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Abstract

This article investigates how changing production processes and increasing market power at the firm level relate to a fall in Germany's manufacturing sector labour share. Coinciding with the fall of the labour share, I document a rise in firms' product and labour market power. Notably, labour market power is a more relevant source of firms' market power than product market power. Increasing product and labour market power, however, only account for 30% of the fall in the labour share. The remaining 70% are explained by a transition of firms towards less labour-intensive production activities. I study the role of final product trade in causing those secular movements. I find that rising foreign export demand contributes to a decline in the labour share by increasing labour market power within firms and by inducing a reallocation of economic activity from non-exporting-high-labour-share to exporting-low-labour-share firms.

Keywords: labour share, market power, labour market distortions, international trade, factor substitution

JEL Classification: D24, E25, F16, J50, L10, L60

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1. INTRODUCTION

THE ECONOMIC VALUATION OF WORK, reflected in the wage share in economic output, is declining. This not only has severe distributional consequences; but it also raises doubts on widely applied Cobb-Douglas production models relying on constant output elasticities of input factors. Not least, the decline in labor shares poses questions about the meaning of work and the future role of people in the economic activities of our society.

Therefore, it is unsurprising that a large body of literature debates the causes and mechanisms behind the global decline of wage shares.[1] Yet, the sources and implications of this decline are still not well understood, making predictions on its future course difficult and limiting our abilities to design appropriate policies in light of this secular trend.

This article contributes to this understanding by developing a parsimonious micro-founded production side theory offering three competing explanations for the fall of the labor share: an increase in firms' product market power, an increase in firms' labor market power, or a fall in firms' output elasticity of labor, which reflects a decreasing importance of labor in firms' production activities. The former two explanations both refer to an increase in market distortions, which, due to the associated reduction in aggregate output, can be viewed as an inefficient scenario. In contrast, a decrease in labor's output elasticity causes a fall in the wage share even within a competitive environment. In this case, a fall in labor's share naturally results from an (aggregate) output maximizing (re)allocation of factor shares.

[1] E.g. Blanchard & Giavazzi (2003); Elsby, Hobijn, & Şahin (2013); Karabarbounis & Neiman (2013, 2014); Lawrence (2015); Acemoglu, & Restrepo (2016); Barkai (2016); Koh, Santaeulàlia-Llopis, & Zheng (2016); Autor, Dorn, Katz, Patterson, & Van Reenen (2017); Caballero, Farhi, & Gourinchas (2017); De Loecker & Eeckhout (2018); Karabarbounis & Neiman (2018); Kehrig & Vincent (2018).

By applying my framework to 20 years of micro-data on German manufacturing sector firms, I provide three novel contributions to the literature. First, I use my theory to quantify the relative contribution of market distortions (inefficient scenario) and transforming production processes (efficient scenario) to a fall of the labor share. This assessment addresses recent and influential work suggesting that falling labor shares might be caused by increasing product market power (e.g. Barkai (2016); De Loecker & Eeckhout (2018); De Loecker, Eeckhout, & Unger (2018)). As result of this recent work, the literature is now confronted with the question about the extent to which market distortions indeed drive the decline of labor shares. Within my framework, I can answer this question by a simple thought experiment: If declining firm-level labor shares result from efficient changes in production processes, output elasticities of labor will decrease in concordance with labor shares. If labor shares, however, fall due to an increase in firms' product or labor market power, one will observe a wedge between the aggregate labor share and the aggregate output elasticity of labor. Applying this idea to the German manufacturing sector, I find that 70% of the decline in its labor share between 1995 and 2014 are explained by a decrease in the output elasticity of labor. The remaining 30% are accounted for by firms' increasing labor and product market power. Although constituting the minor share, I argue that this increase in market distortions implies room for policies that simultaneously increase economic output and labor's share of it. I discuss specific suggestions for such policies for Germany's manufacturing sector, given its observed joint distribution of market power and firm size.

Second, by separately analyzing product and labor market power, I contribute to the recent literature on rising firm market power also from a methodological point of view. Existing studies usually assume competitive labor markets (e.g. Barkai (2016); Autor et al. (2017); De Loecker & Eeckhout (2018); De Loecker et al. (2018)). This attributes variation in labor shares that does not result from changing output elasticities of labor (which are often assumed to be constant) by design to variation in product market power. Furthermore, assuming competitive labor markets makes it unclear whether the "rise of market power" documented in the literature reflects a rise in firms' product or labor market power. Clarifying this is, however, important as policies targeting output market power are different from those targeting labor market power (e.g. trade liberalization or minimum wages affect both types of market power differently). For Germany's manufacturing sector I find a high level of aggregate firm labor market power, whereas product markets are relatively competitive. Hence, labor market imperfections are a more relevant source of firm market power in Germany's manufacturing sector than imperfections in product markets. This echoes recent academic work suggesting that welfare losses from labor market power might even be larger than those from product market power (Naidu, Posner, & Weyl (2018); Marinescu & Hovenkamp (2018)). Over time, however, both types of market power increase.

Third, I use my framework to assess the role of global competition for driving changes in firm-level labor shares, product market power, labor market power, and output elasticities of labor. This sheds new light on the channels through which trade affects labor shares and contributes to an ongoing debate on the extent to which globalization accounts for secular changes in labor shares.[2] Notably, I use detailed information on firms' nine-digit product mix to construct firm-specific measures of final

[2] E.g. Rodrik (1997); Harrison (2005); Elsby et al. (2013); Karabarbounis & Neiman (2014); Autor et al. (2017); Doan & Wan (2017); Gupta & Helble (2018).

product import competition and export market demand, which account for firms being active in multiple industries. For causal identification, I use an instrumental variable strategy, similar to Autor, Dorn, & Hanson (2013) and Dauth, Südekum, & Findeisen (2014, 2018). My main results document a significant role for foreign demand in explaining falling labor shares by increasing labor market power within firms and by reallocating economic activity towards large exporting firms characterized by smaller labor shares than non-exporting firms. In contrast, import competition increases labor shares and reduces labor market power within firms. Notably, I cannot validate that increasing import competition or export demand lead to a restructuring of firms' production that decreases the importance of labor within firms. Instead, other factors seem to drive the observed fall in the output elasticity of labor.

The data to apply my framework is based on an administrative yearly firm-product-level panel on Germany's manufacturing sector for the period 1995-2014. This dataset is particularly suitable for my study as it contains information on firms' product quantities and prices. From that I can capture *firm-specific* price variation, which is crucial for a framework that investigates *firm-specific* market power. In most studies, such information is not accessible.

By providing a micro-econometric framework to analyze the mechanism behind declining labor shares I complement a large existing macroeconomic literature from which Dixon & Lim (2018) is closest to this paper.[3] Those authors derive a model similar to the framework of this article but within a macro-data setting. The advantage of using micro-data is that I can abstain from an extensive set of assumptions on demand and production technology, necessary within a macro-model. In particular, my

[3] See Schneider (2011) and Giovannoni (2014a, 2014b) for a comprehensive review.

approach nests most common models of demand, like CES and VES frameworks, and different models of competition (e.g. monopolistic competition and Bertrand). Besides that, I can loosen typically employed assumptions on competitive labor markets without imposing a priori restrictions on the price setting of factor markets (e.g. whether labor markets are characterized by monopsonistic or efficient bargaining regimes). A particular convenient aspect of using micro-data is that it allows for a simple and unrestrictive way in which I can introduce time variation in firm-level market power parameters and output elasticities. I understand this to be the reason I uncover a stark increase in aggregate firm labor market power and a strong fall in the aggregate output elasticity of labor, which are both undocumented in the literature. The severe implication of the latter is that common production models assuming constant output elasticities, as most applied Cobb-Douglas specifications, are rejected by the data.

In addition to the mentioned literature, this study ties into the long run debate on the movement of labor's share dating back at least to Kaldor (1955-56, 1957), who established the stability of the labor share as one of his famous stylized facts for economic growth. Already in the 1950s Solow (1958) published a "skeptical note" on the presumed constancy of factor shares. In earlier work Keynes (1939) called the factor share stability "a bit of a miracle". Since the observation of a declining global labor share starting in the 1980s, this strand of literature benefits from a renewed research interest. Today, the most prominent arguments explaining falling labor shares feature a vital role for biased technological change or globalization, which facilitates the offshoring of domestic production activities (e.g. Acemoglu (2003); Harrison (2005); Elsby et al. (2013); Karabarbounis & Neiman (2014); Caballero et al. (2017)). Other work highlights the erosion of labor market institutions (e.g. Blanchard & Giavazzi

(2003)) and discusses the importance of measurement error in explaining declining labor shares (e.g. Koh et al. (2016)). Most recently, the literature discusses how rising product market power and firm concentration might have contributed to falling labor shares (Autor et al. (2017); De Loecker & Eeckhout (2018); De Loecker et al. (2018)).

I view my study as nesting most of those potential driving forces into a simple framework, in which changes in the economic environment affect labor shares through changes in i) production processes, ii) labor market power, and iii) product market power. My framework fits the data surprisingly well. When testing it, I find that it accounts for 94% of cross-sectional firm-level variation in labor shares. Thus, it captures nearly the entire change in the labor share in my data.

The remainder proceeds as follows: Section 2 describes the data. Section 3 derives the framework from which I infer on the mechanisms behind declining labor shares. Here I also discuss the estimation routine used to calculate time varying output elasticities. Section 4 shows descriptive evidence for the model components, conducts decomposition exercises, and calculates the contribution of efficient and inefficient sources to the decline of the labor share. Section 5 investigates the casual relationship between international competition and declining labor shares. Section 6 concludes.

2. DATA

I use yearly panel data on German manufacturing sector firms with more than 20 employees from the cost structure survey and the AFiD-database covering a period of two decades from 1995 to 2014. Both data sets are supplied by the Federal Statistical Office of Germany. As firms are obliged to report by law, the data are of comparably high quality and contain only a negligible amount of missing values. Among others, the data contain information on firm-level costs, investment, revenues, employment, and product prices and quantities. To limit administrative burden, however, variables from the cost structure survey are only collected for a representative subsample covering roughly 40% of all manufacturing firms with more than 20 employees. This includes information on intermediate input expenditures or labor costs by various categories.[4]

By using such a long time span of firm-level data, I face a problem with respect to the time consistent classification of firms into industry sectors. This is because the NACE sector classification changed in 2002 and 2008. As I am interested in explaining wage shares with firm-level data over time, having a time consistent industry classification at the firm level is vital to my study. Moreover, the procedure to recover output elasticities and market power parameters heavily relies on time consistent industry codes. Recovering such an industry classification from official concordance tables is, however, problematic as they contain a large amount of ambiguous sector reclassifications.

To circumvent this problem, I use information on firms' product mix to classify all firms into NACE rev 1.1 sectors based on their main production activities.[5] This procedure works because the first four digits of the nine-digit GP product classification reported in AFiD are identical to the NACE sector classification. Applying this method still demands a consistent reclassification of all products into the GP2002 scheme. However, as I only need the first four digits of every product to identify the associated industry, the reclassification of products is less ambiguous than that of industries. Moreover, in ambiguous cases I can follow the firm-specific product mix over the

[4] I drop firms with negative value-added and outliers with respect to value-added and revenue growth, value-added over revenue, and deflated sales over production inputs and wages. I also purge the product data (which is separately given) from outliers in terms of price growth and price deviations from the average product price.

[5] I am thankful to Richard Bräuer with whom I developed this classification cross-walk.

reclassification periods to unambiguously reclassify most products (I observe what firms produce before and after the sector reclassification). Having constructed the product-industry classification, I attribute every firm to the industry in which it generates most of its revenue. In fact, the Federal Statistical Office of Germany uses a similar approach to classify firms into industries.[6] When comparing my classification with the one of the statistical office for the years 2002-2008 (years in which industries are already reported in NACE rev 1.1), I find that the custom two-digit and four-digit classification of firms into industries respectively matches the classification of the statistical office in 95% and 86% of all cases.

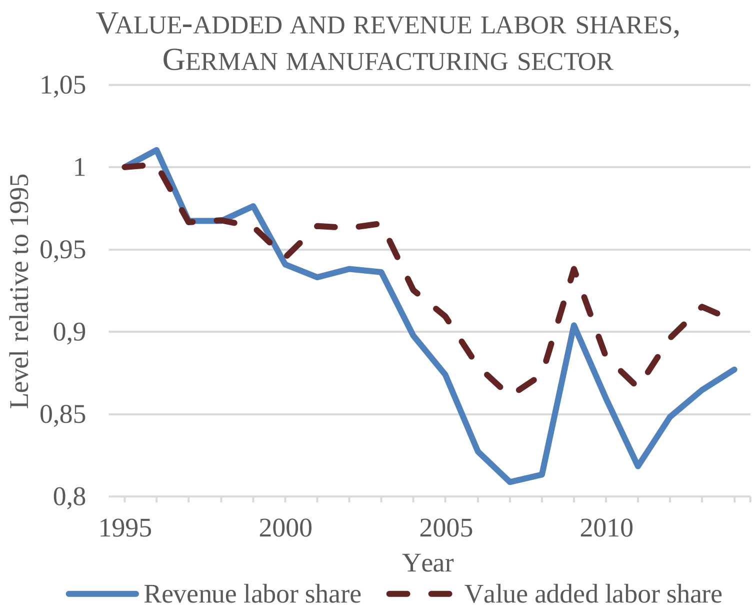

FIGURE 1 – Value-added and revenue labor shares for the German manufacturing sector. Sample firms.

Using the available 20 years of data, Figure 1 shows how aggregate manufacturing sector wage shares in value-added and revenue evolve over the observation period in Germany. The depicted decline in wage shares is impressive. Over those two decades, revenue (value-added) wage shares decline by 12 (9) percent. This corresponds to an

[6] Roughly speaking, the statistical office classifies firms into industries based on their distribution of revenue, employment, and value-added across industries.

absolute decline of the revenue (valued-added) labor share from 0.268 (0.759) to 0.235 (0.688).

Note the large spike during the crisis in 2009. Intuitively, this phenomenon can be explained by sticky wage and labor quantity adjustments (i.e. labor hoarding) in response to negative output shocks. Qualitatively, the decline in value-added and revenue wage shares is similar, with the latter being percentage wise stronger. This indicates a shortening of firms' value chain as one can transform revenue labor shares into value-added labor shares by multiplying them with the revenue over value-added ratio. However, we will focus on potential causes at a later point. Beforehand, the next section derives a simple theory fixing ideas on how labor shares are linked to market power and the importance of labor in firms' production processes.

3. A PRODUCTION SIDE THEORY OF THE LABOR SHARE

This section derives a parsimonious theory that connects firm-level labor shares to output elasticities of labor and firms' market power in product and labor markets. Section 3.1 describes the derivation of this framework and discusses its underlying assumptions. The approach I apply here is similar to Dobbelaere & Mairesse (2013) and De Loecker et al. (2018). Section 3.2 presents the empirical strategy to recover necessary parameters.

3.1 Theoretical framework

A firm i produces physical output in period t using the production function:

$$Q_{it} = Q_{it}(.) = Q_{it}(L_{it}, K_{it}, M_{it}, e^{\omega_{it}}) , \quad (1)$$

where Q_{it} represents total physical output and L_{it}, K_{it}, and M_{it} denote labor, capital, and intermediate inputs used in the production of Q_{it}. Firm-specific total factor productivity is denoted by ω_{it}. The firm knows ω_{it} before choosing its consumption of intermediate inputs. Given the characteristics of German factor markets, I assume that the innovation in productivity is uncorrelated with the input decisions for capital and labor (more details on factor markets are discussed below).[7] The only restriction on the functional form of (1) I impose is that it is continuous and twice differentiable.

Equation (1) describes a physical production process. A production model like (1) that transforms physical inputs into physical outputs approximates firms' underlying production technology more closely than a value-added specification. This is because the value-added concept has no morphological correlate, i.e. there is no market for value-added.[8]

Firms demand labor and capital inputs on imperfectly competitive factor markets. Consequently, those factor markets feature a certain degree of market power, either held by firms or suppliers of labor and capital. With respect to intermediate inputs, I follow the literature covering the estimation of markups and production functions and assume that intermediate input markets are flexible and competitive.[9] For the rest of this article I focus on labor markets because market power on labor markets will be of key interest when exploring potential mechanisms behind declining labor shares.

[7] This is consistent with labor and capital both facing adjustment costs but labor being more flexible than capital. The assumption of quasi-fixed labor inputs is employed in several studies (e.g. in Ackerberg & Hahn (2015) for Chile, in De Loecker et al. (2016) for India, and in Valmari (2016) for Finland). Given the high degree of employment protection in Germany (OECD (2018)), it is justified to the treat labor as a quasi-fixed input in my case.

[8] In fact, Bruno (1978) showed that it demands restrictive assumptions to motivate the existence of a value-added production function. For a discussion on the different production concepts, I refer to Bruno (1978), Diewert (1978), Baily (1986), and Gandhi, Navarro, & Rivers (2017b).

[9] E.g. Levinsohn & Petrin (2003); Petrin & Levinsohn (2012); Petrin & Sivadasan (2013); Dobbelaere & Mairesse (2013); Ackerberg, Caves, & Fazer (2015); Lu & Yu (2015); De Loecker et al. (2016); Gandhi, Navarro, & Rivers (2017a); Dobbelaere & Kiyota (2018); De Loecker et al. (2018).

As shown by a large labor market literature, imperfections in labor markets that give firms or employees labor market power translate into wedges between marginal revenue products of labor and wages:

$$(1+\tau_{it}^{L}) = \frac{w_{it}}{MRPL_{it}}, \qquad (2)$$

where w_{it} and $MRPL_{it}$ denote the wage and the marginal revenue product of labor.[10] $\tau_{it}^{L} > -1$ symbolizes the wedge between both variables. The existence of such a wedge can be interpreted as a signal of labor market power in the broader sense as it reflects an inefficient distortion of rents towards the firm ($\tau_{it}^{L} < 0$) or its employees ($\tau_{it}^{L} > 0$). With respect to the specific frictions that drive τ_{it}^{L}, I stay agnostic. In particular, I do not invoke assumptions on market structure or the exogeneity of wages to restrict τ_{it}^{L} to a specific kind of distortion because such assumption would not change the mathematical nature of τ_{it}^{L} in the data. An important thing to note, however, is that there are typically some underlying adjustment frictions on labor markets that create labor market power (e.g. Manning (2003); Naidu et al. (2018)).

For instance, in situations where $\tau_{it}^{L} < 0$, firms could have wage setting power emerging from worker-specific moving costs or local preferences driving wages below competitive levels. This is typically observed on monopsonistic labor markets. In contrast, reasons for observing labor market power on the employees' side ($\tau_{it}^{L} > 0$) could be the presence of strong trade unions or inefficiently working employees that cannot be dismissed due to hiring and firing costs (e.g. McDonald & Solow (1981); Rebitzer & Taylor (1991); Dobbelaere & Mairesse (2013)). In the framework described here, state interventions like effective minimum wages or a strengthening of

[10] See for instance Dobbelaere & Mairesse (2013) and the literature cited therein.

employment protection laws raise τ_{it}^{L}. To provide more intuition, I present two formally derived examples on how labor market imperfections translate into market power in labor markets in the online Appendix A.

I now derive a formula describing how labor shares connect to output elasticities of labor and market power in product and labor markets. I start by following De Loecker & Warzynski (2012), who have shown that one can formulate an expression for the firm's product market power from its optimization problem by using a first order condition with respect to a flexible input that is bought on a competitive market. In my case, this refers only to the intermediate input. As shown in the online Appendix B, the associated output market power parameter, μ_{it}, is given by:

(3) $$\mu_{it} = \theta_{it}^{M} * \frac{P_{it}Q_{it}}{z_{it}M_{it}},$$

where P_{it} and z_{it} denote the firm's output price and unit costs for intermediate inputs. θ_{it}^{X} denotes the output elasticity of input $X = \{L, M, K\}$. $\mu_{it} > 1$ indicates that the firm possesses product market power. From reformulating equation (2), one receives a similar expression linking product to labor market power:

(4) $$\mu_{it} = \theta_{it}^{L} * \frac{P_{it}Q_{it}}{w_{it}L_{it}}(1 + \tau_{it}^{L}).$$

Combining (3) and (4) gives:

(5) $$\gamma_{it} \equiv \frac{1}{(1 + \tau_{it}^{L})} = \frac{\theta_{it}^{L}}{\theta_{it}^{M}} * \frac{z_{it}M_{it}}{w_{it}L_{it}},$$

where γ_{it} defines a measure of firms' labor market power and $\gamma_{it} > 1$ signals positive labor market power for the firm.[11]

Finally, combining (4) with (5) gives an expression describing the firm-level wage share in revenue as a function of firm-specific output market power, labor market power, and the output elasticity of labor:

$$LS_{it} \equiv \frac{w_{it}L_{it}}{P_{it}Q_{it}} = \frac{\theta_{it}^{L}}{\mu_{it}\gamma_{it}}. \tag{6}$$

Equation (6) implies that a fall in the firm-level wage share in sales can be a result of increasing product market power (μ_{it}), increasing labor market power (γ_{it}), or a decreasing output elasticity of labor (θ_{it}^{L}), which, in the broadest sense, reflects the importance of labor in the firm's production activities.

While being parsimonious, the right-hand side of equation (6) captures a variety of different economic aspects. Preference structures and product demand factors are nested in μ_{it}, which can also be expressed as a function of the product price elasticity of demand (De Loecker & Scott (2016)). Simultaneously, γ_{it} captures labor market imperfections and describes the interplay between labor supply and demand side, while θ_{it}^{L} reflects technological aspects leading to factor substitution. Hence, although not explicitly modelled, equation (6) captures a broad set of different economic forces. This, however, also implies that θ_{it}^{L}, γ_{it}, and μ_{it} are not fundamental or necessary exogenous model parameters. They instead reflect channels through which changes in the economic environment and changes in firms' behavior (e.g. technology adoption) impact on the labor share.

[11] For the derivation see the online Appendix B. In a similar way, Dobbelaere & Kiyota (2018) define a parameter of firm-level labor market imperfections (i.e. labor market power) as: $\gamma_{it} = \theta_{it}^{L}\frac{P_{it}Q_{it}}{w_{it}L_{it}} - \theta_{it}^{M}\frac{P_{it}Q_{it}}{z_{it}M_{it}}$.

Dividing (6) by the ratio of nominal value-added to sales, $\frac{VA_{it}}{P_{it}Q_{it}} \equiv \kappa_{it}$, gives an expression for the value-added labor share:

(7) $$LS_{it}^{VA} \equiv \frac{w_{it}L_{it}}{VA_{it}} = \frac{\theta_{it}^{L}}{\mu_{it}\gamma_{it}\kappa_{it}}.$$

This shows how changes in firms' value-added depth explain the wedge between the time trends of LS_{it}^{VA} and LS_{it} displayed in Figure 1.

For the subsequent paper, I focus on the gross output labor share, as it results more naturally from the firm-level production perspective and lends itself to a more reasonable aggregation and decomposition of wage shares and market power parameters (see below). If I would instead apply a value-added concept, I would down-weight intermediate input intensive firms. This is something I explicitly want to avoid because there might be interesting relationships between the intensity of intermediate inputs used in firms' production activities and i) the importance of labor to firms or ii) firms' labor market power, which I want to capture.[12]

Many recent studies use a similar framework to motivate that rising *output* market power could have a significant role in explaining falling labor shares (e.g. Barkai (2016); Autor et al. (2017); De Loecker & Eeckhout (2018)). The key difference between existing work and the framework used here is that, in addition to product market power, I allow for time varying output elasticities and imperfect functioning labor markets to affect labor shares.

In absence of any output or input market power, revenue wage shares equal the corresponding output elasticities of labor. I term changes in the labor share that

[12] Using the gross output concept also follows De Loecker & Eeckhout (2018) and De Loecker et al. (2018).

correspond to changes in the output elasticity of labor as efficient as they reflect optimal adjustments in firms' production processes that (ceteris paribus) are not accompanied by a reduction of aggregate output. Contrary, I term a fall of the labor share as inefficient when it results from an increase in output or input market power as rising market power on factor and products markets lowers aggregate output. The latter is simply because firms with market power in factor or product markets demand too little production inputs and produce too little output (De Loecker et al. (2018); Mertens (2018); Van Reenen (2018)).

To shed light on whether declining labor shares are an efficient (decrease in θ_{it}^{L}) or an inefficient (increase in μ_{it} or γ_{it}) outcome, I use a gap methodology. The associated measure of inefficiency is:

(8) $$\psi_{it} \equiv LS_{it} - \theta_{it}^{L} .$$

The intuition behind equation (8) is simple. Every deviation from $\psi_{it} = 0$ indicates that labor shares are higher or smaller than under counterfactually competitive output and input markets ($\mu_{it} = \gamma_{it} = 1$). From an efficiency perspective, both, negative and positive gaps are a signal of distortions. When the decline of wage shares is caused by a rise of firms' output or input market power, ψ_{it} declines over time. If this is not the case, then the above framework implies, that declining labor shares are an efficient outcome (i.e. associated with changing production processes).

3.2 Recovering the output elasticity of labor

Before evaluating (6) empirically, one first needs to recover θ_{it}^{L} from estimating a production function. Depending on the functional form of the production function, θ_{it}^{L} varies between firms and across time. Using a traditional Cobb-Douglas specification would lead to *time constant* and *industry-specific* output elasticities. In turn, under a Cobb-Douglas production technology, the entire decline in the labor share is, by definition, attributed to rising output or labor market power. To avoid this, I apply a translog production model, which allows for time- and firm-specific output elasticities:

$$q_{it} = \boldsymbol{\phi}'_{it}\boldsymbol{\beta} + \omega_{it} + \varepsilon_{it} \,, \tag{9}$$

where lower-case letters denote logs. $\boldsymbol{\phi}_{it}$ is a vector capturing production inputs and their interactions, $\boldsymbol{\beta}$ is a vector of coefficients, and ε_{it} is an i.i.d. error term.[13]

Before estimating output elasticities from (9), I first need to calculate q_{it}, which is not directly observable for multi-product firms. To circumvent this problem, I closely follow Eslava, Haltiwanger, Kugler, & Kugler (2004) in their calculation of a firm-specific price index, π_{it}. I use this price index to purge firm revenues (of all firms) from price variation. With slightly abusing notation I keep using q_{it} for the resulting quasi-quantities. Next, I follow De Loecker, Goldberg, Khandelwal, & Pavcnik (2016) and use product-level price information to also control for input price variation across firms. Specifically, I estimate the following production function:

$$q_{it} = \widetilde{\boldsymbol{\phi}}'_{it}\boldsymbol{\beta} + B_{it}(.) + \; g_{it-1}(.) + \varepsilon_{it} + \xi_{it}. \tag{10}$$

Comments on the notation are in order.[14] $B_{it}(.) = B_{it}\big((\pi_{it}, ms_{it}, G_{it}, D_{it}) \times \boldsymbol{\phi}^{c}_{it}; \boldsymbol{\beta}\big)$ is a price control function consisting of the firm-specific output price index (π_{it}), a weighted average of firms' product market shares in terms of revenues (ms_{it}), a headquarter location dummy (G_{it}) and a four-digit industry dummy (D_{it}). $\boldsymbol{\phi}^{c}_{it} =$

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[13] I define the production function as: $q_{it} = \beta_l l_{it} + \beta_m m_{it} + \beta_k k_{it} + \beta_{ll} l_{it}^2 + \beta_{mm} m_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{lk} l_{it} k_{it} + \beta_{lm} l_{it} m_{it} + \beta_{km} k_{it} m_{it} + \beta_{lkm} l_{it} k_{it} m_{it} + \omega_{it} + \varepsilon_{it}$. The output elasticities of labor is given by: $\frac{\partial q_{it}}{\partial l_{it}} = \beta_l + 2\beta_{ll} l_{it} + \beta_{lk} k_{it} + \beta_{lm} m_{it} + \beta_{lkm} l_{it} m_{it}$. Changes in firms' output elasticities reflect a repositioning of firms on their production function.

[14] The estimation routine closely follows Mertens (2018), to whom I refer for further discussions.

$\{1; \widetilde{\boldsymbol{\phi}}_{it}\}$ contains two vectors. $\widetilde{\boldsymbol{\phi}}_{it}$ includes the same input terms as $\boldsymbol{\phi}_{it}$, either given in monetary terms and deflated by an industry-level deflator or already reported in quantity terms. The tilde indicates that some variables in $\widetilde{\boldsymbol{\phi}}_{it}$ are not expressed in true quantities (capital and intermediate inputs in my case).[15] The constant entering $\boldsymbol{\phi}_{it}^{c}$ highlights that elements of $B(.)$ enter the price control function linearly and interacted with $\widetilde{\boldsymbol{\phi}}_{it}$ (a consequence of using a translog production function).

Including a firm-specific price control function deals with unobserved variation in input prices between firms that cannot be eliminated by using industry-level deflators. In the specification above, this encompasses price variation from unobserved differences in firms' input quality, location, and four-digit industry affiliation.

In the spirit of Olley & Pakes (1996) and Levinsohn & Petrin (2003), $g_{it}(.) = g_{it}(e_{it}, k_{it}, l_{it}, \boldsymbol{z}_{it}) = \omega_{it}$ defines a productivity control function which addresses the well-known endogeneity problem, resulting from the dependence of firms' input decision on productivity. Here, e_{it} symbolizes firms' consumption of raw materials and energy inputs. $\boldsymbol{z}_{it}$ captures state variables of the firm that in addition to capital and labor influence demand for e_{it} and affect productivity. In my case, this includes a dummy variable for export activity, firm-level import competition (as defined in section 5), the number of products a firm produces, and the average wage it pays. Including those variables into $g_{it}(.)$ allows for learning and competition effects from import competition and export market participation as well as for (dis)economies of scope to affect firm productivity and demand for e_{it}. Furthermore, including wages into $g_{it}(.)$

[15] The calculation of capital stocks follows Bräuer, Mertens, & Slavtchev (2019). I explain their approach in the online Appendix I.

captures variation in input prices that shifts firms' demand for raw materials and energy (De Loecker & Scott (2016)).[16]

Finally, ξ_{it} denotes the innovation in productivity which is Hicks-neutral and follows a markov process that can be affected by firm actions captured in $\boldsymbol{z}_{it}$. Thus, we have: $\omega_{it} = \omega_{it-1} + \xi_{it} = g_{it-1}(.) + \xi_{it}$. Given my timing assumptions above, ξ_{it} is uncorrelated with firms' input decisions for capital and labor. Firms' input decision for intermediate inputs, however, is affected by ξ_{it}. Therefore, I rely on lagged values of intermediate inputs and their interactions as instruments to identify the associated coefficients. Similarly, I use lagged values of terms containing the firm's market share or output price index to identify the corresponding coefficients. This allows for prices to be adjusted in response to productivity shocks.

I estimate the production function using a one-step estimator as in Wooldridge (2009). The identifying moments are given by:

$$E\big((\varepsilon_{it} + \xi_{it})\boldsymbol{\Upsilon}_{it}\big) = 0 \,, \tag{11}$$

where $\boldsymbol{\Upsilon}_{it}$ includes lagged interactions of intermediate inputs with labor and capital, contemporary interactions of labor and capital, contemporary location and industry dummies, the lagged output price index, lagged market shares, lagged elements of $g_{it}(.)$, and lagged interactions of the output price index with production inputs.[17]

I estimate (10) separately for individual NACE rev. 1.1 two-digit industries. Across all industries, mean (median) output elasticities for capital, labor, and intermediate

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[16] I approximate $g_{it}(.)$ with a third order polynomial in all of its elements, except for the variables in $\boldsymbol{z}_{it}$. Those I add linearly. $B_{it}(.)$ is approximated with a flexible polynomial where I interact the output price index with elements in $\widetilde{\boldsymbol{\phi}}_{it}$ and add the vector of market shares, the output price index, as well as location and industry dummies linearly. This is similar to the implementation in De Loecker et al. (2016).

[17] To save space, I delegated a formal definition of $\boldsymbol{\Upsilon}_{it}$ to the online Appendix D. There, I also show that estimating the production function by OLS yields similar results.

inputs respectively are 0.63 (0.63), 0.28 (0.28), and 0.11 (0.10). I report detailed results from the production function estimation in the online Appendix C.

Having estimated the production function, I can calculate firm-level product and labor market power parameters as well as the contribution of distortions to changing labor shares by using equations (4), (6), and (8).[18] To account for measurement error when calculating μ_{it} and γ_{it}, I apply the error correction of De Loecker & Warzynski (2012), i.e. I project output on a polynomial of variables in $\widetilde{\boldsymbol{\Phi}}_{it}$, $B_{it}(.)$, and $g_{it}(.)$ and use the residuals of this auxiliary regression as a correction factor in equations (4) and (5) (for details see De Loecker & Warzynski (2012)). To ensure that I can compare aggregate statistics, I only keep firms with information for all components of equation (6). This final sample consists of 177,957 firm-year observations, for which the online Appendix C summarizes key variables of this article.

4. DESCRIPTIVE EVIDENCE

This section presents descriptive evidence on the evolution of labor shares, output elasticities, and product and labor market power parameters. Section 4.1 starts with an econometric evaluation of equation (6), showing that the framework of this paper explains nearly the entire cross-sectional variation in firm- and industry-level labor shares. Following this, section 4.2 investigates how variables of equation (6) change over time. Section 4.3 dissects the movements of those variables into within and between firm changes. Finally, section 4.4 discusses the extent to which market inefficiencies and efficient changes in production processes explain the documented change in the labor share.

[18] To avoid that outliers drive my results, I exclude observations with negative output elasticities and the one percent top and bottom outliers in the distributions of θ_{it}^{L} and ψ_{it}.

4.1 *Evaluating the theory with data*

By taking logs from equation (6) one receives a simple econometric model that can be empirically evaluated:

(12) $$\ln(LS_{it}) = \beta_{\theta^L}\ln(\theta_{it}^L) + \beta_\mu \ln(\mu_{it}) + \beta_\gamma \ln(\gamma_{it}),$$

where I expect to estimate: $\beta_{\theta^L} = 1$ and $\beta_\mu = \beta_\gamma = -1$.

Table 1 presents the associated results from estimating equation (12) at the firm level. Note that I do not intend to present causal evidence. Instead, this empirical exercise shall simply validate that the relations derived above hold and that I can explain most of the variation in labor shares through θ_{it}^L, μ_{it}, and γ_{it}.

TABLE 1

LABOR SHARES, MARKET POWER, AND LABOR OUTPUT ELASTICITIES, FIRM-LEVEL ANALYSIS

	LS_{it} (1)	LS_{it} (2)	LS_{it} (3)
θ_{it}^L	0.425***	0.624***	0.987***
	(0.00407)	(0.00626)	(0.00180)
μ_{it}	1.867***	1.462***	-0.913***
	(0.0144)	(0.0161)	(0.00822)
γ_{it}	-	-	-0.979***
			(0.00213)
Time FE	NO	YES	NO
Firm ∗ Industry FE	NO	YES	NO
Observations	177,957	170,482	177,957
R-squared	0.591	0.952	0.940
Number of firms	37,915	31,018	37,915

Notes: Table 1 reports results from estimating equation (12) at the firm level. Standard errors are clustered at the firm level. Stars indicate whether coefficients are significantly different from one for θ_{it}^L and from minus one for μ_{it} and γ_{it}. Significance: *10 percent, **5 percent, ***1 percent.

Columns 1 and 2 show results obtained from a model featuring perfect labor markets, i.e. where $\gamma_{it} = 1$ and $\ln(\gamma_{it}) = 0$. When not accounting for labor market power, I find that firms' product market power, μ_{it}, is positively correlated with their labor shares, even after controlling for several fixed effects. Only after conditioning on γ_{it} the sign of the coefficient on μ_{it} becomes, as predicted by equation (6), negative (columns 3). This change in the coefficient on μ_{it} implies that firms with high product market power, share their higher rents extensively with their employees, leading to *higher* labor shares within firms with higher product market power.[19] Thus, a model with perfect labor markets ignores an important mechanism connecting product market power with labor shares through rent-sharing processes. A model which abstracts from this mechanism "only" accounts for 60 percent of cross-sectional variation in labor shares (column 1). In contrast, after including γ_{it} (column 3), the explaining power of the regression model increases to 94 percent (without any fixed effects). Although the coefficients are significantly different from one and minus one (due to small standard errors), they fit the parsimonious framework above surprisingly well.

MARKET POWER AND LABOR SHARES

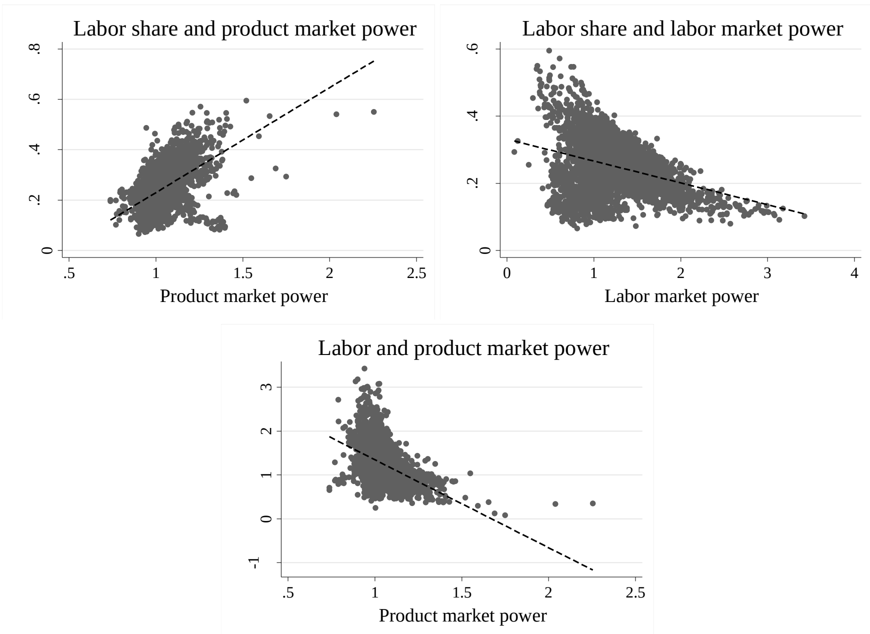

FIGURE 2 – Weighted averages of firm-level labor shares, product market power, and labor market power for four-digit industries with at least three firms. Germany's manufacturing sector. Sample firms.

[19] A theoretical foundation of that result can be found in Nickell (1999).

To explore the relationship between labor shares and market power also graphically, Figure 2 plots weighted averages of LS_{it}, μ_{it}, and γ_{it} at the four-digit industry-level pairwise against each other. In line with the regression results, the unconditional scatter plots in Figure 2 show that labor shares are positively (negatively) associated with product (labor) market power parameters, whereas firms' labor and product market power are negatively correlated. Together those findings support the existence of rent-sharing in the German manufacturing sector.

Given the recent debate on the "rise of market power" and its implication for the labor share (see De Loecker & Eeckhout (2018) and De Loecker et al. (2018)), the finding of a positive correlation between firms' product market power and labor shares, both at the firm and the more aggregate industry level, is striking. When measuring market power, the existing literature typically assumes competitive labor markets. My results demonstrate that this might misguide conclusions on the relationship between product market power and labor shares, as firms with high product market power might share their higher rents with their workforce.

4.2 Aggregate movements

To aggregate variables, I use revenue weights throughout this article. This exploits that the aggregate revenue wage share can be decomposed in the following way:

$$LS_{jt} = \frac{\sum_i w_{it} L_{it}}{\sum_i P_{it} Q_{it}} = \sum_i \frac{P_{it} Q_{it}}{\sum_i P_{it} Q_{it}} * \frac{w_{it} L_{it}}{P_{it} Q_{it}}, \tag{13}$$

where j denotes the aggregation level (i.e. manufacturing sector) and sums are taken over all firms within j. Figure 3 shows the evolution of manufacturing sector wide weighted aggregates of firm-level labor shares, output market power, labor market power, and labor output elasticities. Over the entire observations period the revenue labor share decreased from 26.8 to 23.6 percentage points. Instead of being associated with a change in a single component of equation (6), the fall of the labor share coincides jointly with a fall of the output elasticity of labor and a rise in aggregate product and labor market power. The clear negative time trend of labor's output elasticity over two decades severely questions the assumption of constant output elasticities, frequently applied in Cobb-Douglas production models. The crucial implication of this finding is that production models featuring constant output elasticities produce potentially biased measures of, among others, productivity and misallocation.

REVENUE LABOR SHARE AND ITS COMPONENTS

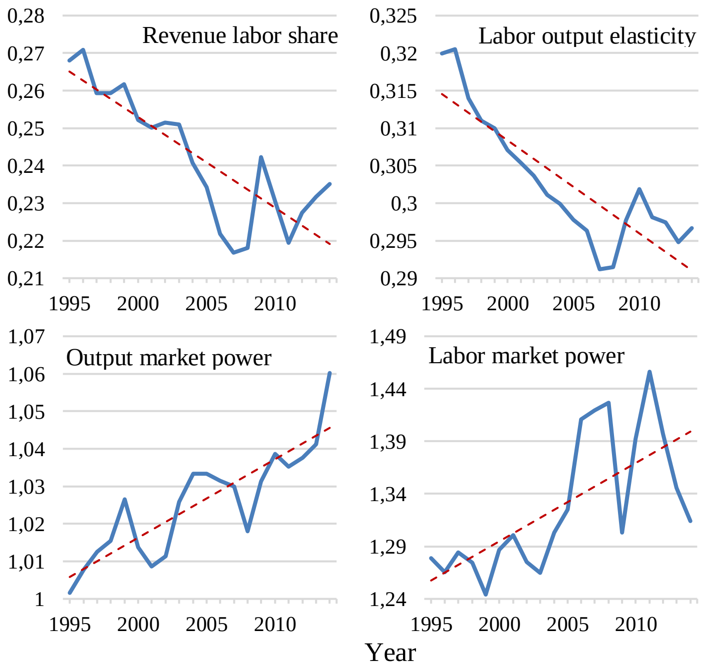

FIGURE 3 – Weighted averages of firm-level labor shares, output elasticities of labor, output market power parameters, and labor market power parameters. Red dashed lines show linear trends. Germany's manufacturing sector. Sample firms.

To investigate more into the evolution of output elasticities, I discuss the movements of labor, capital, and intermediate input output elasticities at the two-digit sector level in the online Appendix E. Most notably, I find that industry-level output elasticities of labor and intermediates also exhibit clear time trends, while output elasticities of capital are more stable. Whereas labor output elasticities decrease, intermediate input output elasticities increase over the observation period. Jointly this suggest an increasing importance of intermediate inputs in firms' production activities that induces a substitution of labor for intermediate inputs. This is exactly what one would expect from an increasing tendency of German manufacturing sector firms to outsource/offshore labor-intensive tasks, as documented in the literature (e.g. Sinn (2006); Goldschmidt & Schmieder (2017)). Notably, a substitution of labor for intermediate inputs also increases the importance of capital, relative to labor, in firm's production processes. For more details, please see the online Appendix E.

With respect to the market power parameters, I find a clear upward trend in both. Compared to the findings of De Loecker & Eeckhout (2018), however, the product market power levels I estimate are lower. Note that my estimates even suggest that product markets where competitive in 1995. The reasons for the differences in output market power levels between De Loecker & Eeckhout (2018) and this study is a consequence of De Loecker and Eeckhout applying a different production model featuring competitive input markets. De Loecker and Eeckhout estimate a production model with gross output on the left-hand side and capital and a joint production factor capturing "variable" inputs (including labor) on the right-hand side of the production function. If the input market for this variable factor is imperfect, the resulting market power parameter reflects market power in output *and* in the variable factor's input market. Hence, in the presence of imperfect labor markets, the measure of De Loecker and Eeckhout is a combination of firms' output and labor market power. As Figure 3 shows positive and increasing levels of firms' labor *and* product market power, product market power as measured in De Loecker & Eeckhout (2018), would be higher and more strongly increasing in my case.

While I find that aggregate product market power is low, I document a high level of aggregate firm labor market power in Germany' manufacturing sector. Hence, imperfect functioning labor markets are a more relevant source of market power for German manufacturing sector firms' than product market imperfections. This finding is striking, given i) that most existing work in the IO literature abstracts from labor market power and focusses on market power in product markets and ii) policy measure to address each type of market power differ.

Intuitively, the rise of labor market power in the early 2000s could be a result of Germany's major labor market reforms (i.e. the "Hartz-reforms"), which decreased unemployment benefits, whereas the fall of labor market power in the years after the crisis could be an early sign of a skill shortage. Moreover, the general increase in firms' labor market power coincides with the fall in the union coverage/density over several decades in Germany (e.g. Dustmann, Fitzenberger, Schönberg, & Spitz-Oener (2014); OECD (2017); Hirsch & Müller (2018)).

With respect to the business cycle, firms' product market power shows a slightly countercyclical or acyclical movement, whereas firms' labor market power behaves cyclical. The latter is very intuitive as labor market power captures the difference between the revenue contribution of labor and its compensation. If, for instance, due to labor hoarding during the crisis, labor expenditures are not perfectly downward adjusted in response to output losses, labor's revenue product will decrease stronger than its compensation (which lowers γ_{it}). This is exactly what we see in Figure 2 during 2009.

4.3 Between vs. within firm changes

The weighted average, x_{jt}, of any variable x_{it} can be decomposed in the following way:

$$x_{jt} = \sum_i s_{it} x_{it} = \bar{x}_{jt} + cov_{jt}(x_{it}, s_{it}), \quad (14)$$

where $s_{it} = \frac{P_{it}Q_{it}}{\sum_i P_{it}Q_{it}}$, $\bar{x}_{jt}$, and $cov_{jt}(x_{it}, s_{it})$ respectively denote the weight of economic activity (revenue weights), the unweighted average of x_{it} across firms, and the covariance between x_{it} and s_{it} (Olley & Pakes (1996)). Changes in the unweighted average reflected within firm changes, while changes in the covariance reflect between firm changes (i.e. reallocation). Figure 4 illustrates this decomposition graphically for the aggregates of LS_{it}, θ_{it}^L, μ_{it}, and γ_{it}. Panel A plots unweighted averages (within firm contribution), whereas Panel B shows the associated covariance term (between firm contribution).

The decline in the labor share has both, a strong within and between firm component. In contrast, the decline in the aggregate output elasticity of labor is a within firm phenomenon, suggesting that it is driven by factors that influence most manufacturing firms similarly. The between firm component is negative for the labor share and product market power parameter, while slightly positive (but close to zero) for labor's output elasticity and strongly positive for the labor market power parameter. This implies that *larger* firms have lower labor shares, less product market power, slightly higher output elasticities of labor, and clearly higher labor market power levels than smaller firms.[20] Interestingly, the unweighted average of the labor market power parameter is below

[20] In the online Appendix E, I show that the relationships between firm size and my variables of interest are robust to defining firms' share of economic activity as employment share.

one, implying that employees have a strong position within most firms. A larger part of economic activity, however, is concentrated in firms with high labor market power, leading to an aggregate labor market power parameter above one.

WITHIN FIRM VS. BETWEEN FIRM CHANGES

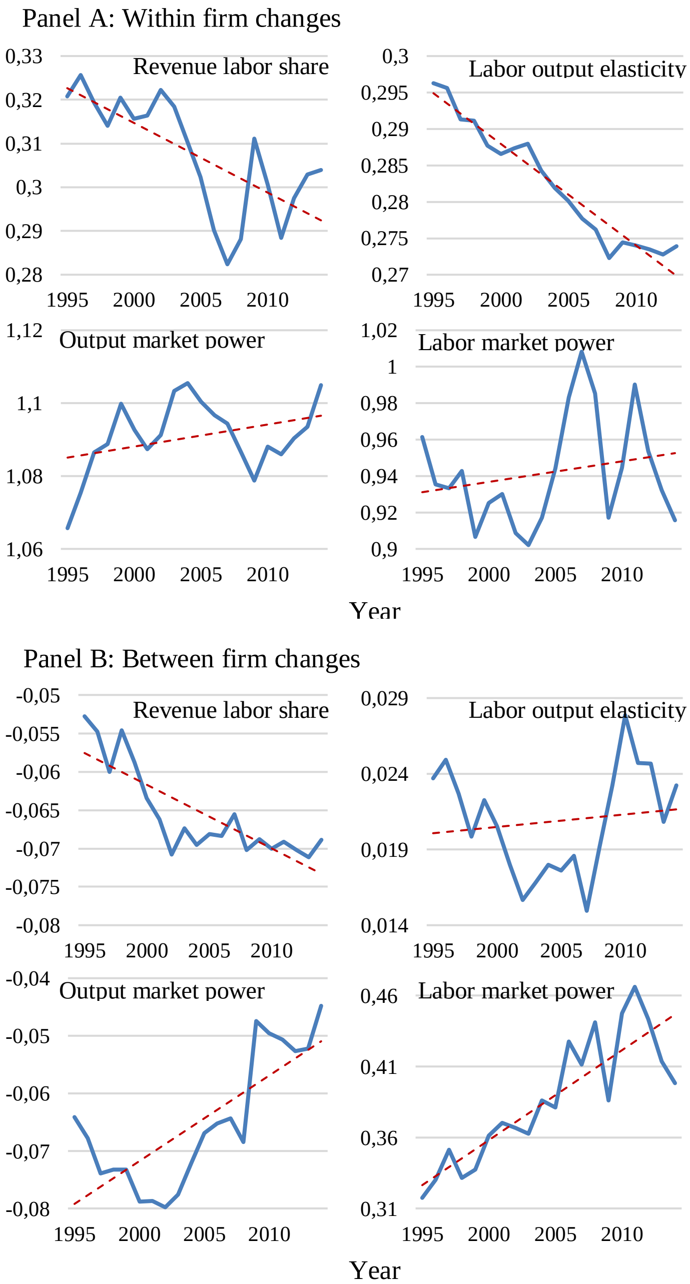

FIGURE 4 – Weighted averages of firm-level labor shares, output elasticities of labor, output market power parameters, and labor market power parameters. Red dashed lines show linear trends. Germany's manufacturing sector. Sample firms.

To give a quantitative impression, I calculate the contribution of within and between firm dynamics to changes in weighted aggregates for the variables of interest in Table 2. For every variable, the first column reports the relative change in its aggregate value, while the second and third columns show the within and between firm contribution to the total change. For instance, the aggregate labor share declined by 6.00% (6.31%) due to between (within) firm dynamics. Thus, the aggregate labor share fell by $6.00\% + 6.31\% = 12.31\%$, showing that its decline is equally driven by within and between firm dynamics.

TABLE 2

RELATIVE CHANGES IN LABOR SHARES, OUTPUT ELASTICITIES, PRODUCT MARKET POWER, AND LABOR MARKET POWER; WITHIN VS. BETWEEN FIRM CHANGES

Period	Labor share			Output elasticity of labor		
	ΔLS_{jt}	Within contribution	Between contribution	$\Delta\theta_{jt}^{L}$	Within contribution	Between contribution
	(1)	(2)	(3)	(4)	(5)	(6)
1995-2000	-5.92%	-1.93%	-3.98%	-4.02%	-3.03%	-0.99%
2000-2005	-7.12%	-5.27%	-1.85%	-3.04%	-2.10%	-0.94%
2005-2010	-1.61%	-0.77%	-0.83%	+1.39%	-2.06%	+3.44%
2010-2014	+2.00%	+1.46%	+0.54%	-1.72%	-0.17%	-1.54%
1995-2014	-12.31%	-6.31%	-6.00%	-7.27%	-7.12%	-0.15%
Period	Product market power			Labor market power		
	$\Delta\mu_{it}$	Within contribution	Between contribution	$\Delta\gamma_{jt}$	Within contribution	Between contribution
	(7)	(8)	(9)	(10)	(11)	(12)
1995-2000	+1.21%	+2.69%	-1.47%	+0.61%	-2,81%	+3.42%
2000-2005	+1.94%	+0.77%	+1.17%	+3.01%	+1.47%	+1.54%
2005-2010	+0.50%	-1.19%	+1.69%	+5.02%	+0.02%	+5.00%
2010-2014	+2.08%	+1.63%	+0.45%	-5.60%	-2.07%	-3.54%
1995-2014	+5.85%	+3.93%	+1.93%	+2.74%	-3.57%	+6.31%

Notes: Table 2 documents the contribution of within and between firm changes to changes in the aggregates of labor shares, labor output elasticities, product market power, and labor market power.

For output market power, two thirds of the increase are a result of within firm changes, whereas the remaining one third results from reallocation processes between firms. With respect to labor market power, the reported changes mask the fluctuations and the general upward trend in labor market power depicted in Figure 3. Note that in 2014 the within firm component of labor market power is even below its initial level.

This decrease, however, is dominated by a reallocation of economic activity towards high-labor-market-power-firms.

4.4 Rise of market power vs. efficient sources of declining labor shares

Using equation (8) and aggregating as beforehand, Figure 5 shows how the aggregate wedge between the labor share and the output elasticity of labor, ψ_{jt}, evolved over the period 1995-2014. The level of ψ_{jt} is depicted on the left vertical axis. The evolution of ψ_{jt}, which is represented by the blue solid line, reflects the extent to which factors other than changing output elasticities can account for the observed decline in labor's share. Through the lens of this study's framework, this corresponds to changes in firms' product or labor market power.

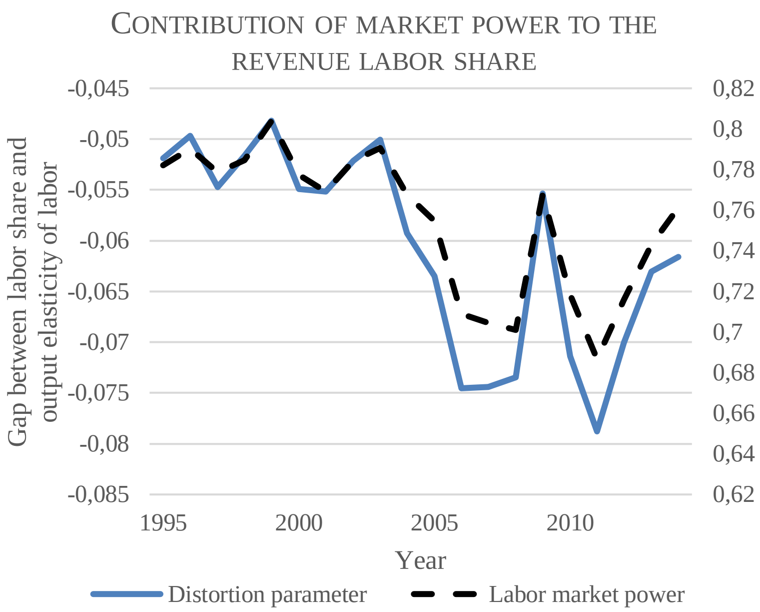

FIGURE 5 – Aggregate labor market power and the aggregate wedge between the observed labor share and the counterfactual labor share under counterfactually competitive product and labor markets. Germany's manufacturing sector. Sample firms.

Already in 1995, labor shares were below their counter factual level of competitive output and input markets. Over the following two decades this wedge displays a clear negative time trend, i.e. the wedge widens. There could be several events explaining this increase in market distortions between 1995-2014. Besides the mentioned introduction of labor market reforms in 2005 or the erosion of labor market institutions starting in the 90s, increased globalization could also have contributed to a rise in market distortions. In particular, an increase in the share of imported foreign intermediate inputs could have led to a substitution of domestic with foreign workers, which could have weakened the bargaining power of the former (Rodrik (1997)). Simultaneously, the availability of cheaper foreign inputs could have led to an increase of domestic product market power by an incomplete pass-through from cost savings to output prices (De Loecker et al. (2016)). Alternatively, rising export demand could have increased domestic firms' profits without an associated increase in domestic wages, also leading to an increase in firms' labor market power (Mertens (2018)). Apart from this, increasing market concentration through modern technologies (e.g. digital platforming or online search engines) that transform markets into "the-winner-takes-it-all-industries" could have contributed to an increase in product and labor market power (Autor et al (2017); Van Reenen (2018)). Naturally, a full investigation of all potential changes in the economic environment that impact on the labor share and its components is beyond the scope of this article. However, to address this interesting question at least to some extent, I investigate how final product import competition and export demand affect LS_{it}, θ_{it}^{L}, μ_{it}, and γ_{it} in the next section.

Beforehand, note that in comparison with Figures 3 and 4, one discovers an astonishing similarity between movements in aggregate labor market power and ψ_{jt}. To highlight this, the dashed black line of Figure 5 displays the invers of the aggregate labor market power parameter (levels are represented on the right vertical axis). The striking similarity between movements in ψ_{jt} and γ_{it} points to a key role of labor market power fluctuations in explaining fluctuations in ψ_{jt}.

In recent years, distortions reduced again, such that over the entire observation period ψ_{jt} decreased by one point, i.e. observed labor shares in 2014 are roughly 1 percentage point further below the counter factual labor share level of competitive markets than in 1995. This implies that 30% of the entire 3.3 percentage point decline in labor shares over the period 1995-2014 are accounted for by increasing product and labor market power. Hence, the remaining 70% can be explained by changes in firms' production processes (output elasticities of labor dropped from 0.320 to 0.297).

Still, from a social planner's point of view, the increase in market power suggests room for policies that simultaneously raise aggregate economic output and labor's share of it by targeting firms' market power. This is clearer for the rise in labor market power than for the increase in product market power because in the presence of sunk research costs there exists a socially optimal level of product market power, necessary to recover costs from creating a new variety (given that consumers value innovations sufficiently). Thus, if entry or innovation costs increased sufficiently strong, the documented trend in product market power could be necessary to create a socially beneficial level of innovation.

Nevertheless, this logic does not hold for the increase in firms' *labor* market power as workers, which are not necessary the consumers of the final good, should not carry the burden of refinancing sunk costs of product innovations. Furthermore, recap that from comparing μ_{it} with γ_{it},we know that the major part of market power distortions in Germany's manufacturing sector results from high and increasing levels of firms' labor market power. Hence, the room for policies targeting labor market power is higher than for policies targeting product market power.

Guiding policies in consideration of high and increasing labor market power levels naturally depends on a variety of aspects, including normative discussions on preferences (e.g. for inequality). If political decisions makers, however, agree on targeting firms' labor market power, the design of an appropriate policy will depend on the underlying distribution of market power across firms. In case of Germany, for instance, I document that the average firm has no market power in their labor markets. The high and increasing level of aggregate labor market power instead results from a positive and increasing covariance between firms' share of economic activity and their labor market power. Consequently, policies targeting all firms equally or small firms especially are unsuitable to reduce aggregate labor market power in Germany's manufacturing sector (some may argue that a uniform minimum wage could be an example of such a policy). A policy to reduce firms' labor market power could instead be an extension of the existing legislative antitrust analysis, which currently mostly focus on market power in product markets, to also consider the effects of labor market power (Naidu et al. (2018)).

5. THE ROLE OF INTERNATIONAL TRADE

This section discusses the extent to which global competition affects labor shares, market power, and output elasticities of labor. Section 5.1 describes the empirical approach and runs a firm-level analysis on the effects of Chinese import competition and export demand on the variables of interest. As this analysis focusses on within firm effects, section 5.2 complements it by investigating the between firm reallocation processes induced by international trade.

5.1 Firm-level labor shares and trade shocks

Having established that a major part of the decline of Germany's manufacturing sector labor share can be explained by a declining output elasticity of labor, it is now interesting to investigate how changes in the economic environment impact on the labor share and its drivers. Within this context, a large body of literature discusses the relative importance of globalization in explaining falling labor shares.[21] To shed new light on this debate, I exploit the firm-product dimension of the AFiD-data to construct measures of *final product* import competition and export opportunities for each individual firm.[22]

Intuitively, international competition has the potential to affect all components of our simple framework. On the one hand, international trade affects firms' rents, which in the presence of imperfect functioning labor markets might affect firms' labor market power (e.g. Mertens (2018)). On the other hand, final product trade may lead to adjustments in firms' product mix or product prices, translating into changes in firm productivity and markups (e.g. Melitz, Mayer, & Ottaviano (2014)). Moreover, besides setting incentives for firms to invest in modern technologies, exposure to international trade gives an impetus for reorganizing existing production structures, potentially affecting the importance of labor to firms (e.g. Caliendo, Monte, & Rossi-Hansberg (2017); Antras, Fort, & Tintelnot (2017)).

To measure import competition and export opportunities, I combine the AFiD data with the United Nations Comtrade Database (Comtrade). I then follow Mion & Zhu (2013) and define a measure of product-level import competition as:

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[21] E.g. Elsby et al. (2013); Karabarbounis & Neiman (2014); Acemoglu & Restrepo (2016); Doan & Wan (2017); Muendler (2017); Gupta & Helble (2018).

[22] I focus on final product trade measures as I do not have information on imported intermediate products at the firm level. It is likely that final and intermediate product trade affect my variables of interest differently (De Loecker & Goldberg (2014); Wang, Wei, Yu, & Zhu (2018)).

(15) $$IM_{gt}^{CHN\rightarrow GER} = \frac{M_{gt}^{CHN\rightarrow GER}}{M_{gt} + Y_{gt}} * 100,$$

where $M_{gt}^{CHN\rightarrow GER}$ measures product level trade flows from China to Germany, and M_{gt} and Y_{gt} respectively denote German world imports and total observed domestic production of product g.[23] Similarly, I define a measure of export opportunities as:

(16) $$EX_{gt}^{GER\rightarrow CHN} = \frac{E_{gt}^{GER\rightarrow CHN}}{M_{gt} + Y_{gt}} * 100,$$

where $E_{gt}^{GER\rightarrow CHN}$ denotes product exports flowing from Germany to China. I aggregate $IM_{gt}^{CHN\rightarrow GER}$ and $EX_{gt}^{GER\rightarrow CHN}$ to the firm level using revenue weights. Specifically, for every firm-product-year combination I first multiply $IM_{gt}^{CHN\rightarrow GER}$ and $EX_{gt}^{GER\rightarrow CHN}$ with the firm-specific sales of product g divided by the firm's total product market sales. This weights product-level trade flows with their importance to the firm. Subsequently, I sum across all weighted product trade flows within a firm. I denote the resulting trade measures by IMP_{it}^{CHN} and EXP_{it}^{CHN}.

To estimate the effect of international trade on labor shares and its components, I run the following regression:

(17) $$\ln(y_{it}) = \beta_{IMP} IMP_{it-1}^{CHN} + \beta_{EXP} EXP_{it-1}^{CHN} + \boldsymbol{C}_{it-1}^{'}\boldsymbol{\beta} + \vartheta_t + \vartheta_{ij},$$

where $y_{it} = \{LS_{it}, \theta_{it}^{L}, \mu_{it}^{M}, \gamma_{it}\}$. The vector $\boldsymbol{C}_{it}'$ controls for a firm's capital over labor ratio, value-added over revenue ratio, and number of products. ϑ_t and ϑ_{ij} control for time and firm times industry fixed effects. Thus, equation (17) specifies a within-firm

[23] AFiD collects product level production information for all manufacturing sector plants/firms with at least 20 employees within Germany. I do not use information on exports when defining the import competition measure as in some cases exports reported in Comtrade exceed domestic production in AFiD. Reason for that could be differences in reporting days or the fact that AFiD contains production information only for all plants with at least 20 employees.

estimator. Consistent with the production model described in section 3, I rely on lagged trade measures to allow for a time frame in which adjustment processes can be realized.

An extensive literature documents that regressing labor market outcomes on trade measures like (15) and (16) suffers from an endogeneity problem because unobserved demand and supply shocks might simultaneously affect the dependent and independent variable (see Autor et al. (2013) and Dauth et al. (2014) for a discussion). To address this problem, I follow the dominant IV strategy in the literature and use trade flows between China and countries similar to Germany as instruments for IMP_{it}^{CHN} and EXP_{it}^{CHN}. Specifically, I define instruments from imports (exports) flowing from China (instrument group countries) to instrument group countries (China) over total imports (exports) flowing from the world (instrument group) to the instrument group (world):

$$EX_{gt}^{INS} = \frac{E_{gt}^{INS \rightarrow CHN}}{E_{gt}^{INS \rightarrow WORLD}} * 100 \quad (18)$$

and

$$IM_{gt}^{INS} = \frac{M_{gt}^{CHN \rightarrow INS}}{M_{gt}^{WORLD \rightarrow INS}} * 100. \quad (19)$$

Identical to the construction of IMP_{it}^{CHN} and EXP_{it}^{CHN}, I aggregate (18) and (19) to the firm level using revenue shares.[24] I report the first stage regression results for all following IV-specifications in the online Appendix F.

[24] The instrument country group includes Australia, New Zealand, Sweden, Norway, Japan, Great Britain, Canada, and Singapore. My results are unaffected from excluding good flows between Germany and the instrument country group in the denominator (results are available on request). One potential threat to my identification is that firms adjust their product mix in expectation of trade shocks, which would introduce an endogeneity problem when aggregating product-level trade flows to the firm level using revenue shares. I address this issue in the online Appendix H by using time constant revenue weights when aggregating product-level trade measures. All results are qualitatively robust.

TABLE 3

LABOR SHARES, MARKET POWER PARAMETERS, LABOR OUTPUT ELASTICITIES, AND INTERNATIONAL TRADE

	OLS				IV			
	LS_{it} (1)	θ^L_{it} (2)	μ_{it} (3)	γ_{it} (4)	LS_{it} (5)	θ^L_{it} (6)	μ_{it} (7)	γ_{it} (8)
IMP^{CHN}_{it-1}	0.00224***	-0.00070	0.00053***	-0.00318***	0.00236***	-0.00112	-0.00001	-0.00406***
	(0.000500)	(0.00049)	(0.000180)	(0.00060)	(0.000828)	(0.000725)	(0.000280)	(0.000863)
EXP^{CHN}_{it-1}	-0.00179**	-0.00059	0.00116***	0.00006	-0.00664**	0.00166	0.00003	0.00777***
	(0.000738)	(0.00042)	(0.000252)	(0.000543)	(0.00251)	(0.00167)	(0.000821)	(0.00232)
Firm x Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm-level controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	114,060	114,060	114,060	114,060	114,060	114,060	114,060	114,060
R-squared	0.915	0.952	0.898	0.939	0.915	0.952	0.898	0.938
First-stage F-test	-	-	-	-	106.00	106.00	106.00	106.00
Number of firms	22,638	22,638	22,638	22,638	22,638	22,638	22,638	22,638

Notes: Table 3 reports results from estimating equation (17) by OLS and IV. OLS-results are reported in columns 1-4. IV-results are reported in columns 5-8. The dependent variable in columns 1-4 and 5-8 are respectively the revenue labor share, the output elasticity of labor, the output market power parameter, and the labor market power parameter. All regressions include time and industry times firm fixed effects and controls for the firm's, capital over labor ratio, value-added over revenue ratio, and number of products. Standard errors are clustered at the firm level. Significance: *10 percent, **5 percent, ***1 percent.

Table 3 reports results from estimating equation (17) by OLS and IV. Both estimators report a highly significant negative (positive) effect of export opportunities (import competition) on firm-level labor shares. According to the IV-results, a one unit increase in export opportunities (import competition) decreases (increases) labor shares within firms by 0.66 (0.24) percent.[25] To put those figures into perspective: Between 1995 and 2014 I observe a total increase in export demand (import competition) from China by 1.11 (1.14) points. Hence, the negative effect of increased export demand accounts for $\frac{0.66*1.11*100}{6.31} \approx 12$ percent of the fall in the aggregate within firm labor share. However, the increase in import competition offsets this effect; such that the net contribution of increased trade with China to the total decline of the within firm labor share equals roughly 7 percent.

Notably, I cannot find any evidence for an associated change in labor output elasticities from international trade. This is striking as the decomposition exercise in section 4.3 shows that the aggregate output elasticity of labor decreased due to within firm dynamics, which is exactly what the within firm-specification in equation (17) should capture. Seemingly, factors other than final product trade cause the within firm change in labor's output elasticity.

Interestingly, both, IV- and OLS- results, document that import competition affects firms' labor market power negatively. The estimators depart, however, with respect to the other coefficients on μ_{it} and γ_{it}. When using OLS, I find a significant positive effect of both trade measures on firms' product market power. While I cannot validate this result by IV, IV-results show a positive impact of export opportunities on labor market

[25] Mertens (2018) provides a rational for these findings by showing that profit gains and losses from trade are not perfectly passed-through into labor expenditure adjustments within firms.

power within firms, which cannot be found using OLS. Given the potential presence of an endogeneity problem in my OLS-estimates, I prefer the IV-specification. Yet, although both estimators depart with respect to the type of market power affected, the result that final product trade affects firms' labor shares through within firm changes in their market power holds regardless of the estimation technique.

5.2 Reallocation of economic activity between exporters and non-exporters

Recap that the labor share decomposition in section 4.3 shows that only half of the decline in the aggregate manufacturing sector labor share is driven by falling within firm labor shares. By design, estimating the effect of trade on labor shares as above cannot account for the large part of the change in the manufacturing sector labor share resulting from a between firm reallocation process. Moreover, although the within firm component of labor market power displays a positive trend, labor market power mainly rose due to between firm dynamics. However, the within firm specification in equation (17) is exactly what allows me to draw causal inferences on how changes in trade flows affect changes in the outcomes of interest. Transferring the analysis in an alternative approach to the industry level would introduce several inaccuracies because i) firms are active in multiple industries simultaneously and ii) industry-level trade measures mix up final product and intermediate product trade flows.

To still shed light on the reallocation process induced by trade, I investigate how the shares of economic activity of exporting and non-exporting firms change in response to final product trade. To motivate this exercise, Table 4 reports mean and median values for selected variables separately for exporting and non-exporting firms. There are several interesting things to note. Exporting firms are larger, have a higher labor productivity, and use more capital and intermediate inputs per employee than non-exporting firms. As expected, exporting firms also pay higher wages. Yet, exporting firms are characterized by lower labor shares and higher labor market power compared to non-exporting firms. Note that exporting firms' high labor market power is not driven by low wages. It instead results from high marginal products of labor, which are potentially far above industry average wages. This supports the presence of a "hide-effect" in wage negotiations which refers to the observation that highly profitable firms "hide" behind industry-wide wage standards to pay wages below their workers' revenue contribution (Hirsch & Müller (2018)).

TABLE 4

SUMMARY STATISTICS,
EXPORTER VS. NON-EXPORTER

	Exporter			Non-exporter		
	Mean	Median	N	Mean	Median	N
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Employees	252.78	107	135,730	115.13	59	42,227
Log of value-added per employee	16.54	16,42	135,730	15.59	15.44	42,227
Deflated capital per employee in thousands	98,674	73,776	135,730	86,214	51,079	42,227
Deflated intermediates per employee in thousands	94,209	74,768	135,730	64,814	46,699	42,227
Value-added over revenue	0.40	0.40	135,730	0.44	0.44	42,227
Average real wage	34,771	34,450	135,730	26,941	26,237	42,227
Revenue labor share	0.30	0.29	135,730	0.33	0.33	42,227
Value-added labor share	0.77	0.75	135,730	0.78	0.77	42,227
Output market power parameter	1.09	1.07	135,730	1.10	1.08	42,227
Labor market power parameter	0.99	0.91	135,730	0.77	0.68	42,227
Output elasticity of labor	0.29	0.29	135,730	0.25	0.25	42,227

Notes: Table 4 reports mean and median values of selected variables separately for exporting and non-exporting firms. Means, medians, and the number of observations used to calculate the statistics are respectively reported in columns 1 and 4, 2 and 5, and 3 and 6.

Notably, exporting and non-exporting firms do not differ in their output market power. If anything, non-exporting firms have slightly higher levels of μ_{it}. As there is a clear difference in labor shares and labor market power between exporting and non-exporting firms, a reallocation of domestic economic activity from non-exporting to exporting firms increases aggregate firm labor market power and decreases aggregate labor shares, ceteris paribus.

TABLE 5

INTERNATIONAL TRADE AND THE REALLOCATION OF ECONOMIC ACTIVITY

	OLS		IV	
Panel A: Exporter	$\frac{L_{it}}{\sum L_{it}}$	$\frac{P_{it}Q_{it}}{\sum P_{it}Q_{it}}$	$\frac{L_{it}}{\sum L_{it}}$	$\frac{P_{it}Q_{it}}{\sum P_{it}Q_{it}}$
	(1)	(2)	(3)	(4)
IMP_{it-1}^{CHN}	-0.00435***	-0.00820***	-0.00847***	-0.0134***
	(0.000869)	(0.00112)	(0.00150)	(0.00189)
EXP_{it-1}^{CHN}	0.00285***	0.00609***	0.0107***	0.0241***
	(0.000940)	(0.00147)	(0.00354)	(0.00466)
Firm x Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Firm-level controls	YES	YES	YES	YES
Observations	88,787	88,787	88,787	88,787
R-squared	0.983	0.982	0.983	0.982
First-stage F-test	-	-	104.50	104.50
Number of firms	17,066	17,066	17,066	17,066
	OLS		IV	
Panel B: Non-exporter	$\frac{L_{it}}{\sum L_{it}}$	$\frac{P_{it}Q_{it}}{\sum P_{it}Q_{it}}$	$\frac{L_{it}}{\sum L_{it}}$	$\frac{P_{it}Q_{it}}{\sum P_{it}Q_{it}}$
	(1)	(2)	(3)	(4)
IMP_{it-1}^{CHN}	-0.00927***	-0.0124***	-0.0126***	-0.0249***
	(0.00226)	(0.00319)	(0.00434)	(0.00610)
EXP_{it-1}^{CHN}	-0.00287	0.00578*	-0.00120	0.00534
	(0.00258)	(0.00312)	(0.0143)	(0.0225)
Firm x Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Firm-level controls	YES	YES	YES	YES
Observations	23,556	23,556	23,556	23,556
R-squared	0.979	0.981	0.979	0.981
First-stage F-test	-	-	3.840	3.840
Number of firms	6,068	6,068	6,068	6,068

Notes: Table 5 reports results from estimating equation (17) by OLS and IV using separate samples for $t-1$ exporters (Panel A) and non-exporters (Panel B). OLS-results are reported in columns 1 and 2. IV-results are reported in columns 3 and 4. The dependent variable in columns 1 and 3 is the firm-level employment share in total employment of sample firms, whereas in columns 2 and 4 it is the firm-level sales share in total sales of sample firms. All regressions include time and industry times firm fixed effects and controls for the firm's number of products, capital over labor ratio, and value-added over revenue ratio. Standard errors are clustered at the firm level. Significance: *10 percent, **5 percent, ***1 percent.

Table 5 presents results from estimating equation (17) separately for exporters (Panel A) and non-exporters (Panel B) using firms' share of employment and revenue in the associated sample totals, respectively denoted by $\frac{L_{it}}{\sum L_{it}}$ and $\frac{P_{it}Q_{it}}{\sum P_{it}Q_{it}}$, as dependent variables. Firms being hit by import competition reduce their share of economic activity. According to the IV-results, a one-point increase in import competition that an exporting firm faces reduces its employment and revenue share by 0.8 and 1.3 percent, respectively. For non-exporters, those effects are larger, respectively with 1.2 and 2.5 percent. The key point is, however, that export opportunities leave non-exporting firms unaffected and exclusively increase exporters' employment and revenue shares. Hence, increasing foreign demand reallocates economic activity towards exporting firms, which are characterized by lower labor shares, higher labor market power, and higher output elasticities of labor. This offers a potential explanation for how international trade can contribute to the observed developments in the between firm components of the aggregate labor share and labor market power parameter. Note, that the reallocation of economic activity towards (highly productive) exporting firms also suggests a potential channel for aggregate productivity gains as described in Melitz (2003). This points to a trade-off between aggregate gains in terms of productivity and a lower aggregate labor share resulting from trade induced reallocation processes.

6. CONCLUSION

This article derives a parsimonious theory to shed light on potential mechanisms driving declining labor shares. The framework of this article offers three competing explanations for a fall in the labor share: an increase in firms' product market power, an increase in firms' labor market power, or a fall in firms' output elasticities of labor, which reflects a decreasing importance of labor in firms' production activities. While being based on a minimal set of assumptions, the applied framework explains 94% of observed variation in Germany's manufacturing sector labor share over the period 1995-2014.

Coinciding with the fall of the labor share, I document an increase in firms' product and labor market power. However, through the lens of this study's production side model, increasing product and labor market power can only account for 30% of the observed decline in the labor share. The remaining 70% are explained by a declining aggregate output elasticity of labor. Latter not only suggests a leading role for changing production processes in explaining the fall in Germanys' manufacturing sector labor share; but it also raises doubts on production models featuring constant output elasticities.

When analyzing potential causes, I find that increasing final product import competition and export demand cannot explain the secular change in the output elasticity of labor. This suggest that other factors cause its fall. However, foreign export demand (import competition) decreases (increases) firm-level labor shares by increasing (decreasing) labor market power within firms. Moreover, I find that an increase in foreign demand reallocates domestic economic activity towards large exporting firms, which are characterized by higher labor market power, higher labor productivity, and smaller labor shares.

Although the documented fall of Germanys' manufacturing sector labor share is mostly driven by changes in firms' production processes, the high and increasing level of aggregate labor market power suggests room for policies that can simultaneously increase aggregate economic output and labor's share of it. A recently discussed example for such a policy is an extension of current antitrust regulations, which mostly focus on market power in product markets, to also consider the effects of labor market power (Naidu et al. (2018)).

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ONLINE APPENDIX – NOT FOR PUBLICATION

Appendix A: Two models of labor market power

In this section I derive two examples on how labor market imperfections translate into labor market power that can be measured by wedges between wages and marginal revenue products of labor. I start with discussing a simple efficient bargaining model in which employees possess labor market power. Following this, I present a model of monopsonistic labor markets. In both models, labor market power materializes in wedges between wages and marginal revenue products of labor. For a combination of both models I refer the interested reader to Falch & Strøm (2007). Throughout this section, I heavily draw on Dobbelaere & Mairesse (2013).

Case 1: Employee-side labor market power – efficient bargaining model

Firms compete in imperfect product markets. As in Dobbelaere & Mairesse (2013), risk-neutral workers collectively bargain with the firm over wages (w_{it}) and employment (L_{it}). Ultimately, this coordination of labor supply, i.e. the absence of a competitive pool of workers that compete over firms' labor demand, will lead to employee-side labor market power.

Employees maximize their utility function, given by:

(A.1) $$U(w_{it}, L_{it}) = w_{it} L_{it} + (\bar{L}_{it} - L_{it})\bar{w}_{it} ,$$

where $\bar{w}_{it} \leq w_{it}$ is the reservation wage and $\bar{L}_{it}$ is the competitive employment level.

As in the main text, firms produce output using the production function:

(A.2) $$Q_{it} = Q_{it}(.) = Q_{it}(L_{it}, K_{it}, M_{it}, e^{\omega_{it}}).$$

Capital is a fixed production input. For mathematical convenience I assume that labor and intermediate inputs are both flexible. This will limit the source of labor market power to pure bargaining power within the Nash-bargaining process between firms and employees (e.g. due to the presence of unions). However, generally, one can additionally allow for inflexible contracts to create employee-side labor market power by defining that a part of the wage bill cannot be adjusted in the short-run.[26] With $R_{it} = P_{it}Q_{it}$ denoting revenue, this implies that firms maximize the following short-run objective function:

(A.3) $$\Pi_{it} = R_{it} - w_{it}L_{it} - z_{it}M_{it} \, ,$$

where z_{it} denotes the unit costs for intermediate inputs. Intermediate input markets are perfectly competitive. Thus, firms can unilaterally set M_{it} given z_{it} (this is not necessary but eases computation). Since employees collectively bargain with firms, wage and employment levels are decided from a bargaining game in which employees have some degree of bargaining power, denoted by $\phi_{it} \in [0,1]$. As shown in Dobbelaere & Mairesse (2013), the outcome of this bargaining is the generalized Nash-solution:

(A.4) $$\max_{w_{it}, L_{it}, M_{it}} (w_{it}L_{it} + (\bar{L}_{it} - L_{it})\bar{w}_{it})^{\phi_{it}}(R_{it} - w_{it}L_{it} - z_{it}M_{it})^{1-\phi_{it}}.$$

Maximization with respect to w_{it} and L_{it} gives:

(A.5) $$w_{it} = \bar{w}_{it} + \chi_{it}\left[\frac{R_{it} - w_{it}L_{it} - z_{it}M_{it}}{L_{it}}\right]$$

and

(A.6) $$w_{it} = MRPL_{it} + \phi_{it}\left[\frac{R_{it} - MRPL_{it}L_{it} - z_{it}M_{it}}{L_{it}}\right],$$

where $\chi_{it} = \frac{\phi_{it}}{1-\phi_{it}}$ denotes the relative extent of rent sharing. In this simple framework all the labor market power of the workforce is collected in ϕ_{it}. As equations (A.5) and (A.6) show, when employees possess positive bargaining power ($\phi_{it} > 0$),

[26] In such a framework, employee-side labor market power can for instance result from employees exploiting long contract durations or institutional dismissal protections to spend below efficient effort levels.

wages are above the marginal revenue product of labor. Note that equations (A.5) and (A.6) also nicely show that if firms can hire from a competitive pool of workers that do not coordinate their actions (i.e. a case where firms and workers do not bargain with each other), wages and marginal revenue products of labor will equalize. In that sense, the source of labor market power in the efficient bargaining model is the fact that firms are bound to hire workers from an organized community. This essentially constitutes a hiring friction (for more details please see McDonald & Solow (1981)).

Case 2: Employer-side labor market power – monopsonistic labor market

On a monopsonistic labor market firms set wages such that wages are below the marginal revenue product. To do so, firms need to face a labor supply curve that is imperfectly elastic (Dobbelaere & Mairesse (2013)). Imperfectly elastic labor supply curves are typically motivated by labor market frictions that prevent workers from a costless switching between many firms. Among others, such frictions include imperfect information, local preferences, or moving costs (Boal & Ransom (1997); Burdett & Mortensen (1998); Bhaskar and To (1999); Dobbelaere & Mairesse (2013)). In the following, I derive an expression showing how imperfectly elastic labor supply curves translate into labor market power that allows firms to pay wages below marginal revenue products of labor.

Firms produce output using the production function (A.2). Now, firms do not engage into a bargain with a community of workers. Instead, firms unilaterally set wages. Consequently, the firm's objective is to maximize the following version of equation (A.3):

(A.7) $$\max_{L_{it},\, M_{it}} \Pi_{it}(w_{it},\, z_{it},\, L_{it},\, M_{it}) = R_{it}(L_{it},\, M_{it}) - w_{it}(L_{it})L_{it} - z_{it}M_{it}.$$

Maximization with respect to labor gives:

(A.8) $$MRPL_{it} = w_{it} + \frac{\partial w_{it}}{\partial L_{it}} L_{it} = w_{it}(1 + \frac{1}{\varepsilon_{it}^{L}}).$$

where $\varepsilon_{it}^{L} \geq 0$ denotes the labor supply elasticity. After reformulating equation (A.8), one receives:

(A.9) $$\frac{\varepsilon_{it}^{L}}{1 + \varepsilon_{it}^{L}} MRPL_{it} = w_{it}.$$

Equation (A.9) shows that only if firms face an imperfectly elastic labor supply, unilateral wage setting of a firm will lead to wages that are below the marginal revenue product of labor. In the absence of adjustment frictions that give firms' labor market power, we will have $\varepsilon_{it}^{L} = \infty$ and $w_{it} = MRPL_{it}$.

Appendix B: Deriving a parameter for labor market distortions

First, I derive equation (3) from the main text, which measures the degree of firms' output market power. The key assumption to derive (3) as a measure of output market power is that intermediate input markets are competitive, i.e. that unit costs for intermediates equal marginal revenue products of intermediate inputs (De Loecker & Warzynski (2012)). Using the firms' production function (1), and the periodic cost function, $C(.) = r_{it}K_{it} + w_{it}L_{it} + z_{it}M_{it}$, where r_{it}, w_{it}, and z_{it} respectively denote the unit input costs for capital (K_{it}), labor (L_{it}), and intermediates (M_{it}), we can formulate the following Lagrangian:

(B.1) $$\mathcal{L}_{it} = r_{it}K_{it} + w_{it}L_{it} + z_{it}M_{it} + \lambda_{it}\big(Q_{it} - Q_{it}(.)\big),$$

As intermediate input markets are competitive, the following first order condition holds:

(B.2) $$z_{it} = \lambda_{it}\frac{\partial Q_{it}}{\partial M_{it}}.$$

where $\lambda_{it} = \frac{P_{it}}{\mu_{it}}$, with P_{it} and μ_{it} being the firm's output price and the firm's price setting output market power (De Loecker & Warzynski (2012)). Latter also refers to the markup when all variable input markets are (equally) competitive.[27] Expanding (B.2) with $\frac{M_{it}}{Q_{it}}$ and reformulating leads to equation (3) of the main text:

(3) $$\mu_{it} = \theta_{it}^{M} * \frac{P_{it}Q_{it}}{z_{it}M_{it}},$$

where $\theta_{it}^{X} = \frac{\partial Q_{it}}{\partial X_{it}}\frac{X_{it}}{Q_{it}}$ denotes the output elasticity of input $X = \{L, M, K\}$.

From equation (2) of the main text, i.e. from $(1 + \tau_{it}^{L}) = \frac{w_{it}}{MRPL_{it}}$, one can derive a similar expression. To see this, first use the assumption that intermediate input markets

[27] Obviously, it is up to the researcher to define which inputs are variable.

are competitive (which we also applied to derive (3) above). From that, we can expand (2) in the following way:

$$(B.3) \qquad (1+\tau_{it}^{L}) = \frac{w_{it}}{MRPL_{it}}\frac{MRPM_{it}}{z_{it}} = \frac{w_{it}}{MPL_{it} * MR_{it}}\frac{MPM_{it} * MR_{it}}{z_{it}},$$

where $MRPM_{it}$, MR_{it}, MPL_{it}, and MPM_{it} respectively denote the marginal revenue product of intermediates, the marginal revenue, the marginal product of labor and the marginal product of intermediates. Rewriting (B.3) and expanding with $\left(\frac{\frac{M_{it}}{Q_{it}M_{it}}}{\frac{L_{it}}{Q_{it}L_{it}}} = 1\right)$ gives:

$$(B.4) \qquad (1+\tau_{it}^{L}) = \frac{w_{it}}{z_{it}}\frac{\frac{\partial Q_{it}}{\partial M_{it}}\frac{M_{it}}{Q_{it}}}{\frac{\partial Q_{it}}{\partial L_{it}}\frac{L_{it}}{Q_{it}}} * \frac{L_{it}}{M_{it}} = \frac{w_{it}}{z_{it}}\frac{\theta_{it}^{M}}{\theta_{it}^{L}}\frac{L_{it}}{M_{it}}.$$

Expanding with $\frac{P_{it}Q_{it}}{P_{it}Q_{it}}$, substituting (3) into (B.4), and rearranging gives equation (4) of the main text:

$$(4) \qquad \mu_{it} = \theta_{it}^{L}\frac{P_{it}Q_{it}}{w_{it}L_{it}}(1+\tau_{it}^{L}),$$

which is equivalent to:

$$(B.5) \qquad \theta_{it}^{M} * \frac{P_{it}Q_{it}}{z_{it}M_{it}} = \theta_{it}^{L}\frac{P_{it}Q_{it}}{w_{it}L_{it}}(1+\tau_{it}^{L}).$$

Finally, rearranging yields equation (5) of the main text:

$$(5) \qquad \gamma_{it} \equiv \frac{1}{(1+\tau_{it}^{L})} = \frac{\theta_{it}^{L}}{\theta_{it}^{M}} * \frac{z_{it}M_{it}}{w_{it}L_{it}},$$

where γ_{it} denotes a measure of the firm's labor market power.

Appendix C: Firm characteristics and production function estimation results

TABLE C.1

SUMMARY STATISTICS FOR SAMPLE FIRMS

Variable	Mean (1)	Sd (2)	P25 (3)	Median (4)	P75 (5)	Observations (6)
Revenue labor share	0.31	0.12	0.22	0.30	0.39	177,957
Value-added share	0.77	0.24	0.64	0.76	0.88	177,957
Output elasticity of labor	0.28	0.10	0.21	0.28	0.35	177,957
Output elasticity intermediates	0.63	0.08	0.57	0.63	0.69	177,957
Output elasticity capital	0.11	0.06	0.07	0.10	0.14	177,957
Output market power parameter	1.09	0.14	1.00	1.07	1.16	177,957
Labor market power parameter	0.94	0.45	0.63	0.85	1.15	177,957
Deflated capital stock in thousands	26,400	124,000	2,370	6,492	19,600	177,957
Deflated intermediate input expenditures in thousands	25,500	118,000	2,446	6,293	19,000	177,957
Employees	220.11	621,41	47	91	209	177,957
Deflated capital per employee in thousands	95.72	95.56	38.16	68.56	119.41	177,957
Deflated intermediates per employee in thousands	87.23	66.99	41.79	68.06	110.92	177,957
Nominal value-added	14,200	59,500	1,981	4,367	11,600	177,957
Nominal revenue	41,500	18,600	4,760	11,300	32,200	177,957
Value-added over revenue	0.41	0.13	0.31	0.41	0.50	177,957
Average real wage	32,913	10,822	25,180	32,699	39,969	177,957
Log of real value-added per employee	16.32	1.39	15.26	16.16	17.22	177,957
Log of revenue weighted product market shares (euro-based)	0.96	1.91	-0.32	1.09	2.40	177,957
Log of firm price index	0.08	0.21	-0.01	0.06	0.19	177,957
Number of products	3.45	6.38	1	2	4	177,957
Export status dummy	0.76	0.43	1	1	1	177,957
Research & development dummy	0.26	0.44	0	0	1	177,957
Share of employment (sample firms)	0.000063	0.000172	0.000013	0.000026	0.000060	177,957
Share of revenue (sample firms)	0.000055	0.000240	0.000006	0.000015	0.000042	177,957
Import competition measure (firm-level)	1.47	4.98	0	0.02	0.53	177,957
Export opportunity measure (firm-level)	0.63	2.00	0	0.02	0.37	177,957

Notes: Table C.1 reports sample summary statistics. Columns 1, 2, 3, 4, 5, and 6 respectively report the mean, standard deviation, 25th percentile, median, 75th percentile, and the number of observations used to produce summary statistics for the respective variable.

TABLE C.2

PRODUCTION FUNCTION ESTIMATION: MEDIAN OUTPUT ELASTICITIES, BY SECTOR

Sector	Number of observations (1)	Intermediate inputs (2)	Labor (3)	Capital (4)	Returns to scale (5)
15 Food products and beverages	25,447	0.65	0.17	0.13	0.94
17 Textiles	7,629	0.66	0.32	0.20	1.17
18 Apparel, dressing, and dyeing of fur	2,930	0.72	0.21	0.11	1.03
19 Leather and leather products	1,672	0.66	0.27	0.13	1.08
20 Wood and wood products	6,163	0.65	0.21	0.08	0.96
21 Pulp, paper, and paper products	6,033	0.68	0.25	0.07	1.00
22 Publishing and printing	5,352	0.57	0.22	0.06	0.84
24 Chemicals and chemical products	12,705	0.69	0.25	0.10	1.06
25 Rubber and plastic products	13,415	0.65	0.24	0.10	0.96
26 Other non-metallic mineral products	12,122	0.62	0.29	0.12	1.04
27 Basic metals	8,457	0.66	0.32	0.08	1.04
28 Fabricated metal products	27,506	0.59	0.30	0.10	0.98
29 Machinery and equipment	29,109	0.60	0.37	0.11	1.07
30 Electrical and optical equipment	1,417	0.63	0.27	0.22	1.12
31 Electrical machinery and apparatus	11,409	0.62	0.30	0.11	1.03
32 Radio, television, and communication	3,070	0.61	0.30	0.08	0.99
33 Medical and precision instruments	7,863	0.57	0.35	0.10	1.02
34 Motor vehicles and trailers	6,823	0.66	0.31	0.13	1.09
35 Transport equipment	2,853	0.60	0.31	0.07	0.95
36 Furniture manufacturing	10,172	0.63	0.32	0.17	1.11
Across all industries	202,147	0.63	0.28	0.10	1.01

Notes: Table C.2 reports median output elasticities calculated after estimating the production function (10) for every NACE rev. 1.1 two-digit industry with sufficient observations. Column 1 reports the number of observations used to calculate output elasticities for each industry. Columns 2-4 respectively report median output elasticities for intermediate, labor, and capital inputs. Column 5 reports median returns to scale. All regressions control for time dummies.

TABLE C.3

PRODUCTION FUNCTION ESTIMATION:
AVERAGE OUTPUT ELASTICITIES, BY SECTOR

Sector	Number of observations (1)	Intermediate inputs (2)	Labor (3)	Capital (4)	Returns to scale (5)
15 Food products and beverages	25,447	0.65	0.17	0.13	0.95
		(0.10)	(0.07)	(0.06)	(0.08)
17 Textiles	7,629	0.65	0.32	0.20	1.17
		(0.10)	(0.08)	(0.12)	(0.15)
18 Apparel, dressing, and dyeing of fur	2,930	0.72	0.22	0.12	1.05
		(0.12)	(0.12)	(0.05)	(0.09)
19 Leather and leather products	1,672	0.66	0.27	0.13	1.06
		(0.10)	(0.07)	(0.04)	(0.10)
20 Wood and wood products	6,163	0.65	0.22	0.08	0.95
		(0.09)	(0.12)	(0.04)	(0.09)
21 Pulp, paper, and paper products	6,033	0.68	0.24	0.07	1.00
		(0.09)	(0.10)	(0.04)	(0.08)
22 Publishing and printing	5,352	0.57	0.21	0.06	0.84
		(0.07)	(0.09)	(0.03)	(0.09)
24 Chemicals and chemical products	12,705	0.69	0.25	0.10	1.03
		(0.08)	(0.06)	(0.05)	(0.10)
25 Rubber and plastic products	13,415	0.65	0.24	0.10	0.99
		(0.07)	(0.08)	(0.05)	(0.10)
26 Other non-metallic mineral products	12,122	0.62	0.29	0.12	1.04
		(0.07)	(0.06)	(0.06)	(0.09)
27 Basic metals	8,457	0.66	0.31	0.08	1.06
		(0.09)	(0.09)	(0.05)	(0.10)
28 Fabricated metal products	27,506	0.59	0.30	0.10	0.99
		(0.08)	(0.10)	(0.03)	(0.09)
29 Machinery and equipment	29,109	0.60	0.38	0.11	1.09
		(0.08)	(0.10)	(0.04)	(0.13)
30 Electrical and optical equipment	1,417	0.64	0.28	0.22	1.14
		(0.09)	(0.07)	(0.08)	(0.08)
31 Electrical machinery and apparatus	11,409	0.62	0.30	0.13	1.05
		(0.06)	(0.09)	(0.07)	(0.15)
32 Radio, television, and communication	3,070	0.62	0.31	0.08	1.01
		(0.06)	(0.12)	(0.04)	(0.12)
33 Medical and precision instruments	7,863	0.57	0.34	0.10	1.01
		(0.05)	(0.06)	(0.02)	(0.11)
34 Motor vehicles and trailers	6,823	0.66	0.31	0.14	1.11
		(0.08)	(0.09)	(0.08)	(0.13)
35 Transport equipment	2,853	0.61	0.30	0.07	0.97
		(0.10)	(0.06)	(0.03)	(0.07)
36 Furniture manufacturing	10,172	0.63	0.31	0.17	1.12
		(0.09)	(0.11)	(0.10)	(0.16)
Across all industries	202,147	0.63	0.28	0.11	1.03
		(0.09)	(0.11)	(0.06)	(0.13)

Notes: Table C.3 reports average output elasticities calculated after estimating the production function (10) for every NACE rev. 1.1 two-digit industry with sufficient observations. Column 1 reports the number of observations used to calculate output elasticities for each industry. Columns 2-4 respectively report average output elasticities for intermediate, labor, and capital inputs. Column 5 reports average returns to scale. Associated standard deviations are reported in brackets. All regressions control for time dummies.

Appendix D: Identifying moments and estimating the production function by OLS

The identifying moments of the main text are formally given by:

(D.1) $$E\big((\varepsilon_{it} + \xi_{it})\mathbf{Y}_{it}\big) = 0,$$

with

(D.2) $$\mathbf{Y}'_{it} = (J_{it}(.),\ A_{it-1}(.),\ T_{it-1}(.),\ g_{it-1}(.),\ \boldsymbol{z}_{it-1}),$$

where for convenience I defined:

$J_{it}(.) = (l_{it}, k_{it}, l_{it}^2, k_{it}^2,\ l_{it}k_{it}, G_{it}, D_{it}),$

$A_{it}(.) = (\ m_{it}, m_{it}^2, l_{it}m_{it}, k_{it}m_{it}, l_{it}k_{it}m_{it}, ms_{it}, \pi_{it}),$

$T_{it}(.) = \Big((l_{it}, k_{it}, l_{it}^2, k_{it}^2,\ l_{it}k_{it}, m_{it}, m_{it}^2, l_{it}m_{it}, k_{it}m_{it}, l_{it}k_{it}m_{it}) \times \pi_{it}\Big),$

$g_{it}(.) = \sum_{n=0}^{3}\sum_{w=0}^{3-b}\sum_{h=0}^{3-n-b}\ l_{it}^n\,k_{it}^b e_{it}^h$, and

$\boldsymbol{z}_{it} = (exp_{it}, IMP_{it}^{CHN}, ProdCount_{it}, w_{it}).$

The notation follows the main text. exp_{it}, IMP_{it}^{CHN}, $ProdCount_{it}$, and w_{it} respectively denote a dummy variable for export status, firm-level import competition (as defined in section 5 of the main text), the number of products a firm produces, and the average wage it pays.

The Wooldridge-estimator used in the main text is based on an instrumental-variable estimator where I instrument endogenous variables with their lags (see also Wooldridge (2009)). In my case, this refers to variables in $A_{it}(.)$ and $T_{it}(.)$. When estimating the production function by OLS (as below), I do not instrument those variables. In that case, $\mathbf{Y}'_{it}$ is given by:

(D.2) $$\mathbf{Y}'_{it} = (J_{it}(.),\ A_{it}(.),\ T_{it}(.),\ g_{it-1}(.),\ \boldsymbol{z}_{it-1}).$$

Figure D.1 presents median output elasticities and returns to scale for estimating the production function of the main text by OLS. As in the main text, I estimated the production function separately for every NACE rev. 1.1 two-digit industry.

TABLE D.1

MEDIAN OUTPUT ELASTICITIES WHEN USING OLS, BY SECTOR

Sector	Number of observations (1)	Intermediate inputs (2)	Labor (3)	Capital (4)	Returns to scale (5)
15 Food products and beverages	25,447	0.65	0.16	0.13	0.95
17 Textiles	7,629	0.67	0.31	0.19	1.17
18 Apparel, dressing, and dyeing of fur	2,930	0.73	0.21	0.11	1.03
19 Leather and leather products	1,672	0.67	0.27	0.12	1.08
20 Wood and wood products	6,163	0.66	0.21	0.07	0.96
21 Pulp, paper, and paper products	6,033	0.68	0.25	0.07	1.01
22 Publishing and printing	5,352	0.57	0.22	0.06	0.84
24 Chemicals and chemical products	12,705	0.70	0.24	0.10	1.06
25 Rubber and plastic products	13,415	0.67	0.23	0.10	0.97
26 Other non-metallic mineral products	12,122	0.63	0.29	0.12	1.04
27 Basic metals	8,457	0.67	0.31	0.07	1.04
28 Fabricated metal products	27,506	0.60	0.30	0.09	0.99
29 Machinery and equipment	29,109	0.62	0.36	0.11	1.08
30 Electrical and optical equipment	1,417	0.63	0.30	0.22	1.17
31 Electrical machinery and apparatus	11,409	0.63	0.30	0.11	1.03
32 Radio, television, and communication	3,070	0.60	0.31	0.08	1.00
33 Medical and precision instruments	7,863	0.57	0.35	0.10	1.01
34 Motor vehicles and trailers	6,823	0.68	0.30	0.13	1.09
35 Transport equipment	2,853	0.61	0.30	0.06	0.96
36 Furniture manufacturing	10,172	0.65	0.31	0.16	1.10
Across all industries	202,147	0.64	0.28	0.10	1.02

Notes: Table D.1 reports median output elasticities calculated after estimating the production function (10) for every NACE rev. 1.1 two-digit industry with sufficient observations by OLS. Column 1 reports the number of observations used to calculate output elasticities for each industry. Columns 2-4 respectively report median output elasticities for intermediate, labor, and capital inputs. Column 5 reports median returns to scale. All regressions control for time dummies.

Note the close similarity between estimates reported in Tables D.1 and C.1. In fact, this implies that the endogeneity problem based on the dependence of firms' flexible input decision on the unobserved innovation in productivity is negligible in my case (after conditioning on all the variables in $B_{it}(.)$ and $g_{it-1}(.)$).

Table D.2 compares summary statistics for the variables of interest, one time derived from the baseline specification of the production function estimation, which I used in the main text, and one time from the specification where I estimated the production function by OLS. I report the former in Panel A and the latter in Panel B of Table D.2.

Given the results from Table D.1, it is unsurprising that there are only minor differences between both.

TABLE D.2

SUMMARY STATISTICS FOR SAMPLE FIRMS,
BASELINE SPECIFICATION VS. OLS

Panel A: Baseline specification	Mean (1)	Sd (2)	P25 (3)	Median (4)	P75 (5)	Observations (6)
Revenue labor share	0.31	0.12	0.22	0.30	0.39	177,957
Value-added share	0.77	0.24	0.64	0.76	0.88	177,957
Output elasticity of labor	0.28	0.10	0.21	0.28	0.35	177,957
Output market power parameter	1.09	0.14	1.00	1.07	1.16	177,957
Labor market power parameter	0.94	0.45	0.63	0.85	1.15	177,957

Panel B: OLS	Mean (1)	Sd (2)	P25 (3)	Median (4)	P75 (5)	Observations (6)
Revenue labor share	0.31	0.13	0.22	0.30	0.39	177,874
Value-added share	0.77	0.24	0.64	0.76	0.88	177,874
Output elasticity of labor	0.28	0.10	0.21	0.28	0.35	177,874
Output market power parameter	1.11	0.14	1.01	1.09	1.18	177,874
Labor market power parameter	0.90	0.41	0.61	0.82	1.10	177,874

Notes: Table D.2 reports sample summary statistics for selected variables. Panel A reports statistics for the baseline specification of the main text, whereas Panel B reports statistics for the specification using an OLS-estimator to estimate the production function. Columns 1, 2, 3, 4, 5, and 6 respectively report the mean, standard deviation, 25th percentile, median, 75th percentile, and the number of observations used to produce summary statistics for the respective variable.

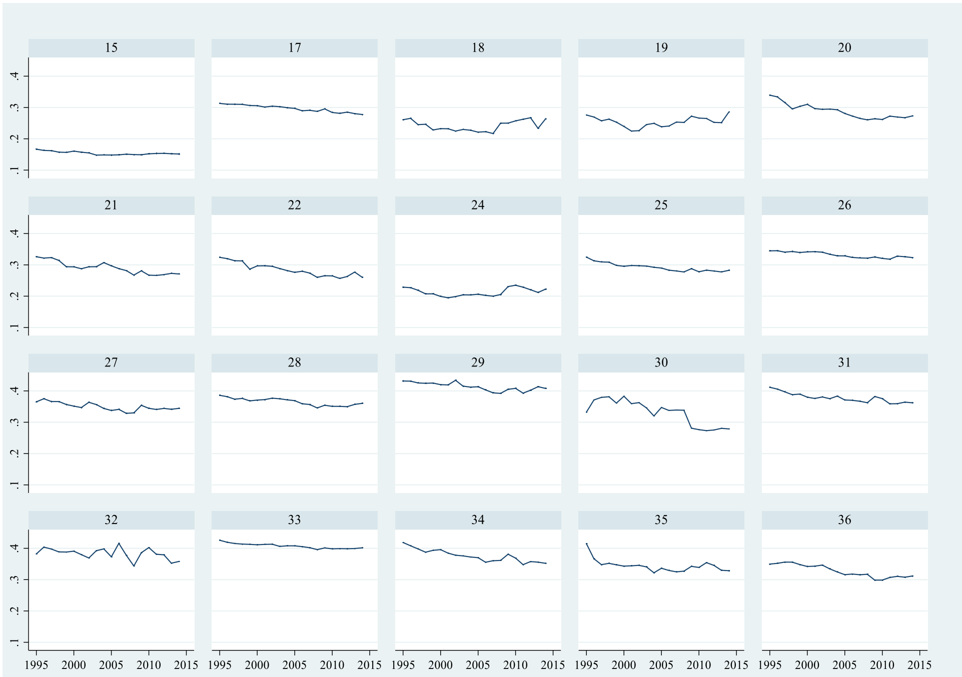
Appendix E: Two-digit industry-level changes of output elasticities

The main text shows the evolution of the aggregate output elasticity of labor and documents a clear time trend for this variable over a period of two decades. This raises doubts on the frequently applied assumption of constant output elasticities (as in many Cobb-Douglas production models) and implies a (potential) bias in estimates of total factor productivity, markups, or misallocation measures when deriving such measures from a framework featuring constant output elasticities of production factors. However, one argument in favor of the constant output elasticity assumption could be that output elasticities are constant at the sector level and that changes in aggregate output elasticities are driven by reallocation processes of economic activity between sectors. In that case, estimating a typical Cobb-Douglas production function for each industry separately would be valid.

To present evidence against this argument, Figures E.1, E.2, and E.3 respectively document the evolution of labor, capital, and intermediate input output elasticities at the two-digit sector level over the years 1995-2014. As can be immediately seen, labor output elasticities display a negative time trend across all 20 two-digit industries investigated in this study. With exception of industry 30 (electrical and optical equipment), changes in capital output elasticities (Figure E.2) are small. Thus, the assumption of constant output elasticities of capital at the two-digit industry-level is approximately fulfilled for most two-digit industries in the German manufacturing sector for the period 1995-2014. In contrast, I find a clear positive trend for output elasticities of intermediates. Besides being further evidence against a production model with time constant output elasticities, this implies an increasing importance of intermediate inputs in the production activities of German manufacturing firms. This is consistent with an increasing tendency of German firms to offshore or outsource production activities (e.g. Sinn (2006); Wang, Wei, Yu, & Zhu (2016)).

The increased importance of intermediate inputs relative to labor and capital naturally implies a reallocation of revenue shares away from labor and capital towards intermediate inputs. This decreases the revenue wage share even in the presence of competitive factor and product markets. Note, however, that if the relative importance of capital and labor in firms' production activities, as well as firms' labor and product market power would stay constant, value-added labor shares would be unaffected from the relative increase in the importance of intermediate input. Yet, this is not the case. From the relative evolution of labor and capital output elasticities we know that the importance of capital in firms' production activities relative to labor increased. Hence, even on counterfactually competitive markets, industry-level gross output labor shares should have decreased relative to capital shares. Equations (6) and (7) of the main text show that we can transfer this conclusion directly to the value-added based factor shares. This also suggests that the increase in the importance of intermediate inputs in firms' production processes led to a substitution of labor for intermediate inputs. This is in line with the common notion that outsourced activities are typically labor-intensive (e.g. Sinn (2006); Goldschmidt & Schmieder (2017)).

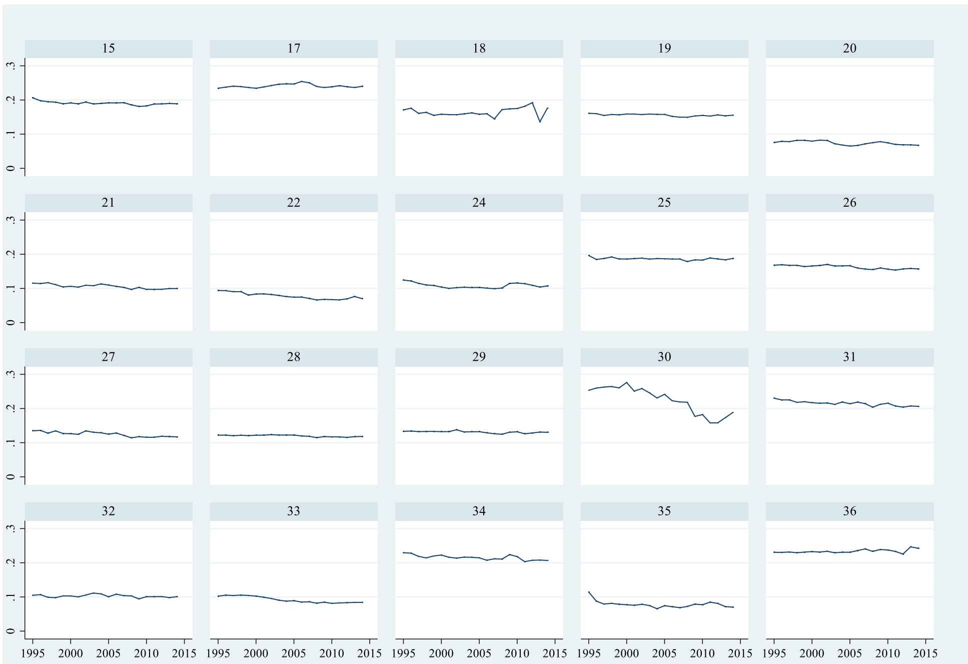
OUTPUT ELASTICITY OF LABOR, TWO-DIGIT SECTORS



Year

FIGURE E.1 – Weighted averages of output elasticities of labor separately for two-digit industries. Sample firms.

OUTPUT ELASTICITY OF CAPITAL, TWO-DIGIT SECTORS



Year

FIGURE E.2 – Weighted averages of output elasticities of capital separately for two-digit industries. Sample firms.

OUTPUT ELASTICITY OF INTERMEDIATES, TWO-DIGIT SECTORS

FIGURE E.3 – Weighted averages of output elasticities of intermediate inputs separately for two-digit industries. Sample firms.

Appendix F: First stage regressions for IV-specifications

Table F.1 reports the first stage regression results for the IV-specification results documented in Table 3 of the main text. Note that the first stage is identical for all IV-regressions included in Table 3 of the main text. Therefore, Table F.1 reports only one regression for each endogenous variable. I denote the firm-level instrument variables for my import competition and export demand measures respectively by IMS_{it}^{INS} and EXS_{it}^{INS}.

TABLE F.1

FIRST STAGE REGRESSION RESULTS
FOR TABLE 3 OF THE MAIN TEXT

	IMP_{it-1}^{CHN} (1)	EXP_{it-1}^{CHN} (2)
IMS_{it-1}^{INS}	0.268***	0.0106***
	(0.0102)	(0.00186)
EXS_{it-1}^{INS}	-0.0523***	0.152***
	(0.00704)	(0.0108)
Firm x Industry FE	YES	YES
Time FE	YES	YES
Firm-level controls	YES	YES
Observations	114,060	114,060
R-squared	0.919	0.758
Number of firms	22,638	22,638

Notes: Table F.1 reports results from the first stage regressions when estimating equation (17) by IV. The dependent variable in column 1 is the lagged import competition measure, while in column 2 it is the lagged export opportunity measure. All regressions include time and industry times firm fixed effects and controls for lagged values of the firm's number of products, capital over labor ratio, and value-added over revenue ratio. Standard errors are clustered at the firm level. Significance: *10 percent, **5 percent, ***1 percent.

Table F.2 reports the first stage regression results for the IV-specification results documented in Table 5. In contrast to Table 3, Table 5 is based on two distinct samples. One is a sample of exporting firms, while the other is a sample of non-exporting.

TABLE F.2

FIRST STAGE REGRESSION RESULTS
FOR TABLE 5 OF THE MAIN TEXT

	Exporters		Non-Exporters	
	IMP_{it-1}^{CHN} (1)	EXP_{it-1}^{CHN} (2)	IMP_{it-1}^{CHN} (3)	EXP_{it-1}^{CHN} (4)
IMS_{it-1}^{INS}	0.273***	0.0102***	0.216***	0.00651
	(0.0112)	(0.00192)	(0.0271)	(0.00541)
EXS_{it-1}^{INS}	-0.0527***	0.156***	-0.0617	0.0951**
	(0.00630)	(0.0111)	(0.0391)	(0.0370)
Firm x Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Firm-level controls	YES	YES	YES	YES
Observations	88,787	88,787	23,556	23,556
R-squared	0.922	0.755	0.908	0.805
Number of firms	17,066	17,066	6,068	6,068

Notes: Table F.2 reports results from the first stage regressions when estimating equation (17) separately for exporting and non-exporting firms by IV. The dependent variable in columns 1 and 3 is the lagged import competition measure, while in columns 2 and 4 it is the lagged export opportunity measure. All regressions include time and industry times firm fixed effects and controls for lagged values of the firm's number of products, capital over labor ratio, and value-added over revenue ratio. Standard errors are clustered at the firm level. Significance: *10 percent, **5 percent, ***1 percent.

Appendix G: Covariance between firms' employment share and variables of interest

Figure G.1 plots the between firm term from the decomposition exercise of the main text, when defining firms' share of economic activity in terms of their share of employment in total employment (of sample firms). As can be seen, the general picture regarding the relationship between firm size and the variables of interest remains unchanged, i.e. larger firms in terms of employment are characterized by higher levels of labor market power, lower levels of product market power, higher output elasticities of labor, and smaller labor shares. Note that the time trends of the between firm terms are also unaffected when using employment weights to define firms' share of economic activity.

COVARIANCE BETWEEN FIRM SIZE AND VARIABLES OF INTEREST,
USING EMPLOYMENT WEIGHTS

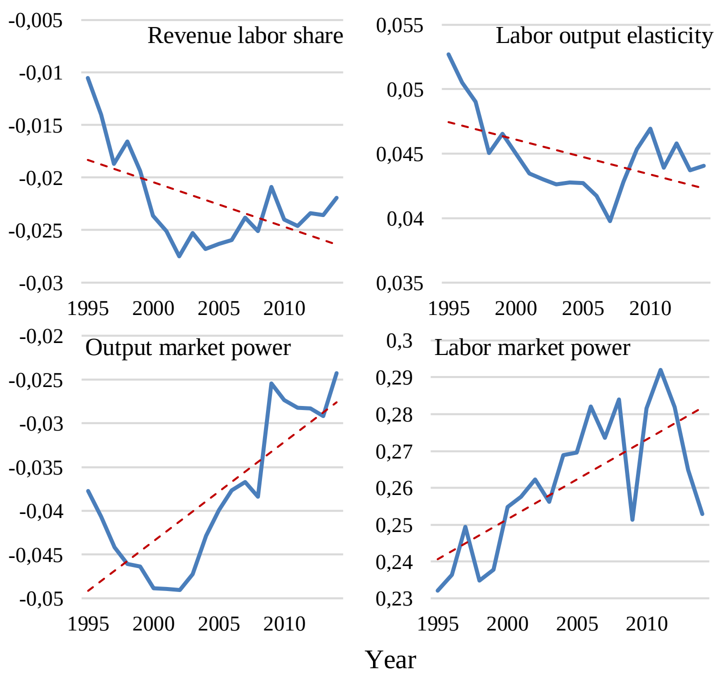


FIGURE G.1 – Covariance between firms' share in economic activity and firm-level labor shares, output elasticities of labor, output market power parameters, and labor market power parameters, when defining firms' share of economic activity as the employment share in total employment. Red dashed lines show trends. Germany's manufacturing sector. Sample firms.

Appendix H: Using constant product mix information to aggregate product-level trade measures

One potential threat to my instrumental variable strategy is that firms might adjust their product mix in expectation of changing foreign import competition or export demand. In that case, weighting product-level trade flows with their importance to the firm before aggregating them introduces an endogeneity problem. To address this issue, I construct new instruments relying exclusively on firms' first observed product portfolio when weighting product-level trade flows. Using these new weights eliminates variation in my instruments from endogenous product mix adjustments when estimating the effects of international trade on my outcomes of interest.

TABLE H.1

LABOR SHARES, MARKET POWER PARAMETERS, LABOR OUTPUT ELASTICITIES, AND INTERNATIONAL TRADE, USING INSTRUMENTS BASED ON FIRMS' FIRST PRODUCT PORTFOLIO

	IV			
	LS_{it} (1)	θ_{it}^{L} (2)	μ_{it} (3)	γ_{it} (4)
IMP_{it-1}^{CHN}	0.00250** (0.00100)	-0.00168* (0.000896)	-0.00020 (0.000338)	-0.00463*** (0.00107)
EXP_{it-1}^{CHN}	-0.00565** (0.00287)	0.00329 (0.00204)	0.00019 (0.000949)	0.00756*** (0.00279)
Firm x Industry FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Firm-level controls	YES	YES	YES	YES
Observations	107,765	107,765	107,765	107,765
R-squared	0.914	0.951	0.899	0.937
First-stage F-test	75.17	75.17	75.17	75.17
Number of firms	21,289	21,289	21,289	21,289

Notes: Table H.1 reports results from estimating equation (17) by IV using newly constructed instruments based on firms' first observed product portfolio. The dependent variables in columns 1-4 respectively are the revenue labor share, the output elasticity of labor, the output market power parameter, and the labor market power parameter. All regressions include time and industry times firm fixed effects and controls for the firm's, capital over labor ratio, value-added over revenue ratio, and number of products. Standard errors are clustered at the firm level. Significance: *10 percent, **5 percent, ***1 percent.

Tables H.1 and H.2 report IV-results from estimating equation (17) using the newly constructed instruments. The structure follows the main text. I do not report OLS-results, however, as I apply the new weighting procedure exclusively to the instrumental variables. In comparison with the main text, one finds that results reported in Tables H.1 and H.2 are qualitatively similar to the baseline results. Yet, there are two effects that are statistically insignificant when using the baseline specifications, while becoming statistically significant at the 10-percent level when using the new instruments.

First, I find a negative effect of import competition on firms' output elasticity of labor when using the new instruments. However, given its imprecise estimation and its small value compared to the fall of the aggregate within firm output elasticity of labor, one should interpret the coefficient on θ_{it}^{L} with caution.

Second, I find a positive effect of export demand from China on non-exporting firms' sales share in total sales of sample firms when using the new instruments. In Table 5 of the main text, one can see that the OLS-specification estimates a similar coefficient. Yet, as it is only statistically significant at the 10-percent level, one should not interpret too much into it. That being said, a plausible explanation for this positive effect is that some non-exporting firms enter the export market in response to growing foreign demand, leading to an increase in their sales share in total sales of sample firms.

TABLE H.2

INTERNATIONAL TRADE AND THE REALLOCATION OF ECONOMIC ACTIVITY, USING INSTRUMENTS BASED ON FIRMS' FIRST PRODUCT PORTFOLIO

Panel A: Exporter	IV	
	$\frac{L_{it}}{\sum L_{it}}$	$\frac{P_{it}Q_{it}}{\sum P_{it}Q_{it}}$
	(1)	(2)
IMP_{it-1}^{CHN}	-0.00937***	-0.0149***
	(0.00187)	(0.00228)
EXP_{it-1}^{CHN}	0.0177***	0.0281***
	(0.00455)	(0.00591)
Firm x Industry FE	YES	YES
Time FE	YES	YES
Firm-level controls	YES	YES
Observations	83,987	83,987
R-squared	0.982	0.981
First-stage F-test	65.98	65.98
Number of firms	16,065	16,065

Panel B: Non-exporter	IV	
	$\frac{L_{it}}{\sum L_{it}}$	$\frac{P_{it}Q_{it}}{\sum P_{it}Q_{it}}$
	(1)	(2)
IMP_{it-1}^{CHN}	-0.0186***	-0.0314***
	(0.00525)	(0.00757)
EXP_{it-1}^{CHN}	0.0211	0.0510*
	(0.0209)	(0.0287)
Firm x Industry FE	YES	YES
Time FE	YES	YES
Firm-level controls	YES	YES
Observations	22,165	22,165
R-squared	0.979	0.980
First-stage F-test	16.64	16.64
Number of firms	5.692	5.692

Notes: Table H.2 reports results from estimating equation (17) by IV using newly constructed instruments based on firms' first observed product portfolio. The dependent variable in columns 1 and 2 respectively is the firm-level employment share in total employment of sample firms and the firm-level sales share in total sales of sample firms. All regressions include time and industry times firm fixed effects and controls for the firm's number of products, capital over labor ratio, and value-added over revenue ratio. Standard errors are clustered at the firm level. Significance: *10 percent, **5 percent, ***1 percent.

Appendix I: Calculation of the capital stock

The following approach closely follows the Appendix of Bräuer, Mertens, & Slavtchev (2019), who, similar to Müller (2008), use information on the expected lifetime of capital goods to calculate an industry- and time-specific depreciation rate of capital. Having calculated this depreciation rate, one can use a perpetual inventory method to calculate a capital stock series for every firm in the data:

(I.1) $$K_{it} = K_{it-1}\left(1 - \alpha_{jt-1}\right) + I_{it-1},$$

where K_{it}, α_{jt}, and I_{it} respectively denote the capital stock, the depreciation rate of capital in industry j, and investment. I will now explain how to derive an expression for α_{jt}.

The statistical office of Germany supplies information on the expected lifetime of capital goods bought in period t, separately for buildings and equipment. As everything what follows is equivalent for both types of capital goods, let us abstract from different capital good types and denote the expected lifetime of any capital good bought in period t simply by D_t. Let us further assume that the depreciation rate of a capital good stays constant throughout its lifetime. Hence, the average (or expected) lifetime of a capital stock bought in period $t = 0$ can be defined as:

(I.2) $$D_0 = \frac{1}{K_0}\sum_0^\infty (\alpha K_t)t,$$

where the sum is taken over all periods t. αK_t denotes the amount of depreciated capital in period t. Assuming a linear capital depreciation, consistent with (I.1), implies: $K_t = K_0(1 - \delta_0)^t$. Substituting this into (I.2) and switching to continuous time gives:

(I.3) $$D_0 = \frac{1}{K_0}\int_0^\infty (\alpha K_0(1 - \alpha)^t)t\, dt.$$

After rearranging we have:

(I.4)
$$D_0 = \alpha \int_0^{\infty} (1-\alpha)^t t \, dt.$$

Using partial integration gives:

(I.5)
$$D_0 = \alpha \left[\frac{(1-\alpha)^t}{\ln(1-\alpha)} t \right]_0^{\infty} - \alpha \int_0^{\infty} \frac{(1-\alpha)^t}{\ln(1-\alpha)} dt.$$

Note that the first term on the right-hand side of (I.5) equals zero because $0 < \alpha < 1$. Integrating the remaining expression gives:

(I.6)
$$D_0 = \frac{\alpha}{\ln(1-\alpha) * \ln(1-\alpha)}.$$

Given that the expected lifetime, D_0, is known, (I.6) can be solved numerically.

Recap that the statistical office reports the expected lifetime of capital goods separately for buildings and equipment. Hence, I calculate a separate depreciation rate for each of those capital good types. To receive a single industry-specific depreciation rate, I weight the depreciation rates for buildings and equipment respectively with the industry-level share of building capital in total capital and equipment capital in total capital and sum up (this information is also supplied by the statistical office). For the practical implementation, I assume that the depreciation rate of a firm's whole capital stock equals the depreciation rate of newly purchased capital. Thus, for every industry and year I compute:

(I.7)
$$\alpha_{jt} = \alpha_{jt}^{Build} \frac{K_{jt}^{Build}}{K_{jt}} + \alpha_{jt}^{Equip} \frac{K_{jt}^{Equip}}{K_{jt}},$$

where the superscript indicates whether the variable refers to a building or equipment specific variable. K_{jt}^{Build}, K_{jt}^{Equip}, and $K_{jt} = K_{jt}^{Build} + K_{jt}^{Equip}$ respectively denote the total building capital stock, the total equipment capital stock, and the total capital stock of an industry j in period t. Having calculated this depreciation rate, I use equation (I.1) to calculate firm-specific capital series.

To calculate the first capital stock of every capital series, I divide the reported tax depreciation (given in my data) by the depreciation rate. I do not use the tax depreciation variable in my law of motion because reported tax depreciations vary due to state induced tax incentives and, thus, do not necessary reflect the true amount of depreciated capital (e.g. House & Shapiro (2008)). Given that firms likely report too high values of depreciated capital due to such incentives, the first capital stock in each of my capital series is likely an overestimate of the true capital stock used in the firm's production activities. Over longer periods, however, observed investment decisions gradually receive a larger weight in the estimated capital stocks. This should mitigate the impact of the first capital stock over time. Given that I estimate very reasonable output elasticities for capital (see the online Appendix C), I am confident that my capital variables reliably reflect firms' true capital stocks.[28]

[28] Given that firms likely overstate their capital depreciation, my capital stocks are likely a closer approximation of the true capital stock used in firms' production activities than existing capital measures based on book values.

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