-level employment growth rate, shows on average the expected negative sign, though not statistically significant. For what concerns markup, we find a positive and significant relationship with the labor share in the whole economy, even though the magnitude of the estimated coefficient is very small. This result goes against the prediction of our model but is compatible with the model of Kaplan and Zoch (2020) which shows that that whether an increase in the markup leads to an increase or a decrease in the labor share depends on the share of N-type labor in the economy. Indeed, when a sufficiently large fraction of labor income compensates N-type activities, the established and negative co-movement can be reversed.[40] However, when considering one sector at a time, the sign of markup is generally negative or not significant, which is in line with our theoretical predictions.

Our estimates in Table 1 are in line with the results in these two sets of studies, which are however not readily comparable to ours, since they use aggregate data for many countries, rather than firm-level data for European countries as we do.

At this point we would like to draw attention on the most important result of our paper. Given that the theoretical model suggests potential non-linearities in the elasticity of the labor share with respect to the capital-output ratio and given that we find both positive and negative coefficients in different industries, we now try to capture this effect and hence a possible more complex relationship between k and the LS. For this purpose, we employ a third-degree polynomial by adding the squared and cubic log capital-labor ratio and interactions among control variables (Equation 6). This specification allows us to examine the relationship between the capital-output ratio and the labor share within a more flexible empirical framework. The cubic function used to capture the relationship allows the effect of the independent variable (k) on the dependent variable (the LS) to change with the value if k. As the value of k increases (or decreases), the impact of the dependent variable may increase or decrease. Table 2 presents our empirical estimations of the non-linear model. As already stated, the coefficients of the shifters are difficult to interpret, but the regression function is interpretable as far as the *k* – *LS* relationship is concerned. We will discuss as the marginal effects obtained from the non-linearity of k give us interesting insights on how the capital-output ratio affects the labor share.

[40] For instance, if all workers perform production activities, then a higher markup decreases the labor share of income. However, if enough workers perform expansionary activities, a higher markup can increase the labor share. This should be of interest to policymakers since it would mean that to understand the impact of markups on the labor share, they must know the composition of the labor force.

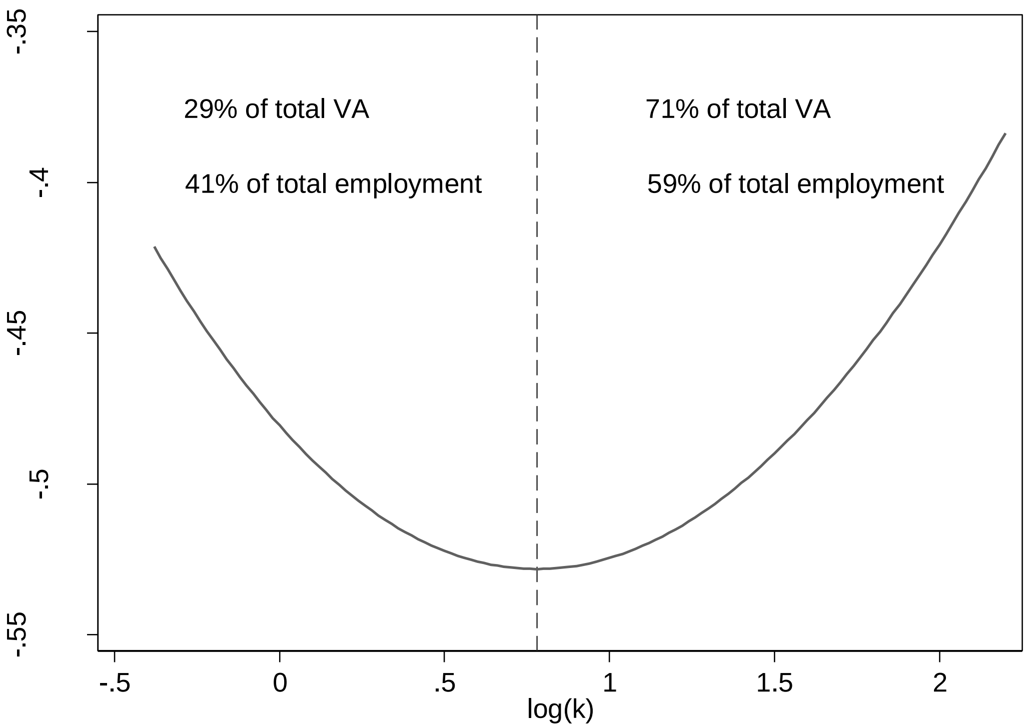
Table 2 - Estimation of LS equation with saturated interaction terms for control variables (non-linear hypothesis). Dependent variable: $lnLS_{it}$

Code	Sector name	log(k)	log(k) sq	log(k) cub	f'(log k)=0 [1st TP]	f'(log k)=0 [2nd TP]
A	Agriculture, forestry and fishing	0.263*** (10.58)	0.137*** (16.33)	-0.012*** (-8.95)	-0.866	0.421
B	Mining and quarrying	-0.386 (-0.94)	0.134*** (5.18)	-0.012*** (-3.07)	1.961	7.109
C	Manufacturing	0.248*** (-9.18)	0.080*** (5.32)	-0.004 (-1.31)	-1.393	0.248
D	Electricity, gas, steam and air conditioning supply	0.017 (0.08)	0.145*** (7.38)	-0.010*** (-4.22)	-0.057	0.945
E	Water supply; Sewerage, waste management	-0.063 (-0.44)	0.151*** (10.01)	-0.015*** (-4.71)	0.215	1.240
F	Construction	-1.541*** (-12.77)	0.086*** (7.22)	-0.004** (-2.04)	-	-
G	Wholesale and retail trade; Repair of motor vehicles	-0.530*** (-12.65)	0.108*** (5.77)	-0.010*** (-2.84)	-	-
H	Transportation and storage	-0.222*** (-4.76)	0.068*** (9.57)	0.001 (0.4)	1.588	4.892
I	Accomodation and food service activities	-0.247*** (-2.75)	0.082*** (7.78)	-0.005 (-1.21)	1.764	5.835
J	Information and communication	-0.438*** (-10.45)	0.064*** (14.72)	-0.002 (-1.36)	4.160	64.083
K	Financial and insurance activities	-0.056 (-0.69)	0.085*** (11.28)	-0.003*** (-3.46)	0.334	1.397
L	Real estate activities	-0.847*** (-5.19)	0.107*** (12.23)	-0.007*** (-3.33)	-	-
M	Professional, scientific and technical activities	-0.199** (-2.07)	0.104*** (11.89)	-0.006*** (-3.01)	1.058	2.882
N	Administrative and support service activities	-0.431*** (-4.31)	0.070*** (16.27)	-0.003* (-1.76)	4.334	76.263
O	Public administration and defence; Compulsory social security	-0.186 (-1.36)	0.046*** (8.04)	0.002 (0.83)	1.818	6.162
P	Education	-0.299*** (-2.86)	0.097*** (13.07)	-0.001 (-0.51)	1.591	4.910
Q	Human health and social work activities	0.070*** (3.71)	0.038*** (9.39)	0.003* (1.73)	-1.066	0.344
R	Arts, entertainment and recreation	0.080 (1.56)	0.101*** (13.26)	-0.005*** (-3.01)	-0.384	0.681
S	Other service activities	0.316** (2.31)	0.080*** (10.86)	-0.001 (-0.48)	-1.896	0.150
ALL	Whole economy	-0.124*** (-9.68)	0.083*** (17.02)	-0.003*** (-3.14)	0.775	2.170

Note: Fixed effect model. t-statistics based on standard errors clustered by firm in parenthesis. Additional control variables: year dummies; all possible interaction terms between log(TFP), markup, ΔE. Period: 2011-2019.

We can draw important considerations on how technological/institutional factors affect the relationship of the LS with k. In particular, the capital-output ratio and the TFP both enter the equation with either positive or negative signs. This result reflects the complementarity/sustainability between capital and labor (i.e., respectively a $\sigma >$ or < 1) in different industries, together with a negative influence of technological change and market power on the labor share. Starting from this base-run model, we then add interactions between control variables and non-linear terms for the capital-output ratio. Notably the relationship between LS and k turned out to be significantly different from zero for the whole economy and for many of the industries considered (all the industries with p-value<1% for the quadratic term and all but 6 for the cubic term at p-value<5%). The estimation is conducted with a panel regression model and fixed effects. The curve for the aggregate economy is shown in Figure 11.

Figure 11 - The labor share/capital-output curve for the aggregate economy.



Note: The estimates shown are for the entire economy, i.e., last row of Table 2.
Source: Authors' elaboration on Amadeus data.

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The effect k on the LS is no longer constant, nor it is the elasticity of substitution. Even if we do not assume that capital per unit of output and σ_{KL} are linked by any specific functional form, this eventuality is consistent with the literature on endogenous (and variable) elasticity of factor substitution. Revankar (1971) assumes that σ_{KL} varies with the capital-output ratio around the intercept term of unity; Duffy and Papageorgiou (2000) show that σ_{KL} increases as the economy grows; Miyagawa and Papageorgiou (2007) built a static model where σ_{KL} in each period is endogenously determined by the existing endowments of capital and labor and their sectoral allocation. In Variable Elasticity of Substitution (VES) frameworks, the elasticity interacts with the level of economic activity, and from this perspective we can say that literature which provides empirical validity to the use of VES technology predates a lot from recent growth in research on labor income shares (Paul, 2019).[41]

Here we can reconcile findings of the previous literature and shed more light on the connections between these two strands of research and the distribution of income. More specifically, the elasticity of substitution is lower than one in the first part of the curve (i.e., capital and labor are gross complements for low levels of k) and hence an increase in k contributes to a decrease in the labor share. Then the curve reaches a minimum, which we estimate for $\frac{\partial lnLS}{\partial lnk} = 0$, corresponding roughly to $k = 2.17$. In this point, the labor share is perfectly independent of the capital-output ratio (i.e., the Cobb-Douglass case). On the other hand, for higher levels of the capital-output ratio (i.e., capital and labor are gross substitutes for high levels of k) the elasticity of substitution becomes greater than one and a higher capital intensity has a negative effect on the labor share, which decreases as soon as the price of capital goes down. This is known as "accumulation view." This classification suggests a consistent and statistically significant role that the capital-labor relationship plays in explaining LS variation over time and across sectors and firms, also suggest more carefulness in modeling choices.

What is more interesting to note from our point of view is that despite the largest share of firms in our sample is operating on the upward-sloped part of the curve, a significant proportion of firms is on the downward-sloped part. Indeed, within our sample we have that the share of the latter amounts to 29.5% of the value added and as much as 41% of the total employment which is equal to roughly 37% of the firms in the sample. Further these shares turn

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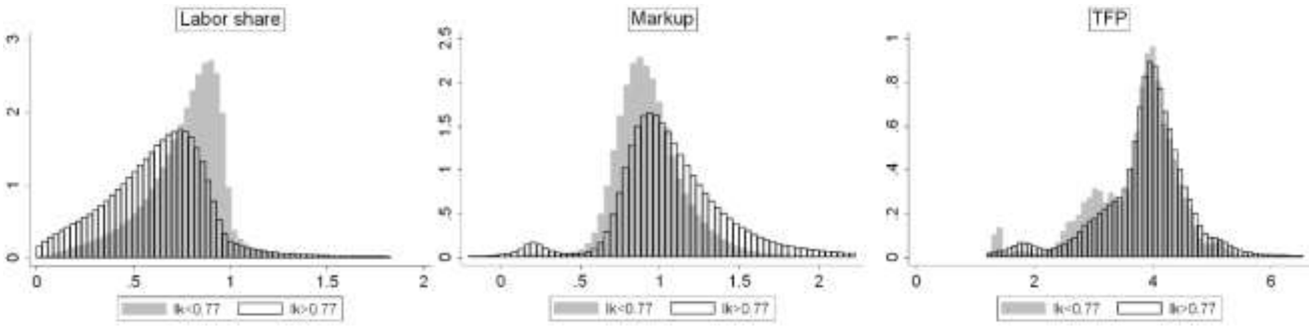
[41] A standard CES production function assumes: (i) the existence of a relationship between value added per unit of labor and the wage rate independent of the changes in the stock of capital; and (ii) the elasticity of substitution between factor inputs as a constant (but not unity) along the isoquant. However, both the assumptions are unrealistic in the presence of an upward trend in capital-labor ratios as documented by many studies (Acemoglu and Guerrieri 2008). Sato and Hoffman (1968), Meyer and Kadiwala (1974) and Kazi (1980) reject CD and CES model specifications in favor of the VES. On the other hand, Lovell (1973), Tsang (1976) and Zellner and Ryu (1998) provide evidence that in some specific industries the CES model performs better compared to VES.

out to be even more relevant in some sectors of the economy, i.e., Education (82.38%); Human health and social work activities (78.09%); Public administration and defense (72.53%); Administrative and support service activities (69.97%); Other service activities (62.56%); Accommodation and food service activities (61.61%); Arts, entertainment and recreation (55.09%). Even if the latter industries account for only 7.80% of the total value added in the economy, firms with low levels of capital intensity have not negligible shares and are also present in the biggest industries since they constitute roughly 23.45% of the total observations in Manufacturing, 24.82% in Real estate activities and 19.70% in Financial and insurance activities.

On average (Figure 12 and Table A5 in Appendix A), firms on the downward-sloped part of the curve are characterized by an average capital-output ratio of roughly 1.39 and have, as expected, higher labor shares (0.76), lower TFP (4.00), lower labor productivity (0.61), lower markups (1.38) and a lower labor productivity (value added per employee, 48.80). On the other hand, firms on the upward-sloped part of the curve are characterized by an average capital-output ratio of roughly 4.76 and have, as expected, lower labor shares (0.55), higher TFP (4.11), higher labor share (0.88), higher markups (1.62) and a higher labor productivity (value added per employee, 80.77).

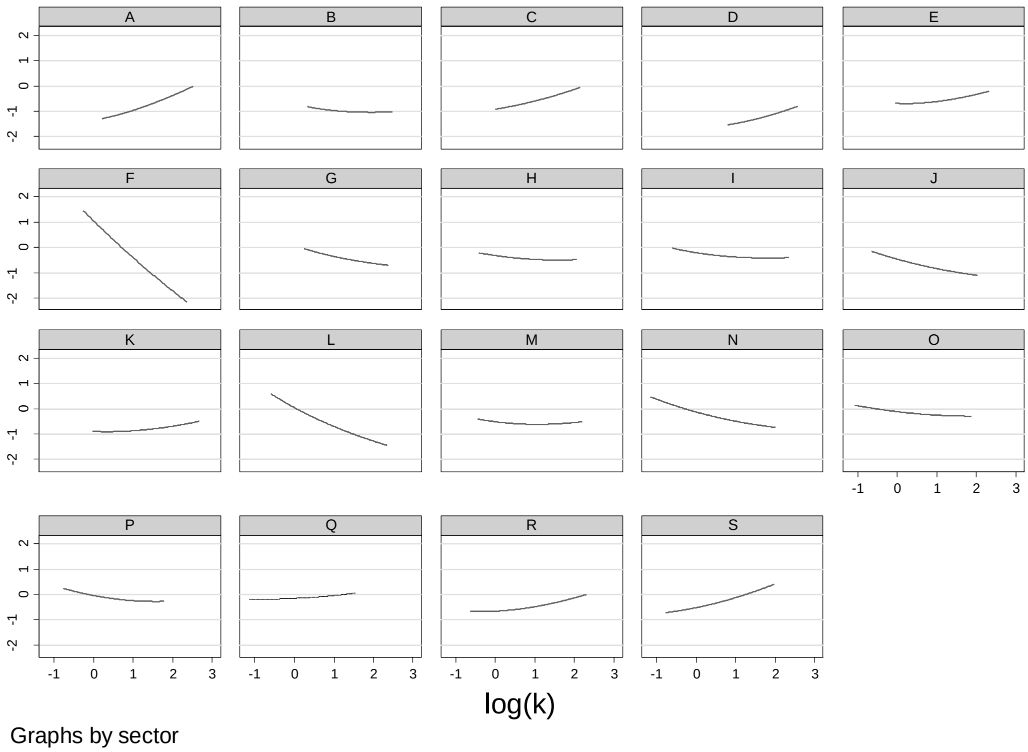
Figure 12 - Distribution of the labor share, markups and TFPs for the aggregate economy for lk > or < 0.77.



Source: Authors' elaboration on Amadeus data.

As shown in Figure 13, while in some sectors the relationship between labor share and capital-output ratio is monotonically decreasing in k (meaning that an increase in k always reduce the labor share and hence the elasticity of substitution is higher than 1) such as G, H and J, in other sectors (C, D, E and K) the same relationship it is strictly increasing in k, meaning that an increase in k always raise the labor share and hence the elasticity of substitution is lower than 1. It is precisely this heterogeneity in the movements of the various sectors that overall characterizes the complex behavior that we observe in the economy. It is also worth noting that in all the cases for intermediate values of k, the curve is virtually flat and the upward pressures on the LS starts only behind a certain threshold. Indeed, for the range of k which goes from 0.74 to 1.37, increases in k do not increase nor decrease the LS (with changes below 1%).

Figure 13 - The labor share/capital-output curve by industry.



Source: Authors' elaboration on Amadeus data.

6. Conclusions

The structural decline of the labor share in recent decades is now a generally recognized stylized fact. Rapid technological progress, the globalization of trade and capital, product and labor market institutions, market concentration, the bargaining power of labor have been proposed as key factors driving this fall. Macroeconomic evidence emphasizes the role of capital accumulation. A crucial parameter is the elasticity of substitution between capital and labor (Lawrence, 2015). Several recent studies argue that the elasticity is greater than one and that an increase in the capital-labor ratio is responsible for a major part of the fall in the labor share observed in advanced economies. These claims are, however, at odds with equally valid studies that found the elasticity to be lower than one. In this paper we propose a reassessment of the role played by labor share driving forces in a more flexible empirical framework than the one usually followed by the literature. We start our analysis with a benchmark model, the one-to-one relationship between the labor share and the capital-output ratio derived by Bentolila and Saint-Paul (2003). First, we replicate their estimated model at the firm level to create partially comparable coefficients and correctly identify shifting factors. From a theoretical perspective, a firm-level focus is relevant because in developed economies, most economic activity is organized in heterogeneous firms and the labor share is the result of production decisions and wage-setting processes that take place inside production plants. From a technical one, firm-level data allow us to address in the most effective way composition bias and endogeneity issues. At this purpose we employed firm-level data on 19 industries in 28 European countries, over the period 2011-2019 and estimated the relationship between the labor share and the capital-output ratio, controlling for variables intended to capture the shifting factors mentioned above. We found that among factors which can shifts the $LS - k$ curve and cause deviations from it, TPF plays a major role, while deviations from marginal cost pricing, labor adjustment costs, and changes in workers' bargaining power are less important for the aggregate economy. However, when considering cross-sector heterogeneity, we found markups to be important in services and construction.

We also make several operational changes that increase the magnitude of the results for the behavior of LS along the $LS - k$ curve. We estimate the model with multiplicative interaction and a non-linear term for k. We find a significant and generally non-linear relationship between the labor share and the capital-output ratio. These non-linearities cause the capital-output ratio to cease being a critical driving force of the labor share which operates in just one direction and open the door to a flexible framework that makes the effects of k on the labor share depending on the range of k in which the single firm is operating. This finding is very relevant both in terms of modelling advances and in terms of policy implications. Indeed, our results support the increasing number of studies that have recently introduced the variable elasticity of substitution (VES) framework as an alternative to the traditional CES model to analyze movements in the labor income share and their connection with the elasticity of substitution. We found that for low levels of the capital-output ratio firms usually have higher labor shares, and the elasticity of substitution is greater than one, meaning that an increase in k leads to a decrease of the LS. On the other hand, when k is above a certain threshold and firms have usually lower labor share, the pressures exerted by an increase in k on the labor share is upward. Beyond this result, we uncover heterogeneous dynamics of the labor share at the firm/industry level.

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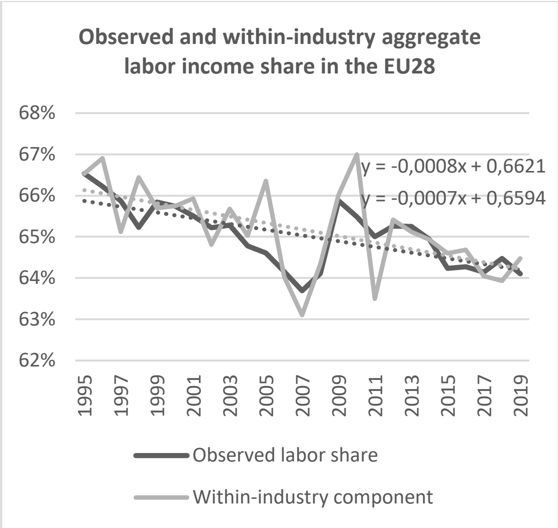
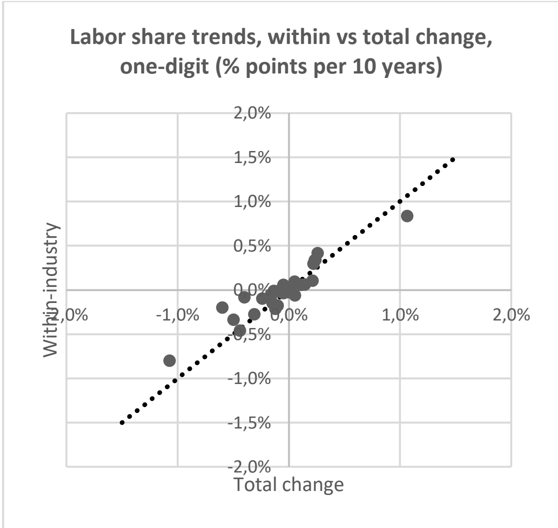
Appendix A: Additional figures and tables

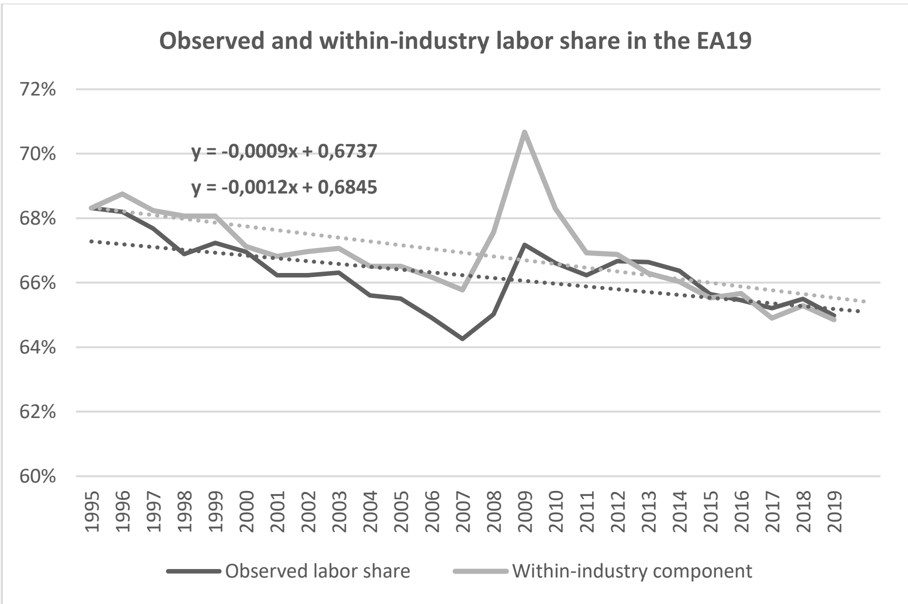
Figure A1 - Observed and within-industry component of the labor share (cross-country average for EU28) (panel a). Contribution of the within-industry change defined as weighted average of within-industry changes (panel b).





Note: relevant period 1995-2019. More than 70 percent of variation in labor share trends across countries is explained by within one-digit sector variation. The role of between-sector reallocation is small on average but plays a dominant role in Ireland, Romania, Poland and Bulgaria. Source: Authors' calculation on Eurostat data.

Figure A2 - Observed and within-industry aggregate labor income share in the Euro Area (EA).



Note: 1995-2019. Source: Authors' calculation on Eurostat data.

Table A1 - Shift-share decomposition of the labor share, between and within-industry effects.

Industry	Within sectors	Between sectors	Total change
Ireland	-0.53%	-0.54%	-1.07%
Romania	0.02%	-0.62%	-0.60%
Slovenia	-0.34%	-0.16%	-0.50%
Croatia	-0.46%	0.02%	-0.44%
Poland	-0.08%	-0.31%	-0.40%
Hungary	-0.28%	-0.03%	-0.31%
Portugal	-0.10%	-0.14%	-0.24%
Austria	-0.07%	-0.09%	-0.17%
Spain	-0.08%	-0.08%	-0.16%
Finland	-0.15%	0.00%	-0.15%
Cyprus	-0.01%	-0.12%	-0.13%
Netherlands	-0.22%	0.10%	-0.12%
Belgium	-0.18%	0.08%	-0.10%
EA19	-0.02%	-0.06%	-0.08%
EU28	0.00%	-0.07%	-0.07%
Germany	-0.04%	-0.01%	-0.05%
Italy	0.06%	-0.10%	-0.05%
Denmark	-0.03%	0.02%	-0.01%
Estonia	0.04%	-0.01%	0.03%
France	0.09%	-0.04%	0.05%
Sweden	-0.06%	0.12%	0.05%
Luxembourg	0.06%	0.06%	0.11%
Slovakia	0.06%	0.09%	0.14%
United Kingdom	0.10%	0.11%	0.21%
Czechia	0.29%	-0.07%	0.22%
Lithuania	0.33%	-0.10%	0.23%
Greece	0.34%	-0.10%	0.24%
Latvia	0.42%	-0.16%	0.26%
Bulgaria	0.84%	0.23%	1.07%
Mean	0.00%	-0.07%	-0.07%
Standard Deviation	0.0027	0.0018	0.0036

Note: sampling period 1995-2019. Source: Authors' calculation on Eurostat data.

Table A2 - Shift-share decomposition of the labor share, between and within-firms effects.

Code	Industry	Within firms	Between firms	Total change
D	Electricity, gas, steam and air conditioning supply	-1.74%	1.40%	-0.35%
J	Information and communication	-0.20%	0.12%	-0.08%
R	Arts, entertainment and recreation	-0.14%	-0.30%	-0.44%
N	Administrative and support service activities	-0.02%	0.08%	0.06%
E	Water supply; Sewerage, waste management	-0.02%	0.42%	0.40%
A	Agriculture, forestry and fishing	-0.02%	0.23%	0.21%
I	Accomodation and food service activities	-0.01%	-0.10%	-0.11%
O	Public administration and defence	-0.01%	-0.09%	-0.10%
P	Education	-0.01%	-0.22%	-0.23%
C	Manufacturing	-0.01%	-0.01%	-0.01%
B	Mining and quarrying	0.00%	-0.30%	-0.30%
S	Other service activities	0.01%	0.00%	0.02%
L	Real estate activities	0.02%	0.04%	0.06%
F	Construction	0.03%	-0.11%	-0.08%
H	Transportation and storage	0.03%	0.14%	0.17%
K	Financial and insurance activities	0.03%	-0.39%	-0.36%
M	Professional, scientific and technical activities	0.11%	-0.25%	-0.14%
Q	Human health and social work activities	0.29%	-0.03%	0.26%
G	Wholesale and retail trade; Repair of mothor vehicles	0.71%	-0.84%	-0.13%
Mean		-0.05%	-0.01%	-0.06%
Standard Deviation		0.005	0.004	0.002

Note: sampling period 2011-2019. Source: Authors' calculation on Amadeus data.

Table A3 - Estimation of labor share equation for manufacturing sectors.
Dependent variable: $lnLS_{it}$

Code	Sector name	log(k)	- σ_{KL} η=(-0.39)	- σ_{KL} η=(-0.51)	log(TFP)	Markup	ΔE	F test excl. IV	N obs.
C10-C12	Food products and beverages	0.120* (1.73)	-1.030	-1.030	0.542 (1.10)	-0.723*** (7.00)	-0.010 (0.49)	2328.03	91,307
C13-C15	Textiles, wearing apparel and leather products	-0.100 (-0.99)	-0.980	-0.970	1.520*** (8.89)	-0.740*** (16.99)	-0.010 (1.02)	750.54	68,454
C16	Wood and of products of wood and cork, except furniture	0.790*** (4.31)	-1.200	-1.260	1.320*** (5.16)	-0.730*** (13.81)	0.010 (0.98)	403.80	24,352
C17	Paper and paper products	0.380 (1.36)	-1.080	-1.100	1.590** (2.42)	-0.730*** (4.94)	-0.010 (0.55)	321.41	15,678
C18	Printing and reproduction of recorded media	0.880** (2.45)	-1.250	-1.310	2.490*** (5.53)	-0.920*** (9.10)	0.010 (1.12)	322.72	18,255
C19	Coke and refined petroleum products	0.070 (0.13)	-1.010	-1.010	-0.160 (0.14)	-0.130* (1.91)	-0.460*** (6.53)	21.96	1,528
C20	Chemicals and chemical products	-0.020 (-0.11)	-1.000	-0.990	1.220 (0.08)	-0.620 (0.25)	0.000 (0.009)	420.99	26,468
C21	Basic pharmaceutical products & pharmaceutical preparations	-0.430 (-0.71)	-0.910	-0.890	1.220 (0.61)	-0.530 (1.57)	-0.050 (0.99)	45.94	5,268
C22	Rubber and plastic products	0.420*** (3.2)	-1.100	-1.130	1.120*** (3.52)	-0.590*** (9.15)	0.010 (0.48)	782.14	41,863
C23	Other non-metallic mineral products	0.140*** (3.95)	-1.030	-1.040	0.170** (2.42)	-0.930*** (14.89)	-0.010 (0.57)	582.87	31,712
C24	Basic metals	0.270 (0.99)	-1.080	-1.100	1.470 (1.38)	-0.780*** (2.88)	0.020 (0.40)	220.56	15,231
C25	Fabricated metal products, except machinery & equipment	0.220** (2.19)	-1.060	-1.080	1.930*** (4.96)	-0.780*** (8.74)	0.010 (0.65)	1627.01	122,870
C26	Computer, electronic and optical products	0.160 (1.13)	-1.040	-1.050	1.250 (1.48)	-0.960*** (3.42)	0.000 (0.10)	209.85	17,693
C27	Electrical equipment	-0.410 (-1.57)	-0.890	-0.860	1.820*** (2.68)	-0.790*** (5.06)	0.010 (0.81)	247.40	23,946
C28	Machinery and equipment n.e.c.	0.220 (1.60)	-1.060	-1.080	1.830*** (3.11)	-0.750*** (4.73)	0.000 (0.01)	626.66	72,909
C29	Motor vehicles, trailers and semi-trailers	0.030 (0.24)	-1.010	-1.010	0.190 (0.03)	-0.880 (0.47)	0.010 (0.02)	355.09	15,053
C30	Other transport equipment	0.240 (0.82)	-1.060	-1.080	1.030 (0.90)	-0.680** (2.35)	0.020 (0.45)	73.41	6,467
C31_C32	Furniture	-0.280** (-2.23)	-0.930	-0.910	1.130* (1.65)	-1.010*** (5.43)	-0.020 (0.74)	736.65	38,395
C33	Repair and installation of machinery and equipment	-0.440** (-2.36)	-0.870	-0.830	2.290*** (5.43)	-0.810*** (5.59)	0.040*** (4.26)	194.57	24,566
C	Manufacturing	0.080*** (4.86)	-1.020	-1.020	0.050*** (3.02)	-0.480*** (-3.72)	-0.010** (-2.16)	7013.92	662,015

Note: IV fixed effect model. Instruments for levels of log(k), log(TFP), markup, ΔE: lagged first differences. t-statistics based on standard errors clustered by firm in parenthesis. Additional controls: year dummies. Period: 2011-2019.

Table A4 - Estimation of labor share equation.
Dependent variable: $lnLS_{it}$; independent variables are not instrumented.

Code	Sector name	log(k)	log(TFP)	Markup	ΔE	N obs
A	Agriculture, forestry and fishing	-0.006 (-2.45)	-0.080 (-11.55)	-0.093 (-139.27)	-0.021 (-1.81)	73,941
B	Mining and quarrying	0.128 (20.48)	0.372 (4.77)	-0.323 (-52.75)	0.012 (0.42)	9,925
C	Manufacturing	0.006 (9.01)	0.052 (30.02)	-0.484 (-372.29)	-0.006 (-2.16)	662,015
D	Electricity, gas, steam and air conditioning supply	-0.017 (-1.35)	-0.322 (-4.09)	0.000 (14.49)	-0.007 (-0.16)	18,276
E	Water supply; Sewerage, waste management	-0.027 (-7.90)	0.970 (31.90)	-0.568 (-100.84)	-0.012 (-0.41)	29,365
F	Construction	-0.057 (-59.27)	1.953 (113.68)	-0.619 (-240.32)	0.015 (3.44)	238,267
G	Wholesale and retail trade; Repair of motor vehicles	-0.048 (-64.13)	-0.163 (-34.39)	-0.271 (-220.16)	0.013 (4.48)	719,367
H	Transportation and storage	-0.114 (-86.99)	0.154 (21.51)	-0.239 (-103.96)	0.017 (3.58)	146,307
I	Accomodation and food service activities	0.030 (21.73)	1.529 (79.67)	-0.807 (-181.70)	-0.016 (-0.68)	105,435
J	Information and communication	-0.074 (-37.46)	-0.323 (-49.41)	-0.174 (-78.53)	-0.007 (-0.98)	74,619
K	Financial and insurance activities	-0.182 (-64.47)	0.766 (40.37)	0.002 (72.99)	0.017 (1.00)	112,630
L	Real estate activities	-0.117 (-58.08)	1.250 (47.50)	-0.306 (-80.89)	0.008 (1.07)	56,387
M	Professional, scientific and technical activities	-0.154 (-65.35)	-0.558 (-46.35)	-0.001 (-22.51)	0.024 (2.22)	83,428
N	Administrative and support service activities	-0.122 (-104.64)	1.017 (61.17)	-0.419 (-83.49)	0.005 (0.92)	81,066
O	Public administration and defence; Compulsory social security	-0.018 (-6.62)	1.809 (48.42)	-1.066 (-63.38)	-0.008 (-0.72)	14,317
P	Education	0.005 (2.35)	2.218 (97.35)	-1.538 (-105.62)	0.004 (0.44)	37,125
Q	Human health and social work activities	-0.069 (-52.17)	0.450 (24.39)	-0.822 (-82.28)	0.005 (0.90)	27,145
R	Arts, entertainment and recreation	-0.036 (-10.31)	-0.042 (-3.14)	-0.499 (-80.81)	-0.026 (-1.98)	23,606
S	Other service activities	-0.031 (-9.63)	0.260 (11.24)	-0.686 (-75.47)	0.009 (0.57)	15,179
ALL	Whole economy	-0.133 (-348.99)	-0.152 (-82.83)	0.001 (99.48)	-0.001 (-0.21)	2,528,400

Note: Fixed effect estimation.

Table A5 - Estimation of labor share equation for manufacturing sectors.
Dependent variable: $lnLS_{it}$; independent variables are not instrumented.

Code	Sector name	log(k)	log(TFP)	Markup	ΔE	N obs
C10-C12	Food products and beverages	0.091	0.541	-0.722	-0.008	91,307
		(53.87)	(34.38)	(-21.82)	(-1.54)	
C13-C15	Textiles, wearing apparel and leather products	0.012	1.524	-0.735	-0.007	68,454
		(7.09)	(65.19)	(-124.42)	(-0.75)	
C16	Wood and of products of wood and cork, except furniture	0.096	1.324	-0.725	0.006	24,352
		(27.13)	(32.49)	(-86.98)	(0.62)	
C17	Paper and paper products	0.107	1.593	-0.728	-0.010	15,678
		(22.21)	(39.59)	(-80.79)	(-0.90)	
C18	Printing and reproduction of recorded media	0.074	2.491	-0.919	0.015	18,255
		(17.63)	(39.81)	(-65.51)	(0.81)	
C19	Coke and refined petroleum products	-0.026	-0.137	-0.127	-0.458	1,528
		(-1.40)	(-1.12)	(-16.62)	(-5.67)	
C20	Chemicals and chemical products	0.170	1.216	-0.620	-0.004	26,468
		(40.68)	(32.61)	(-94.17)	(-0.34)	
C21	Basic pharmaceutical products & pharmaceutical preparations	0.130	1.234	-0.531	-0.049	5,268
		(12.89)	(11.49)	(-28.88)	(-1.83)	
C22	Rubber and plastic products	0.131	1.122	-0.588	0.007	41,863
		(43.28)	(47.69)	(-123.80)	(0.66)	
C23	Other non-metallic mineral products	0.090	0.169	-0.933	-0.008	31,712
		(29.98)	(18.42)	(-113.20)	(-0.44)	
C24	Basic metals	0.110	1.467	-0.782	0.016	15,231
		(22.66)	(31.60)	(-65.93)	(0.92)	
C25	Fabricated metal products, except machinery & equipment	0.067	1.930	-0.783	0.007	122,870
		(44.08)	(100.37)	(-176.39)	(1.34)	
C26	Computer, electronic and optical products	0.089	1.251	-0.963	-0.003	17,693
		(20.59)	(27.18)	(-62.54)	(-0.20)	
C27	Electrical equipment	0.088	1.816	-0.788	0.015	23,946
		(22.46)	(38.43)	(-72.51)	(1.16)	
C28	Machinery and equipment n.e.c.	0.087	1.830	-0.750	0.001	72,909
		(40.37)	(78.31)	(-118.93)	(0.03)	
C29	Motor vehicles, trailers and semi-trailers	0.177	0.189	-0.873	0.006	15,053
		(40.59)	(5.61)	(-81.29)	(0.37)	
C30	Other transport equipment	0.081	1.027	-0.678	0.016	6,467
		(13.63)	(15.01)	(-39.24)	(0.75)	
C31_C32	Furniture	0.119	1.132	-1.010	-0.017	38,395
		(48.06)	(35.60)	(-117.21)	(-1.61)	
C33	Repair and installation of machinery and equipment	-0.053	2.293	-0.814	0.043	24,566
		(-18.33)	(42.12)	(-43.40)	(3.31)	
C	Manufacturing	0.006	0.052	-0.484	-0.006	662,015
		(9.01)	(30.02)	(-372.29)	(-2.16)	

Note: Fixed effect estimation. Source: Authors' calculation on Amadeus data.

Table A6 - Summary statistics (ls, TFP, markup, labor productivity and VA) by sector, for lk > or < 0.77.

Firms with lk<0.77							
Code	k	LS	tfp	m	LP	E	VA
A	1.58	0.66	2.74	1.02	0.47	46.81	1465.42
B	1.48	0.42	4.3	1.31	0.88	77.65	8132.23
C	1.63	0.67	3.78	1.39	0.72	111.28	6533.79
D	1.65	0.39	5.48	1.25	0.98	116.64	15000.00
E	1.43	0.75	4.17	1.23	0.47	131.07	5462.04
F	1.44	0.82	3.75	1.3	0.56	50.15	2571.10
G	1.6	0.71	3.74	1.51	0.64	82.11	4128.69
H	1.39	0.8	3.45	1.49	0.52	139.97	6269.76
I	1.22	0.83	3.68	1.41	0.32	107.2	2962.97
J	1.34	0.73	3.31	1.29	0.8	147.25	11200.00
K	1.37	0.76	4.67	1.3	0.64	753.38	32100.00
L	1.43	0.78	4.92	1.54	0.64	673.81	39700.00
M	1.29	0.79	4.2	1.33	0.68	136.03	7402.40
N	0.78	0.9	4.03	1.36	0.35	320.63	9209.65
O	1	0.88	4.55	1.06	0.44	72.73	2852.21
P	1.32	0.88	4.29	1.01	0.52	271.65	13000.00
Q	1.01	0.91	1.42	1.1	0.34	177.42	5600.62
R	1.28	0.69	3.28	1.45	0.67	68.55	4667.28
S	1.24	0.81	3.67	1.34	0.54	142.21	6567.37
Total	1.39	0.76	4	1.38	0.61	153.47	7489.25

Firms with lk>0.77							
Code	k	LS	tfp	m	LP	E	VA
A	5	0.52	2.57	1.25	0.62	34.92	1400.28
B	4.84	0.42	3.23	1.58	0.92	119.46	12200.00
C	4.39	0.58	3.56	1.57	0.96	129.38	10800.00
D	7.04	0.35	4.51	1.78	1.33	283.79	52600.00
E	5.69	0.57	4.5	1.59	0.77	126.94	8288.02
F	5.04	0.69	3.64	1.43	0.67	43.75	2342.64
G	4.6	0.65	3.94	1.55	0.68	48.45	2537.33
H	5.68	0.61	3.63	1.57	0.75	129.24	9295.41
I	4.95	0.6	3.81	1.47	0.5	52.41	2010.87
J	4.04	0.46	4.2	1.72	1.21	193.95	27300.00
K	5.38	0.49	4.5	1.52	0.87	225.37	20200.00
L	4.43	0.57	4.71	1.86	0.84	1337.87	113000.00
M	4.05	0.53	4.29	1.46	0.93	96.74	9131.11
N	4.37	0.6	4.22	1.62	0.78	112.56	7888.77
O	3.84	0.77	4.58	1.16	0.5	67.19	2326.77
P	3.3	0.75	4.29	1.02	0.54	110.73	5133.76
Q	3.65	0.75	1.61	1.31	0.44	147.51	5807.76
R	4.27	0.58	3.27	1.53	0.72	55.64	3348.54
S	4.51	0.65	3.78	1.5	0.75	98.95	6156.7
Total	4.76	0.55	4.11	1.62	0.88	116.8	9434.37

All firms							
Code	k	LS	tfp	m	LP	E	VA
A	4.48	0.54	2.59	1.21	0.6	36.71	1410.09
B	4.54	0.42	3.33	1.53	0.91	112.79	11600.00
C	3.78	0.60	3.61	1.53	0.91	123.3	9357.39
D	6.99	0.35	4.52	1.77	1.33	276.07	50900.00
E	4.76	0.61	4.43	1.5	0.71	128.22	7411.80
F	3.58	0.74	3.68	1.38	0.62	46.25	2431.75
G	3.74	0.67	3.88	1.54	0.67	55.33	2862.51
H	3.76	0.69	3.55	1.53	0.64	134.77	7735.10
I	2.69	0.74	3.74	1.43	0.39	80.97	2507.24
J	3.03	0.56	3.87	1.49	0.97	165.55	17500.00
K	4.63	0.54	4.53	1.47	0.82	295.98	21800.00
L	3.7	0.62	4.77	1.76	0.79	1016.58	77400.00
M	2.89	0.64	4.25	1.39	0.82	115.79	8292.74
N	1.81	0.81	4.09	1.43	0.47	251.17	8768.69
O	1.76	0.85	4.56	1.09	0.45	70.97	2685.59
P	1.67	0.85	4.29	1.02	0.52	215.24	10200.00
Q	1.58	0.88	1.46	1.15	0.36	171.05	5644.73
R	2.68	0.64	3.27	1.49	0.69	61.68	3965.88
S	2.42	0.75	3.71	1.39	0.61	125.35	6407.36
Total	3.8	0.61	4.08	1.54	0.8	129.48	8761.65

Source: Authors’ calculation on Amadeus data.

Appendix B: Technical Appendix

(i) Derivation of the formulas employed in the shift-share analysis

Starting from the definition of labor share we can write the following identity:

$$Labor\ Share_t = LS_t = \frac{Labor\ cost_t}{Value\ Added_t} = \frac{W_t L_t}{Y_t} = \frac{W_t L_t}{Pc_t L_t}\frac{Pc_t}{Pva_t}\frac{L_t}{Y_t} = \frac{w_t}{y_t}p_t \qquad \text{B1}$$

Where:

- W_t = nominal unit labor cost;
- L_t = number of workers (employees and self-employed);
- Y_t = value added;
- Pc_t = consumption price index (CPI);
- Pva_t = production price index (VA deflator).

If we set the real compensation of employees per person employed as $w_t = W_t/Pc_t$; labor productivity (value added per worker) as $y_t = Y_t/L_t$ and the relative prices as $p_t = Pc_t/Pva_t$ we obtain the last synthetic expression of the LS on the right side of A1. Since the economy of a country is made up of several sectors/firms, the aggregate labor share can be written as a weighted average of individual industries/firms' labor shares:

$$LS = \sum_i s_i \frac{w_i}{y_i} \qquad \text{B2}$$

Where: s_i is the weight of sector i in total value-added. The shift-share analysis allows us to decompose changes in the aggregate labor share into changes of that variable within industries/firms and structural changes in industry/firm composition. A standard *shift share decomposition* can be written as:

$$\Delta LS = (LS_t - LS_{t-1}) = \underbrace{\sum_i \bar{s}_i (ls_{it} - ls_{it-1})}_{within-industry} + \underbrace{\sum_i (s_{it} - s_{it-1})\,\overline{ls}_i}_{between-industry} \qquad \text{B3}$$

Where: LS_t and ls_{it} represent respectively the aggregate and industry labor shares; s_{it} is the share of industry i in terms of (nominal) value added and a bar over the letter represents the average of the variable between the initial and final period. The first term on the right-hand side is a weighted average of within-industry/firm changes (the so-called *within component*) while the last term represents the contribution of sectoral reallocation (the so-called *between component*).

(ii) Estimation of TFP and Markups at the firm level

The markup is commonly defined as the price of output divided by the marginal cost (i.e., the ability of a firm to set a price which is above its marginal costs). Measuring markups is notoriously a difficult task since data on marginal costs are not readily available. Three distinct approaches have been developed by the literature. (i) The first one, the so called "accounting approach" relies on directly observable gross (or net) margins of profits. (ii) The second one, developed within the boundaries of the Industrial Organization, is based on the specification of a specific demand system that provides the price-elasticity of demand (Berry et al., 1995). Then, along with some additional information retrieved by making assumptions about firm competition, it provides markup measures through the first-order condition associated with optimal pricing. (iii) Here, following De Loecker and Warzynski (2012) we rely on a third approach, i.e., the production approach. This approach is based on the insight of Hall (1988) to estimate markups from the firm's cost minimization decision. Hall (1988) developed it with an analysis on industry aggregates, recently De Loecker and Warzynski (2012) extended it to estimate markups at the firm level. The method uses information from the firm's balance sheet and has the advantage of not requiring any assumptions about demand and competition patterns of the firms. Markups are obtained by exploiting cost minimization of a variable input of production.

Consider an economy with N firms, indexed by $i = 1, \dots, N$. Firms are heterogeneous in terms of their productivity (A_{it}) and production technology $Y_{it}(\cdot)$.[1] In each period t, firm i minimizes the contemporaneous cost of production given the production function:

$$Y_{it} = Y_{it}(A_{it}, V_{it}, K_{it}) \qquad \text{B4}$$

[1] The expression to compute markups is derived from a general firm-specific production technology. The only requirement is the production function to be twice differentiable.

Where: $V = (V^1, \ldots, V^j)$ is a vector which contains all the variable inputs of production (including labor, intermediate inputs and raw materials)[2]; $K_{it}$is the capital stock and A_{it} is productivity. The key assumption is that within one period (a year in our data), variable inputs adjust without friction, whereas the fixed input (i.e., capital) is subject to adjustment costs and other frictions.[3] We can write the Lagrangian objective function associated with the firm's cost minimization problem in the following way:

$$\mathrm{L}(V_{it}, K_{it}, \lambda_{it}) = P^{VI}{}_{it}V_{it} + r_{it}K_{it} + F_{it} - \lambda_{it}(Y(\cdot) - \bar{Y}_{it}) \qquad \text{B5}$$

Where:

- P^{VI} is the price of the variable input;
- r_{it} is the user cost of capital;
- F_{it} is the fixed cost;
- $Y(\cdot)$ is the general technology of production;
- $\bar{Y}_{it}$ is a scalar and λ is the Lagrange multiplier.

If variable input prices are given to the firm. The first order condition with respect to the variable input V, is then given by:

$$\frac{\partial L_{it}}{\partial V_{it}} = P^{VI}{}_{it} - \lambda_{it}\frac{\partial Y(\cdot)}{\partial V_{it}} = 0 \qquad \text{B6}$$

Multiplying all terms in B6 by $\left(\frac{V_{it}}{Y_{it}}\right)$, and rearranging yields an expression for the output elasticity of input V:

$$\frac{\partial L_{it}}{\partial V_{it}} = \frac{P^{VI}{}_{it}V_{it}}{Y_{it}} - \lambda_{it}\frac{\partial Y(\cdot)}{\partial V_{it}}\frac{V_{it}}{Y_{it}} = 0$$

$$\frac{P^{VI}{}_{it}V_{it}}{Y_{it}} - \lambda_{it}\frac{\partial Y(\cdot)}{\partial V_{it}}\frac{V_{it}}{Y_{it}} = \frac{P^{VI}{}_{it}V_{it}}{Y_{it}} - \lambda_{it}\theta^{v}{}_{it} = 0$$

---

[2] In the implementation we use information on a bundle of variable inputs, and not individual inputs, however, in the exposition (for simplicity) we treat the vector L as a scalar.

[3] The conditional statement refers to the fact that it affects the factors of production that are dynamically chosen. e.g., if capital faces adjustment costs or simply time to build, the firm chooses variable inputs to minimize cost, given the level of capital that was set in the previous period.

$$\frac{P^{VI}{}_{it}V_{it}}{Y_{it}} = \lambda_{it}\alpha^{V}{}_{it}$$

$$\alpha^{V}{}_{it} = \frac{1}{\lambda_{it}}\frac{P^{VI}{}_{it}V_{it}}{Y_{it}} \qquad \text{B7}$$

i.e., the Lagrange multiplier λ is itself a direct measure of marginal cost. Therefore, since we define the markup as price to marginal cost ratio $\left(\mu_{it} = \frac{P_{it}}{\lambda_{it}}\right)$, where P is the output price. Substituting this expression for the markup into A7, we obtain a simple expression for the markup:

$$\lambda_{it} = \frac{P_{it}}{\mu_{it}}$$

$$\alpha^{V}{}_{it} = \frac{\mu_{it}}{P_{it}}\frac{P^{VI}{}_{it}V_{it}}{Y_{it}}$$

$$\mu_{it} = \alpha^{V}{}_{it}\frac{P_{it}Y_{it}}{P^{VI}{}_{it}V_{it}} = \alpha^{V}{}_{it}\left(\frac{P^{V}{}_{it}V_{it}}{P_{it}Y_{it}}\right)^{-1} \qquad \text{B8}$$

The markup derived in this way does not rely on the specification of any demand system. Note that with this approach to markup estimation, there are in principle multiple first order conditions (one for each of the variable input in production) that yield to an expression for the markup. However, regardless of which variable input of production is used, there are two key ingredients needed in order to measure the markup: (i) the revenue share of the variable input, $\frac{P^{V}{}_{it}V_{it}}{P_{it}Q_{it}}$, and (ii) the output elasticity of the variable input, $\alpha^{V}{}_{it}$. Therefore, the marginal cost of production is derived from a single variable input in production, without imposing any substitution elasticity with respect to other inputs in production (variable or fixed) or returns to scale. The only crucial component that we need for the estimation is the output elasticity of a variable input of production ($\alpha^{V}{}_{it}$). While the production approach to markup estimation, described in De Loecker and Warzynski (2012) does not restrict the output elasticity, when implementing this procedure, the estimation of this latter parameter is dependent on a specific production function, and assumptions of underlying producer behavior which are all necessary to identify and estimate the elasticity from the data. To this purpose we estimate a parametric Translog production function for each firm-year using recent techniques that consider the well-known potential biases discussed in the literature. This implies that $f(\cdot)$ is approximated by a second-order polynomial where all (logged) inputs, (logged) inputs squared, and interaction terms between all (logged) inputs are included. More specifically the Translog production technology with Hicks-neutral productivity employed as a production function on the value added takes the following form:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_{ll} l^2{}_{it} + \beta_{kk} k^2{}_{it} + \beta_{lk} l_{it} k_{it} + \omega_{it} + \varepsilon_{it} \qquad \text{B9}$$

Where: all variables are in logs, y_{it} is value added of production, l_{it} and k_{it} denote labor and capital, respectively, and the βs are parameters. Total factor productivity (the TFP) is captured by ω and ε is the error term containing unanticipated shocks to the producer and measurement error. To allow for industry differences in the production technology parameters, we do the estimation procedure separately for 19 broad industry groups.[4] We measure value added with firm revenue less expenditures on material inputs, labor with the number of employees, and capital with the book value of tangible assets. Unfortunately, we observe neither physical quantities nor firm-level prices. Therefore, we deflate all variables with available industry specific price indices.[5] For robustness, we experimented also alternative specifications of the production function, including a Cobb-Douglas specification.

[4] These are the one-digit NACE industries from A to S.

[5] While the use of deflation is clearly inferior, De Loecker and Warzynski (2012) show that it affects only the level of the markup estimates, and not the correlation between markups and firm-level characteristics.

Appendix C: Data Appendix

(i) Data sources and definition of variables

The variables we use in the estimation are constructed from Amadeus - Bureau Van Dijk database. Amadeus is a database of comparable financial information for public and private companies across Europe. It covers the period 2011-19, with disaggregated data on a sufficient scale for all the variables employed. On the other hand, deflators used to compute the real value of the variables are obtained from the National accounts aggregates by industry (up to NACE A*64) of Eurostat (nama_10_a64). The variables we use are as follows (original Amadeus variables are denoted by their full name in parentheses):

- E = Number of employees (key financial & employees);
- CE = Compensation of employees, at current prices, thousand Euro (Costs of employees);[6]
- YN = Value added at market prices, current prices, thousand Euro (Added Value) ;
- YR = Value added at market prices, 2010 prices, thousand Euro;
- Def = Price index (implicit deflator), 2010=100, euro (PD10_EUR);
- KT = Gross (tangible) capital stock at market prices, current prices, thousand Euro (Tangible fixed assets);
- KINT = Gross (intangible) capital stock at market prices, current prices, thousand Euro (Intangible fixed assets);
- DA = Depreciation & Amortization, current prices, thousand Euro;
- K = (KT+KINT)-DA;
- Capital-output ratio: k = K/YN;
- Labor share: LS = (CE/E)/YN;
- TFP(CD) = TFP computed with the Cobb-Douglass specification;
- TFP(TL) = TFP computed with the Translog specification;
- MARKUP(CD) = Markup computed with the Cobb-Douglass specification;
- MARKUP(TL) = Markup computed with the Translog specification.

[6] As in National Accounts, total employee compensation reported by individual firms includes non-wage expenses, such as pension and health insurance costs, as well as social security contributions.

The sectoral breakdown we follow refers to the statistical classification of economic activities in the European Community, commonly referred to as NACE rev. 2 and used distinguishes between 21 industries at the level 1 of disaggregation (identified by alphabetical letters A to U). The number of unique firms and observations available for the econometric estimation by industry are shown, respectively, in Tables C1 and C2.

Table C1 - Number of unique firms by industry.

NACE	N. of firms	lk<0.77	lk>0.77	% total
A	19582	3217	16365	2.73%
B	2696	485	2211	0.38%
C	160960	59548	101412	22.48%
D	5548	287	5261	0.77%
E	7823	2549	5274	1.09%
F	72792	30952	41840	10.17%
G	199583	46422	153161	27.87%
H	41054	22252	18802	5.73%
I	33865	19144	14721	4.73%
J	22763	14024	8739	3.18%
K	43298	5915	37383	6.05%
L	18756	8952	9804	2.62%
M	26232	13140	13092	3.66%
N	26613	18099	8514	3.72%
O	4588	3244	1344	0.64%
P	10327	6937	3390	1.44%
Q	7521	5948	1573	1.05%
R	7415	3603	3812	1.04%
S	4656	2941	1715	0.65%
T	18	16	2	0.00%
U	4	2	2	0.00%
Total	716094	267677	448417	100%

Source: Authors' calculation on Amadeus data.

Table C2 - Number of observations by industry.

NACE	N. of obs	lk<0.77	lk>0.77	% total
A	97377	14664	82713	2.90%
B	13249	2113	11136	0.39%
C	848415	284927	563488	25.23%
D	24720	1142	23578	0.74%
E	38573	11960	26613	1.15%
F	324038	126389	197649	9.64%
G	951841	194500	757341	28.31%
H	193493	99783	93710	5.75%
I	144411	75287	69124	4.29%
J	101097	61486	39611	3.01%
K	163971	21929	142042	4.88%
L	77998	37737	40261	2.32%
M	114189	55378	58811	3.40%
N	111648	74376	37272	3.32%
O	19744	13483	6261	0.59%
P	49230	31974	17256	1.46%
Q	35751	28138	7613	1.06%
R	32307	15124	17183	0.96%
S	20468	12493	7975	0.61%
T	69	66	3	0.00%
U	8	6	2	0.00%
Total	3362597	1162955	2199642	100%

Source: Authors' calculation on Amadeus data.

Table C3 - Descriptive Statistics of the main variables (2011-19)

Variable	Obs	Mean	Std. Dev.	Min	Max
Labor share (LS)	3,339,369	0.612	0.236	0.000	1.832
Capital-output (k)	3,192,976	3.799	2.581	-8.884	16.297
Employment growth (dE)	2,342,821	0.019	0.095	-0.423	0.493
Labor productivity (Y/L)	3,192,976	0.798	0.418	-0.369	1.91
Tfp (translog)	3,340,295	4.077	0.965	1.203	6.555
Tfp (cobb-douglass)	3,337,590	3.786	1.625	0.236	6.826
Markup (translog)	3,279,032	1.539	0.408	0.197	2.233
Markup (cobb-douglass)	3,249,452	0.921	0.342	0.030	2.131

Note: The labor share and the employment growth rate are percentages, total factor productivity and the markup are indexes, and the remaining variables are ratios. The data correspond to an unbalanced panel of 19 industries and 28 European countries. Total number of observations: 3,057,782.