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The anatomy of costs and firm performance: Evidence from Belgium ⋆

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ABSTRACT

We separately observe variable input expenditure and expenditure on fixed inputs and overhead in novel firm-level data covering the Belgian manufacturing sector over the last decades. This permits a deeper investigation of two potential drivers of the globally observed widening gap between firms' revenue and variable input expenditure: *technology* and *market power*. Across the board, cost structures have become less reliant on variable input expenditure over time, while expenditure on fixed inputs and overhead costs have increased in prominence. We relate these changes in firms' cost structures to performance measures and document that markups and gross profit ratios increase substantially as the role of variable costs in production diminishes. Profit ratios net of fixed input expenditure also increase, but by substantially less than gross profit ratios. Our results suggest that technological change can explain a considerable portion of the widening gap between revenue and variable input expenditure, but that markups increase by somewhat more than necessary to break even. Moreover, this phenomenon operates remarkably similarly across different firms and industries.

1. Introduction

A growing number of studies report secular trends in measures of firm performance, including increased markups and profits, across a wide range of industries and countries.[1] How to interpret these facts remains the topic of research, as it is challenging to disentangle the two leading explanations behind an increase in the sales-to-variable input expenditure ratio: changes in *technology* versus changes in *market power*. It is difficult to attribute patterns to these two forces because they are not mutually exclusive and

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[1] See, for instance, De Loecker et al. (2020) and Autor et al. (2020) for the US, and De Loecker and Eeckhout (2018) for a global analysis using listed companies. Syverson (2019) and Miller (2025) provide overviews of the literature.

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potentially interconnected.[2] While the separate identification of these sources requires specifying a model of firm heterogeneity and taking it to the data, an equally important challenge is measurement. More specifically, separately measuring variable costs and expenditure on fixed inputs or overhead costs – beyond the classic labor capital distinction.[3] This measurement is critical to the estimation of markups and, therefore, the separation of market power from technological change, and ultimately matters for a host of policy questions.[4]

Measuring variable input expenditure is challenging as accounting measures often conflate variable and fixed or overhead costs. In the classic setup, a firm produces output using variable inputs (*labor* and *intermediates*). Financial statements routinely measure such variable expenditure by the Cost of Goods Sold (COGS). In addition, output depends on quasi-fixed inputs (*capital*), and firms potentially incur expenses not directly related to output – overhead or fixed costs.[5] Such fixed costs and overhead expenditure typically fall under Selling, General, and Administrative expenses (SG&A) in financial statements.[6] In practice, however, the COGS/SG&A distinction does not perfectly separate variable and fixed or overhead costs (Syverson, 2019; Shapiro and Yurukoglu, 2024). In particular, COGS often contains fixed or overhead expenditure.[7] A similar phenomenon exists outside of financial statements based on the Generally Accepted Accounting Principles (GAAP), with intermediate inputs typically capturing both variable and non-variable costs. This bundling of variable and fixed costs, hampers markup estimation and the study of underlying causes of aggregate trends in firm performance (De Loecker and Syverson, 2022).

This article is concerned with separately measuring variable factors of production and fixed or overhead factors. We do this in the context of rich firm-level data covering the Belgian manufacturing sector from 1985 to 2016. In particular, we utilize a convenient feature of the Belgian data: we observe a breakdown of manufacturers' intermediate input expenditure into *goods* and *services*. Goods measures purchases of raw materials and consumables, while services consists of the purchase of fixed or overhead factors and all other goods. This split of the total intermediate input bundle allows us to delve into the potential technology and market power channels by distinguishing the role of variable and non-variable production costs. We describe the use of services and the increase of their relative importance in the production process over several decades, and relate these changes to a host of measures of firm performance, including the markup of price over marginal cost and profitability.

We estimate markups and generate several cost measures and profit ratios. Markups of price over marginal cost are obtained using the production approach (De Loecker and Warzynski, 2012), where a considerable advantage of our data is the existence of a variable input: goods. We estimate output elasticities using a cost share approach where technology is assumed constant at the 3-digit-industry-by-year level to accommodate technological differences in the cross section and over time. COGS – the sum of expenditure on labor and intermediate inputs – is split into a variable component containing labor and goods that we call VCOGS, and services. VCOGS and services, therefore, split COGS into variable and non-variable input expenditure. We construct a gross profit ratio that does not take into account services expenditure, while a net profit ratio is based on total costs – including overhead expenditure captured by services.

Our starting point is that markups have increased over the past decades, like in the US and many other countries. In addition, the ratio of revenue to total cost has increased, but by less than markups, suggesting that variable production factors have become less important over time. A researcher who observed only a split of input expenditure into COGS and SG&A would not observe this divergence, as markups estimated under the assumption that all components of COGS are variable trend similarly to the net profit ratio. Moreover, the COGS cost share, typically interpreted as the importance of variable costs in total costs, is stable over time. As noted, certain elements of COGS do not correspond to variable input expenditure. Our data allows us to separate common measure of variable input expenditure into variable and non-variable components and to explain the apparent contradiction between the increasing markup-profitability gap and the stable COGS share.

We show that the stable COGS share obscures a substantial change in firms' cost structures over time, as the VCOGS share smoothly trends down while the services share smoothly trends up over the past decades. While more pronounced in the top percentiles of the cost share distributions, these patterns are present in their entire distributions, making them remarkably general. These secular trends cannot be explained by between-industry differences or entry and exit, as firms substitute services for variable inputs over time. An important implication is that researchers who only observe a bundle of intermediate inputs, or COGS, rather than a breakdown into variable and non-variable input expenditure potentially miss the required information to study markups and technology, or at least are confronted with this complication.

The changing cost structure of firms is linked to changes in firm performance. In particular, both markups and gross profit ratios substantially increase as firms' services cost shares rise and their variable cost shares decrease. Simultaneously, we observe increased services costs and decreased variable costs. Net profit ratios, which take into account services expenditure, also grow, suggesting

[2] In particular the work of Sutton (1991), and see De Loecker et al. (2021) for a structural analysis permitting to identify the specific role of technology and market power in the US economy.

[3] See De Loecker and Syverson (2022) for a discussion on measuring inputs in production. Foster et al. (2022) focus on the measurement of production technology.

[4] For instance, the appropriate response of antitrust policy to aggregate markup and concentration trends. See Shapiro and Yurukoglu (2024) for a discussion.

[5] The distinction between quasi-fixed inputs and factors of fixed cost depends on the time horizon, of course, and it greatly varies across production processes.

[6] A prominent example of a firm-level dataset that uses this distinction is Compustat.

[7] For instance, Grieco et al. (2024) report that large automobile manufacturers sometimes report all operating expenses as COGS, even though they report fixed costs as being important in their operations.

that firms increase markups by more than would occur in a perfectly competitive manufacturing sector. However, net profit ratios increase only somewhat. Therefore, an important driver of markup growth appears to be the changing cost structure of firms. Note that our results are related to, but distinct from results linking increased SG&A spending to increased markups (e.g., De Loecker et al. (2020)), although our services measure might also contain some components of SG&A.[8]

Detailed survey data allows us to further decompose the reported intermediate services bundle into specific cost items from the years 2008 to 2016. The *Enquête Structurelle des Entreprises* (ESE) separately reports firm-level expenditure on (i) external labor, (ii) gifts, (iii) insurances, (iv) rent, and (v) software. As a share of overall services expenditure, external labor and rent are by far the most pronounced of the five types of expenditure. Nonetheless, the shift from variable to fixed expenditure that occurs as overall services expenditure becomes more important in firms' cost structures is not observed for external labor or rent, and the resulting increase in markups is only minor. Moreover, the sum of expenditure on all five ESE elements corresponds to, on average, 18 percent of total services expenditure. While labor outsourcing and information technology have received much attention in recent academic work, they do not appear to be able to explain the secular changes in cost structures and firm performance that we observe.[9]

We make three main contributions thanks to our observed split of intermediates into variable and non-variable costs. First, we demonstrate a secular shift towards services and away from variable inputs, and this across a wide range of sectors over several decades.[10] Second, we show evidence consistent with technological change being an important mechanism behind aggregate changes in markups and profitability. Finally, we show that labor outsourcing and expenditure on information technology are unlikely candidates to entirely explain these secular trends. Our overall contribution is to provide evidence that certain aspects of technological change appear to operate quite similarly throughout the manufacturing sector and that these secular changes are linked to markups and profitability. Moreover, our findings raise concerns for researchers who only observe bundled expenditure measures that conflate variable and non-variable expenditure and who wish to study markups and technology. To pinpoint the relative importance of different mechanisms underlying markup changes, a model of firm behavior is required, which is the topic of other work (e.g., De Loecker et al. (2021)).

Our work is related to research on technology, markups, and profitability beyond that cited above. In particular, we are interested in the age-old question of whether market outcomes are efficient or not – e.g., due to barriers to entry and lack of competition or economies of scale and firm heterogeneity.[11] In Sutton's (1991) theory of endogenous sunk costs, all these factors are determined jointly in equilibrium based on firms' investment decisions. Because services contain overhead costs and because markups increase with firms' reliance on services, such services could represent an endogenous response of firms to their competitive environment in line with Sutton's ideas.

Fixed costs and markups are studied in several recent articles. De Loecker et al. (2020) show that the rise in markups seems to go hand in hand with a rise in fixed production costs as captured by Selling, General, and Administrative (SG&A) expenses. De Ridder (2024) estimates fixed costs from the gap between markups and profitability and finds that cost structures have become more reliant on fixed costs over the last decades in the US and France, which can be explained by a model where firms invest in marginal-cost-reducing intangible inputs that come at a fixed cost.[12] Using Belgian data, Abraham et al. (2024) utilize a Solow-residual-based approach to estimate input-specific shares of fixed costs in total expenditure and argue that markups primarily reflect the need to cover fixed costs rather than excess profit. We contribute by providing data-based, rather than model-based, measures of changing cost structures over time.

The evolution of market power in particular industries is studied for airlines (Bet, 2021), automobile manufacturing (Grieco et al., 2024), beer (De Loecker and Scott, 2016), cement (Miller et al., 2023), consumer packaged goods (Döpper et al., 2022), steel (Collard-Wexler and De Loecker, 2015), and wholesaling (Ganapati, 2025). Miller (2025) surveys these and other industry studies and concludes that technological change is an important driver of long-run economic outcomes in most industries, although the particulars of such technological change appear industry-specific. We show that a shift in production away from variable inputs and towards services occurs over several decades in the entire manufacturing sector in Belgium, suggesting that some aspects of technological change operate broadly in the economy.[13]

Finally, we speak to a discussion of which input to use as variable input when estimating markups using the approach of De Loecker and Warzynski (2012). De Loecker et al. (2020) resort to COGS as it is the only measure that is available for several decades in the US.

[8] In the baseline analysis we treat services as overhead. Ultimately, services are a bundle of both fixed and overhead factors so we also provide results assuming that services are a fixed input and, hence, enter the production function. Our main results are not affected by this distinction although, of course, the interpretation of certain variables is.

[9] For an in-depth analysis of the components of external labor costs see Antonecchia et al. (2024). Grossman and Helpman (2005) and Bilal and Lhuillier (2021) focus on outsourcing, and Bloom et al. (2012) on software.

[10] This project draws from preliminary facts presented in De Loecker et al. (2018) using the observed split of intermediates into goods and services. They show distinct markup patterns depending on whether one relies on goods or the bundle of intermediates as variable input in the approach of De Loecker and Warzynski (2012). We depart from that study by focusing on the underlying cost structure and relating it to measures of firm performance.

[11] Robinson (1933), for instance, argued that technological progress would create capital-intensive firms with market power in concentrated industries. See Stigler (1982) for a historical overview.

[12] Similarly, Ganapati (2025) studies US wholesalers and suggests that 'superstar' wholesalers make sunk investments in global sourcing capacity – for instance, by acquiring information technology capacity – which leads to lower average operating costs and increased markups.

[13] In line with this, for a subset of firms in Compustat for 1980–2018, Conlon et al. (2023) show that markup changes are only very weakly correlated to changes in industry-wide price indices, suggesting that markup changes are primarily due to marginal costs.

Where available, subsequent work has mainly employed intermediate inputs, interpreting differences in markup estimates based on labor and intermediates as evidence of either monopsony power in labor markets (e.g., Yeh et al. (2022)) or factor-biased technological change (e.g., Raval (2023)).[14] We show that intermediate inputs contain several components unlikely to be purely variable, and this in turn has implications for identification of production functions and the selection of variable inputs to measure markups. This highlights the advantage of the production approach to markup estimation, as the variable input can be selected among potentially many candidates and this provides not only econometric benefits, but also helps to detect underlying mechanisms and sources for changes in markups and performance broadly defined.

In the next section, we discuss the data and present the empirical framework. Section 3 presents the anatomy of costs for Belgian firms active in the manufacturing sector, and we relate this to measures of firm performance in Section 4. In Section 5, we further disaggregate the bundle of service intermediates using our survey data and highlight a few key facts that connect to the reported changes in performance and cost structures, drawing final conclusions in Section 6.

2. Data and empirical framework

2.1. Data

We construct a firm-level dataset on manufacturing firms obliged to submit their annual accounts (AA) to the Belgian authorities, covering 1985 to 2016. We limit our sample to firms that report a breakdown of intermediate inputs into goods and services – as we focus on the role of services in production – and have at least 20 employees. While AA are collected for the vast majority of firms in Belgium, only large firms are required to provide a breakdown of intermediates. Our final sample is, however, representative of the Belgian manufacturing sector as it contains more than 82 percent of all reported revenue in manufacturing between 1985 and 2016. Further details on the data sources and sample selection are in Appendix A and Tables A1 and A2.

The AA contain yearly firm-level data on balance sheets and income statements. We observe revenue, full-time equivalent (FTE) employment, capital (tangible fixed assets), labor expenditure, intermediate input expenditure broken down by goods and services, and the firm's 3-digit NACE industry. Our final sample contains 73,768 observations covering 5,933 firms. This sample is quite balanced over time, with the number of firms in a given year varying between 1,923 in 2016 and 2,561 in 1992 (2,305 firms per year on average).

A key contribution of this paper is the decomposition of the cost of goods sold (COGS) into expenditure on fixed production factors or overhead and variable inputs. COGS, typically defined as the sum of expenditure on labor and intermediate inputs, is a common accounting measure of variable production costs. In datasets on financial statements, however, both labor and intermediates are bundles of heterogeneous inputs. This is particularly true for intermediate inputs, which typically contain elements better described as expenditure on fixed inputs or overhead costs, such as capital rents and outsourced overhead labor. Nevertheless, for lack of better alternatives, researchers have been forced to rely on intermediates expenditure as a measure of variable input expenditure when using accounting data to study costs, productivity, and markups.[15] To the extent that different accounting practices vary in terms of which of these cost items are included in the bundle of intermediate inputs, results on markups, for example, can vary.

A useful feature of the AA data is the available breakdown of intermediate inputs into goods and services. Goods represent items that are best thought of as variable factors of production and consists of expenditure on raw materials and consumables. Services, on the other hand, consist of purchases of intermediate services and all other intermediate goods, which are mostly fixed production factors and overhead costs. This breakdown allows us to decompose COGS into services and VCOGS, which contain expenditure on labor and goods:

$$\begin{aligned} \text{COGS} &= \text{VCOGS} + \text{Services Expenditure}, \\ &= (\text{Goods expenditure} + \text{Labor expenditure}) + \text{Services expenditure}. \end{aligned} \tag{1}$$

Of course, some elements of services may have a variable component, for instance, external labor. Moreover, firms might report certain elements of SG&A as services – for instance, intermediate services related to advertising. We do not claim to separate variable and fixed factors of production perfectly but rather to have a measure closely corresponding to variable input expenditure (VCOGS) and a bundle containing mainly overhead and fixed costs (Services). We will show that VCOGS and services behave fundamentally differently, suggesting that standard accounting data on intermediate inputs obscure substantial heterogeneity which is informative about firms' production technology and performance in the output market.

We observe more detailed information on services expenditure for a subset of firms and years. This data is taken from the *Enquête Structurelle des Entreprises* (ESE), an annual firm-level survey conducted by Statistics Belgium since 2008. As our AA sample is only available before 2017, we use survey data for the 2008–2016 period. We observe expenditure on five categories of services: (i) external labor, (ii) gifts, (iii) insurance, (iv) rent, and (v) software. Inclusion in the ESE is determined by firm size. Firms with more than 50 employees and revenue in excess of eight million euros are obligated to participate in the survey, which is supplemented by yearly samples of smaller firms. ESE data is available for 13,959 of the 19,104 AA observations between 2008 and 2016 (73.07

[14] Rubens et al. (2024) propose a framework that can separately identify wage markdowns in labor markets and factor-augmenting productivity. In contrast, previous work assumed away the one to identify the other.

[15] See De Loecker and Syverson (2022) for a discussion on standard measurement practices of firm-level input data. Compustat is a prominent example of a firm-level dataset that reports COGS and SG&A, but not their individual components.

Table 1
Summary statistics.

variable	p(25)	p(50)	p(75)	mean	s.d.
Revenue	7,261	14,250	36,428	58,528	260,115
Capital	760	1,807	4,871	7,664	32,419
Labor (FTE)	41.2	71.7	149	187.57	533.14
VCOGS	5,165	10,212	26,508	44,445	213,456
Labor Expenditure	1,298	2,317	5,316	7,893	27,056
Goods Expenditure	3,341	7,430	20,352	36,551	196,776
Services Expenditure	1,081	2,323	5,802	9,598	45,691

Notes: Summary statistics for key variables. Based on the full sample of 73,768 observations covering 1985 to 2016. p(25), p(50), and p(75) refer to the 25th, 50th, and 75th percentile of the distribution, respectively. Mean and s.d. are the unweighted mean and standard deviation. Monetary values are in thousands of 1991 Belgian Francs. Labor rounded to two decimal points.

percent) and these observations cover 89.74 percent of all post-2007 AA revenue, ensuring that the ESE sample is representative of Belgian manufacturing in general. In Section 5, we discuss the ESE sample in more detail.

Table 1 displays descriptive statistics for our firm-level annual accounts data. The distributions of labor expenditure and services expenditure are fairly similar, with median expenditure on both inputs close to 2.3 million euros. Goods expenditure tends to be substantially higher, over seven million at the median. Most distributions are considerably skewed, with the mean significantly exceeding the 75th percentile. For instance, median employment is 71.7 while mean employment is 187.57.

Before moving on to our empirical framework, we briefly dwell on how variable input market conditions in Belgium differ from the more familiar American setting. In Belgium, close to 100 percent of all employment relationships are governed by at least one collective bargaining agreement throughout our sample years. Participation in such agreements is mandatory for firms, and once an agreement has been signed, it automatically applies to all employees of the involved firms, regardless of union membership status. This has allowed collective bargaining coverage to remain near-complete as union membership has dropped over time.[16] Employment protection is high (compared to the US) and stable throughout the sample.[17] Belgium is a small open economy, and has become even more open throughout our sample. In 1985, the ratio of imports to GDP was 63.8 percent, compared to 79.4 percent in 2016. In contrast, the US relies less on imports but has seen the importance of imports grow by more – the ratio of imports to GDP increased from 9.6 to 14.6 percent in the US over the sample period.[18]

2.2. Empirical framework

We next introduce our empirical framework, used to obtain estimates of markups, revenue productivity, and profit ratios. In principle, input expenditure on each input that we observe can be treated as either variable, fixed, or overhead expenditure in this framework. We, therefore, elaborate on how we classify input expenditure – particularly goods and services – and how this impacts the estimation and interpretation of our outcome measures.

The measurement of markups is based on the framework put forward by De Loecker and Warzynski (2012) and Hall (1988). This production approach obtains firm-level markups based on input and output or revenue data. Assumptions on demand or the nature of competition are not required. Instead, the firm's production function is specified, and cost-minimizing behavior with respect to a variable input is required.

Consider the production function of a firm i at time t

$$Q_{it} = Q_t(\mathbf{V}_{it}, \mathbf{F}_{it}, \Omega_{it}), \tag{2}$$

where $\mathbf{V}_{it} = (V_{it}^1, \dots, V_{it}^J)$ is a vector of J variable inputs, $\mathbf{F}_{it} = (F_{it}^1, \dots, F_{it}^K)$ is a vector of K fixed inputs, and Ω_{it} is firm-time-specific physical productivity. In addition, a firm might engage in overhead activities that do not directly influence output and, hence, do not enter the production function – captured by the vector $\mathbf{O}_{it} = (O_{it}^1, \dots, O_{it}^L)$. For expositional simplicity, we assume that a single variable and a single fixed input are used to produce a single good, and that firms engage in a single overhead activity, but the analysis below straightforwardly extends to multiple variable inputs, fixed inputs, overhead activities, and outputs (e.g., De Loecker et al. (2016)).

We assume that firm i minimizes its contemporaneous cost of production with respect to its frictionlessly adjustable input V_{it}, given the price of the variable input P_{it}^V, expenditure on the fixed input, $P_{it}^F F_{it}$ and overhead, $P_{it}^O O_{it}$, Ω_{it}, and the production technology captured by production function (2). The associated Lagrangian objective function is

$$\mathcal{L}(V_{it}, F_{it}, \Omega_{it}) = P_{it}^V V_{it} + P_{it}^F F_{it} - \lambda_{it}(Q(V_{it}, F_{it}, \Omega_{it}) - Q_{it}) + P_{it}^O O_{it}, \tag{3}$$

[16] A similar situation characterizes most countries in (Western) Europe. In the US, in contrast, collective bargaining coverage dropped from 20.5 percent in 1985 to 12 percent in 2016.

[17] See the statistics on "Collective bargaining coverage" and "Strictness of employment protection" in the OECD's data tool available at https://data-explorer.oecd.org.

[18] See https://data.worldbank.org/indicator/NE.IMP.GNFS.ZS?locations=BE-US.

where λ_{it} is the Lagrange multiplier, which represents the marginal cost of production – the change of the objective function as the output constraint is relaxed.

We define the markup as $\mu_{it} = \frac{P_{it}}{\lambda_{it}}$, where P_{it} is the price of firm i's output. Following De Loecker and Warzynski (2012), the first-order condition of the Lagrangian with respect to the variable input V_{it} can be rewritten to obtain a simple expression for the markup

$$\mu_{it} = \theta_{it}^{V} \frac{R_{it}}{P_{it}^{V} V_{it}}, \tag{4}$$

where R_{it} is revenue and $\theta_{it}^{V} = \frac{\partial Q(\cdot)}{\partial V_{it}} \frac{V_{it}}{Q_{it}}$ is the output elasticity of V_{it}. Eq. (4) shows that the two components required to measure markups are the revenue share of a variable input and that input's output elasticity. We observe revenue shares in our data and need to estimate output elasticities.

The existence of a variable input for which firms are price takers is a key requirement to identify markups based on Eq. (4). If an input for which these requirements are not satisfied is used in the place of V_{it}, the estimated markup is a joint measure of imperfections in the output and input markets.[19] A typical firm-level dataset based on accounting standard that covers several industries will have no more than three inputs: capital (K_{it}), labor (L_{it}), and intermediate inputs ($G_{it} + S_{it}$). The current standard in the literature is to rely on intermediate inputs as a variable input when estimating markups – assuming that all components of $G_{it} + S_{it}$ are variable and substitutable. However, as noted, services S_{it} contains fixed inputs and overhead activities, violating the necessary assumptions for markup estimation. Due to, among other factors, adjustment frictions and price-setting power, capital and labor are rarely attractive alternatives.

We use goods as the variable input on which markups are based. Our ability to separate services expenditure from the bundle of intermediates is critical to obtaining accurate estimates of markups. While labor might be seen as a variable input, as discussed, the prevalence of imperfections such as collective bargaining in Belgian labor markets make it an unappealing for markup estimation. Capital is assumed a fixed input of production. Of course, conditional on observing a further breakdown of inputs, one might have several suitable candidates for markup estimation in specific cases.[20]

Whether services are best thought of as overhead or a fixed input is less clear – the survey data discussed in Section 5 suggests that the bundle of services expenditure contains expenditure on both categories. Throughout this section and in the baseline results we assume that services expenditure consists entirely of overhead costs and does not enter the production function: $S_{it} = O_{it}$. This is not an innocuous assumption, as it influences markup estimates through the output elasticity of goods, and influences the interpretation of the profit ratios that we introduce below. We, therefore, explain how our empirical framework can be adjusted if services is characterized as a fixed input of production instead, and provide results for this alternative approach throughout the main text that complement our baseline results. Our main results on the rise of services expenditure and its correlation to higher markups and profit ratios hold in either approach. A more detailed analysis of whether services are best thought of as overhead or a fixed input, which motivates our decision to give both interpretations weight, are in Appendix B and Fig. B.6.

We estimate output elasticities using a cost share approach (e.g., Foster et al. (2008); Autor et al. (2020)). This approach identifies the output elasticity of the inputs given returns to scale and no factor market imperfections, and avoids having to deal with the challenge of identifying output elasticities using standard production and cost data, with unobserved productivity shocks under imperfect competition (Ackerberg and De Loecker, 2024). To allow production technology to differ in the cross-section and over time, and to allow for measurement error, we take the median within each 3-digit-industry-by-year cell (s) – i.e., we assume the technology is 3-digit-industry-by-year specific, such that the output elasticity of input $x \in \{L, K, G\}$ is given by

$$\theta_{st}^{X} = Median_{st}\left(1.1 \frac{P_{it}^{X} X_{it}}{PC_{it}}\right), \tag{5}$$

where PC_{it} represents total production costs: the sum of expenditure on labor (L_{it}), capital (K_{it}), and goods (G_{it}).[21] Where we to assume that services are a fixed production input rather than overhead costs, then services expenditure would be added to PC_{it} in the denominator of Eq. (5). Qualitatively, our results are robust to taking the median cost share at a more aggregated level and to estimating firm-time-specific output elasticities using a proxy variable approach to production function estimation (Olley and Pakes (1996); Levinsohn and Petrin (2003); Ackerberg et al. (2015)). Table A3 in Appendix A provides descriptive statistics on output elasticities and markups by 2-digit industry.[22]

We assume that that returns to scale are increasing and equal to 1.1, which is in line with some recent estimates (e.g., Ruzic and Ho (2023)). As this number simply scales the cost share, it has little qualitative influence on our results, which are robust to assuming

[19] Indeed, an emerging literature uses this insight to document evidence of monopsony power and adjustment frictions in labor markets (e.g., Yeh et al. (2022); Mertens (2022)).

[20] There exists some evidence of buyer power for intermediate inputs in European manufacturing (e.g., Morlacco (2020); Treuren (2022)). If this is the case for goods in our sample, our markup measure captures both seller power in output markets as well as buyer power in intermediate input markets, which does not materially affect our main conclusions.

[21] We approximate yearly capital expenditure as $0.1 \times K_{it}$. Results are robust to alternative definitions, for example, $\frac{r}{100} K_{it}$ with $r \in \{5, 8, 12, 15\}$.

[22] When cost shares are disaggregated to the firm level we obtain the well-known result that – in the absence of overhead costs – markups equal profit ratios (e.g., Foster et al. (2022)). We strike a balance between allowing for meaningful heterogeneity in output elasticities without equating markups to profits.

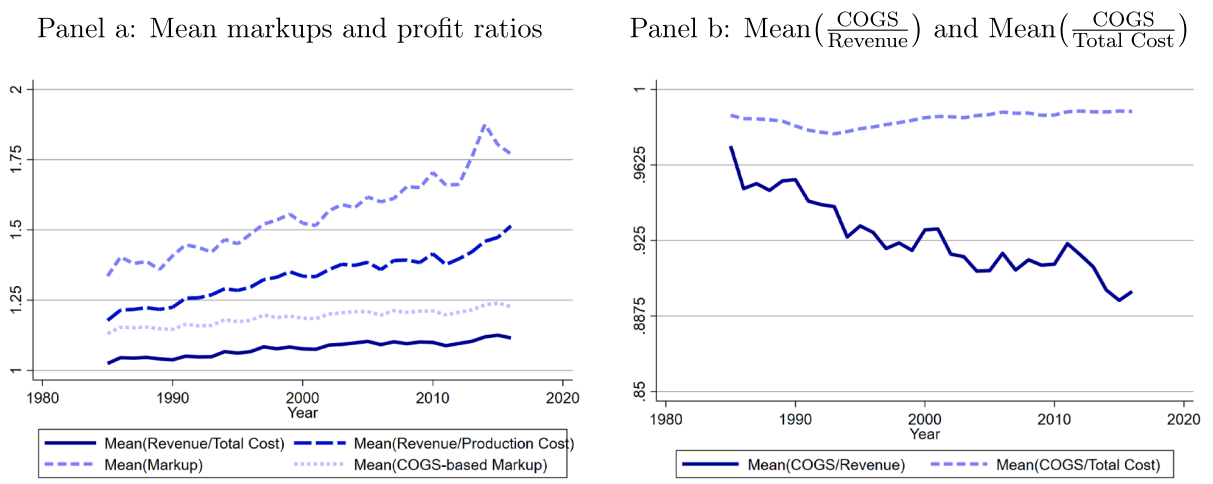


Fig. 1. Revenue-weighted averages of markups, profitability, and COGS shares, over time.
Notes: The revenue-weighted averages of the markup (calculated assuming that either goods or COGS are variable), and the net and gross profit ratios (panel a), and the revenue-weighted averages of the shares of COGS in revenue and total cost (panel b), over time. COGS refers to the sum of labor expenditure and intermediate input expenditure. Based on the full samples of 73,768 observations covering the years 1985 to 2016.

constant or decreasing returns to scale. However, if we assume constant returns to scale, our cost share approach implies that the gross profit ratio – defined below – would be identical to the markup. Returns to scale varying over time and in the cross-section might impact our results in several ways. In particular, if returns to scale are (partially) the consequence of firms' overhead expenditure, as suggested by Sutton (1991), then we underestimate the correlation between markups and services expenditure. Second, if returns to scale have increased over time, as suggested by De Loecker et al. (2020), then we underestimate the increase in markups over time.

To estimate total factor revenue productivity, we follow Foster et al. (2008) and rely on revenue data and a Cobb-Douglas production function with Hicks neutral productivity, in combination with cost share output elasticities

$$\ln(TFPR_{it}) = \ln(R_{it}) - \theta^L_{st}\ln(L_{it}) - \theta^K_{st}\ln(K_{it}) - \theta^G_{st}\ln(G_{it}). \tag{6}$$

TFPR is thus a residual of the log difference between revenue and the production function so that it captures both physical productivity and demand-side factors that cause revenue to differ between firms with identical output, inputs, and production technology. If consider services to be an input in production, the term $-\theta^S \ln(S_{it})$ is added to Eq. (6).[23]

In line with the distinction between production costs and services, we define two profit ratios. These gross and net profit margins for firm i at time t are given by

$$\pi^G_{it} = \frac{R_{it}}{PC_{it}}, \quad \text{and} \quad \pi^N_{it} = \frac{R_{it}}{TC_{it}}, \tag{7}$$

where TC_{it} is the sum of total production costs and expenditure on services. The gross profit ratio π^G_{it} only takes into account expenditure on inputs that we always consider inputs of production while net profit ratio π^N_{it} additionally considers expenditure on services. If services expenditure consists of overhead costs, these profit ratios can be interpreted as profits before and after overhead costs. If services are a fixed input in production, these profit ratios are simply profit before and after accounting for services expenditure. In neither specification is either of the profit ratios equal to the markup under the assumptions required to estimate output elasticities, as returns to scale are assumed non-constant.[24]

3. The cost structure of Belgian manufacturing firms

3.1. Starting point

Our starting point is an increase in markups over time. Panel a of Fig. 1 shows that the revenue-weighted average markup has increased from 1.34 in 1985 to 1.77 in 2016 (a 32.09 percent increase). This trend is even more pronounced at the top percentiles of the markup distribution, with the 95th percentile increasing by 40.35 percent – from 2.85 to 4.00. Similar broad trends have

[23] Integrating product-level price data allows estimation of quantity-based production functions and physical productivity and is the topic of future work. As only labor is measured in physical units, any firm-level input price deviations from the sector-level deflators will also enter out measure of TFPR, scaled by output elasticities. We follow the literature by still referring to the residual as TFPR.

[24] As a consequence of our estimation approach, the relationship between the profit ratios and the estimates markups can be written as $\hat{\mu}_{it} = \frac{Median(1.1P^G_{it}G_{it}/PC_{it})}{P^G_{it}G_{it}/PC_{it}}\pi^G_{it}$ and $\hat{\mu}_{it} = \frac{Median(1.1P^G_{it}G_{it}/PC_{it})}{P^G_{it}G_{it}/TC_{it}}\pi^N_{it}$.

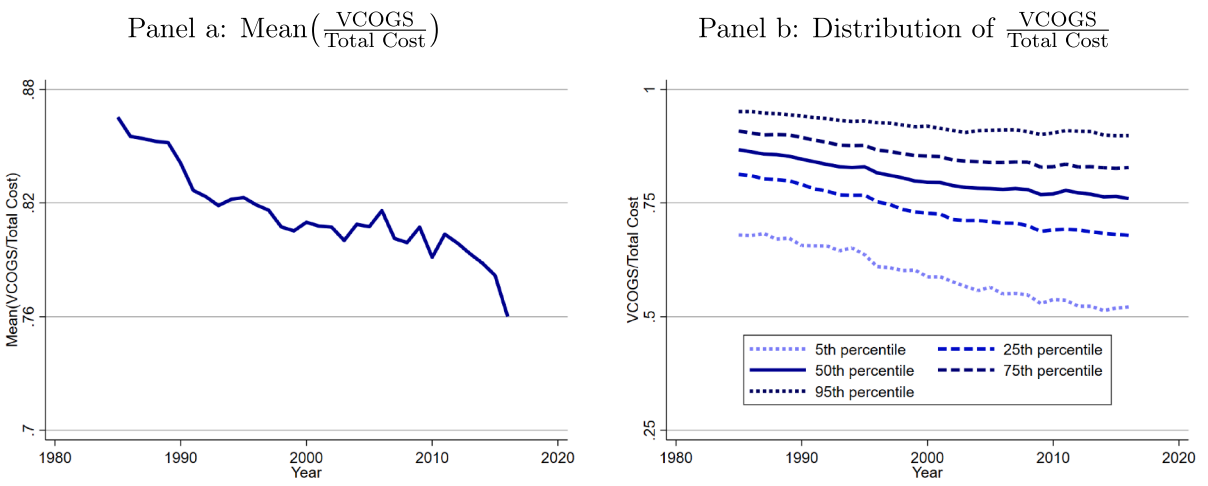


Fig. 2. VCOGS cost share, over time.

Notes: The total-cost-weighted average (panel a), and selected percentiles from the distribution (panel b), of the share of VCOGS in total cost. VCOGS refers to the sum of labor expenditure and goods expenditure. Based on the full samples of 73,768 observations covering the years 1985 to 2016.

been reported in the United States and around the world (De Loecker and Eeckhout (2018), De Loecker et al. (2020)), and are also documented in a host of markets for which detailed product-level price and quantity data is available (Döpper et al., 2022).

Although increasing markups are a robust fact in many markets and countries, the causes of such trends are difficult to pin down. Two leading explanations are increased market power of firms and changing production technology. While the market power hypothesis would imply that markup increases go hand-in-hand with profit increases, this is not necessarily the case if technological change is the leading cause. Indeed, if firms have no price-setting power, technological change that reduces variable costs but increases fixed or overhead costs could cause firms to charge higher markups without affecting overall profitability. Therefore, it is informative to compare markup trends to firm profitability trends.

Panel a of Fig. 1 reveals that the revenue-weighted average net profit ratio has also increased over time, but by less than markups. Between 1985 and 2016, this ratio increased from 1.02 to 1.12 – a 9.80 percent increase. Again, the 95th percentile displays a much more significant increase, from 1.18 to 1.46 (23.73 percent). The gross profit ratio has also increased – from 1.18 to 1.51 (27.97 percent) – with the magnitude of the increase falling in between that of the markup and the net profit ratio. These patterns suggest that a non-negligible part of the increase in markups over the last four decades might be explained by firms becoming more reliant on overhead costs and less on production costs. The fact that the markup increases by more than net profit ratio is maintained if we instead view services as a fixed input of production – see panel a of Fig. C.7 in Appendix C.[25]

These patterns would not be observed by a researcher that only observes COGS, and is, therefore, forced to estimate markups under the assumption that COGS are variable. In that setting, only the revenue-weighted average net profit ratio and COGS-based markup in Fig. 1 could be constructed, which have near-identical trends over time. COGS-based markups, that incorrectly assume that all components of COGS are variable, therefore, appear to underestimate both the level of and the increase in markups over time. In addition, from Panel b of Fig. 1, it is apparent that the cost share of COGS is remarkably stable over time – this share is typically interpreted as the importance of variable costs in total costs.[26] While the revenue share of COGS declines by about 7.5 percent between 1985 and 2016, this discrepancy in trends can be explained by revenue increasing relative to total cost.

On the basis of COGS data alone, then, one might conclude that markups and profit ratios track each other well, and that the cost structure of firms is stable over time – i.e., that the technological change explanation for increased markups holds little merit. In this paper, we use our observed split of COGS into variable costs (VCOGS) and services expenditure to argue that such a conclusion appears misguided. We show that the stable COGS cost share obscures significant heterogeneity. Cost shares of VCOGS have substantially declined over time while expenditure on services markedly increased. We show that markups and gross profit ratios increase substantially as cost structures become more services-centered. Profit ratios net of services expenditure, however, increase much less strongly, suggesting that markups increase in large part to cover expenditure on other things than variable inputs.

3.2. *The anatomy of production*

We examine the evolution of VCOGS and services to uncover the underlying heterogeneity of the stable COGS cost share displayed in Fig. 1. Over time, the role of VCOGS in production has diminished. Panel a of Fig. 2 shows that the VCOGS cost share decreased by

[25] While averages in Fig. 1 are revenue-weighted, cost-weighted averages produce near-identical graphs (Fig. C.8 in Appendix C).

[26] Throughout this paper, the revenue share of an input refers to the ratio of expenditure on that input to revenue, and the cost share of an input refers to the ratio of expenditure on that input to total cost.

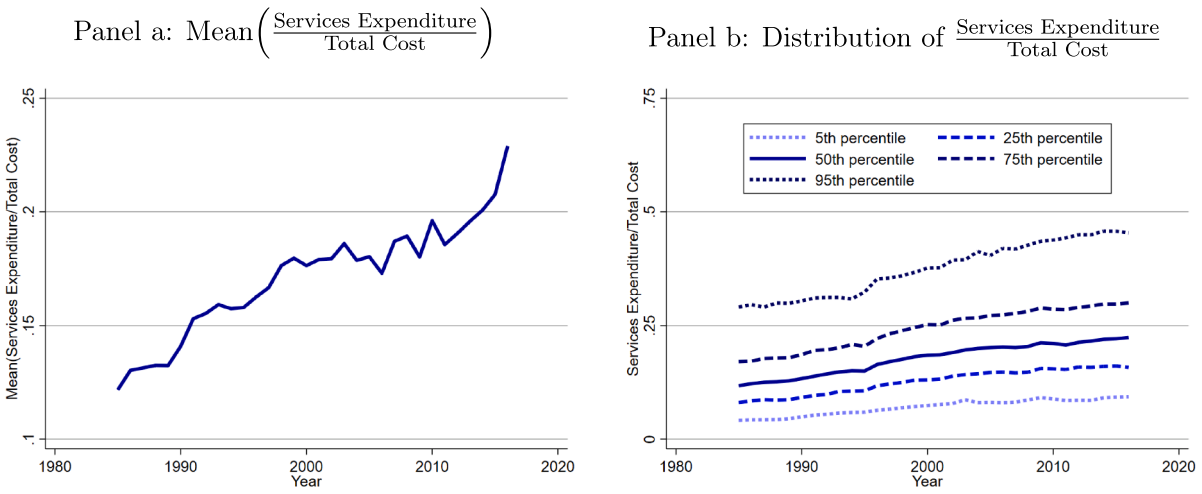


Fig. 3. Services cost share, over time.
Notes: The total-cost-weighted average (panel a), and selected percentiles from the distribution (panel b), of the share of services expenditure in total cost. Based on the full samples of 73,768 observations covering the years 1985 to 2016.

roughly ten percentage points between the mid-1980s and 2016. This average contains information on both the trend of firm-level VCOGS cost shares and the reallocation of total cost across firms. Panel b of Fig. 2, therefore, graphs selected percentiles of the unweighted distribution of VCOGS over total cost. Throughout the entire distribution, the VCOGS cost share decreases smoothly over time. These trends starkly contrast the stable COGS shares in Fig. 1.

On the other hand, the role of services in production has increased significantly since the 1980s. The total-cost-weighted average of the services cost share increases by roughly ten percentage points between 1985 and 2016, as Panel a of Fig. 3 shows, offsetting the decrease in the VCOGS cost share. The entire distribution of the services total cost share smoothly moves up during the entire sample period (Panel b of Fig. 3). The increase in the cost share of services is particularly pronounced in absolute terms at the top of the distribution. The 95th percentile increased from 0.29 to 0.45 between 1985 and 2016, compared to a change from 0.12 to 0.22 at the median.

Figs. 2 and 3 are based on cost shares, as these are more closely related to the production process than revenue shares because revenue can differ between firms with identical input use, productivity, and production technology. However, results for cost and revenue shares are qualitatively similar. Figs. C.9 and C.10 in Appendix C show that the VCOGS revenue share decreased by more, and the services revenue share increased by less, than their cost share counterparts. This can be explained by the growth of revenue with respect to total cost over time displayed in Fig. 1. As with cost shares, the entire cost share distribution of VCOGS moves down over time while the opposite occurs for services.

Overall, our results suggest that the role of services in production has substantially increased between 1985 and 2016. As the entire distribution of the services cost share moves up and the entire distribution of the VCOGS cost share moves down, the substitution of services for VCOGS appears to occur both within industry and within firm. To test this prediction, we run regressions of the form

$$\ln\left(\frac{\text{Services Expenditure}_{it}}{\text{Total Cost}_{it}}\right) = \beta_0 + \beta_1 \ln\left(\frac{\text{VCOGS}_{it}}{\text{Total Cost}_{it}}\right)_{it} + \mathbf{FEs} + \epsilon_{it}, \tag{8}$$

where **FEs** contains either 3-digit-industry-by-year fixed effects or both firm and year fixed effects. Standard errors are clustered at the 2-digit-industry level to account for any dependency caused by firms in the same broad industry interacting. Table 2 displays the results of this exercise.

Within industry-year, firms with higher services cost shares have lower VCOGS cost shares (Column 1 of Table 2), confirming that between-industry differences do not fully explain our results. Moreover, firms substitute services for VCOGS over time (Column 2), and the magnitude of this within-firm association is very similar to that of the within-industry-year association. Between 1985 and 2016, the median VCOGS cost share dropped from 86.71 percent to 77.92 percent, a 10.14 percent decrease. Our within-firm estimates imply that a firm following this trend increased its services cost share by 27.78 percent, while at the industry-year level a 31.03 percent increase is implied. Overall, then, the production process of firms appears to change over time, rather than the exit of VCOGS-intensive firms and entry of services-intensive firms driving the rise of services shares.

Decomposing VCOGS into expenditure on labor and goods uncovers heterogeneity underlying the substitution of services for VCOGS. Within industry-year, firms with relatively high services shares have relatively low goods shares but high labor shares (Columns 3 and 5 of Table 2). Over time, a similar pattern emerges within firm. A one percent increase in the labor cost share (goods

Table 2
Input use: Substitutes and complements.

	Dependent variable: ln(Services Expenditure/Total Cost)					
	(1)	(2)	(3)	(4)	(5)	(6)
ln(VCOGS/Total Cost)	-3.06	-2.74				
	(0.101)***	(0.093)***				
ln(Labor Expenditure/Total Cost)			0.30	0.16		
			(0.052)***	(0.026)***		
ln(Goods Expenditure/Total Cost)					-0.65	-0.55
					(0.066)***	(0.036)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.80	0.93	0.31	0.81	0.46	0.85

Notes: Table 2 reports output from regressions relating the total cost shares of different inputs; VCOGS refers to the sum of labor expenditure and goods expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the full sample of 73,768 observations covering the years 1985 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

cost share) goes hand-in-hand with a 0.16 (0.55) percent increase (decrease) in the services cost share (Columns 4 and 6).[27] Goods and services, typically reported as a single bundle, appear to be substitutes. Using the ESE survey data, we discuss potential mechanisms behind this heterogeneity in Section 5.[28]

Table D1 in Appendix D reports results from regressions similar to Eq. (8) but using revenue shares instead of cost shares. Again, the results suggest that labor and services are complements while goods and services are substitutes (Columns 3–6). Moreover, VCOGS as a whole and services are negatively related, both within firm and within industry-year. Our results, therefore, are not determined by our choice of shares. Of course, cost shares are more directly linked to a firm's cost structure than revenue shares.

As the top percentiles of the services cost share distribution experience a more significant percentage point increase over time, we zoom in on those percentiles. Table D2 in Appendix D replicates Table 2 on the sample of all firms in the top five percentiles of the services cost share distribution for each 2-digit-industry-year combination with at least 20 observations. The results are qualitatively unchanged, with one exception. For firms with services-intensive cost structures, labor and services expenditure are negatively related, rather than positively, suggesting that labor and services are substitutes for these firms.

Summing up The stable COGS share in Fig. 1 obscures substantial heterogeneity. Expenditure tied closely to fixed inputs and overhead has become significantly more important in firms' total costs since the mid-1980s. On the other hand, expenditure on variable inputs, such as labor and goods expenditure, has decreased in importance. These secular trends occur throughout the distribution. The increased reliance on services is also a within-firm phenomenon. As goods and services are typically reported as a single bundle – intermediate inputs – our analysis highlights that this bundling obscures changing cost structures over time.

4. Technology and firm performance

So far, we have shown that firms' cost structures have shifted away from expenditure on variable inputs and towards services expenditure throughout the manufacturing sector. What remains to be done is to determine if these changes are linked to increased markups and whether they might explain the wedge between markups and profitability implied by Fig. 1. In this section, therefore, we relate services cost shares to a host of firm-level outcomes such as markups and profit ratios. We show that markups and gross profit ratios indeed increase as firms' cost structures rely more on services. Net profit ratios also increase, but substantially less, suggesting that markup increases are mainly driven by the need to cover higher expenditure on non-variable production factors and overhead costs.

Panel a of Fig. 4 shows that the cost share of VCOGS is negatively correlated to the markup of price over marginal cost throughout the sample period. In contrast, services cost shares and markups are positively correlated (Panel b).[29] Moreover, as markups and service shares increase over time, the association between the two becomes stronger. For instance, at the beginning of the sample, going from the 25th to the 75th percentile of the markup distribution implies an increase of the services share of about 0.1. In contrast, at the end of the sample, this would imply an increase roughly equal to 0.15 – a 50 percent increase. As the separate components of services are mostly expenditure on overhead factors or fixed inputs, high markups need not imply high profits.

[27] As the VCOGS share is the sum of the labor share and the goods share, the point estimates reported in Columns 3 to 6 of Table 2 do not aggregate to the point estimates in Columns 1 and 2.

[28] Labor and goods are negatively related. Regressing the log of the cost share of labor on the log of the cost share of goods results in a within-industry-year point estimate (standard error) of -0.90 (0.059). The concomitant within-firm point estimate is -0.70 (0.033).

[29] The magnitude of these correlations is very similar when considering revenue shares instead of cost shares, and when estimating markups under the assumption that services are a fixed input that enters the production function (Fig. C.11 and panel b of Fig. C.7 in Appendix C, respectively).

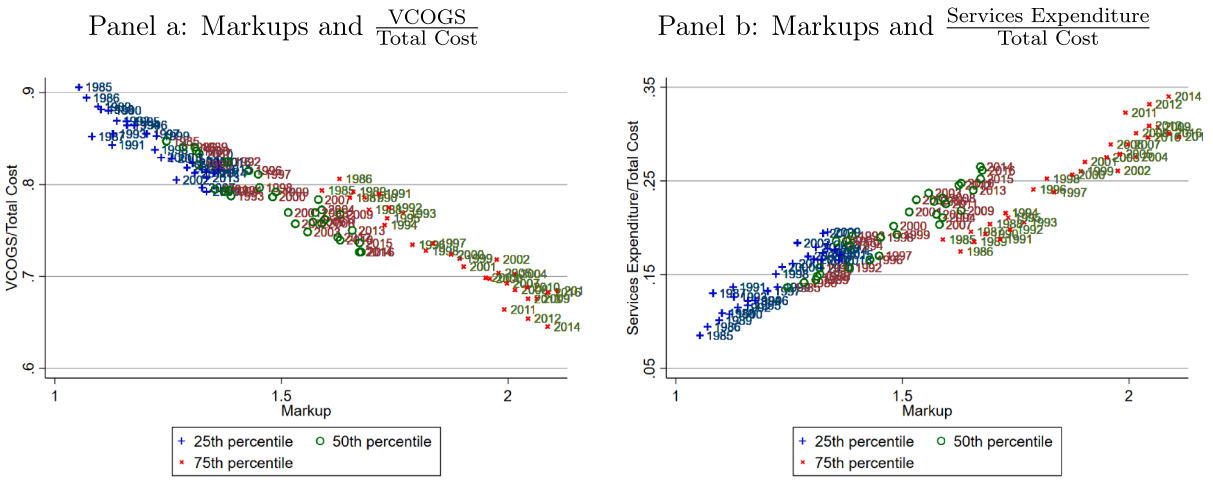


Fig. 4. Correlation between markups and input expenditure cost shares.

Notes: The sample for the p^{th} percentile in year t consists of all observations between the $(p-5)^{th}$ and $(p+5)^{th}$ percentile of the markup distribution in year t. Using this sample, the weighted average markup and either the weighted average VCOGS share of total cost (panel a), or the weighted average services expenditure share of total cost (panel b) are calculated. Weights are given by total cost shares.

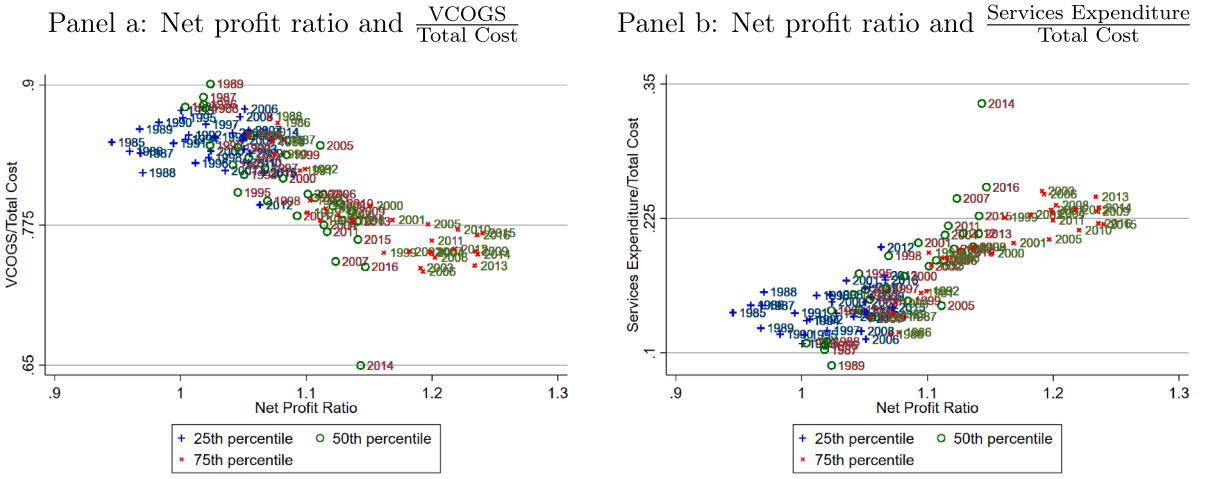


Fig. 5. Correlation between net profit ratios and input expenditure cost shares.

Notes: The sample for the p^{th} percentile in year t consists of all observations between the $(p-5)^{th}$ and $(p+5)^{th}$ percentile of the profit ratio distribution in year t. Using this sample, the weighted average profit ratio and either the weighted average VCOGS share of total cost (panel a), or the weighted average services expenditure share of total cost (panel b) are calculated. Weights are given by total cost shares.

Fig. 5 displays the correlations between the cost share of either VCOGS or services and the net profit ratio. Firms with higher VCOGS cost shares have lower net profit ratios. The reverse is true for services, and the absolute magnitude of both changes is very similar. As with markups, the correlations are very alike when using revenue shares instead of cost shares (Fig. C.12 in Appendix C). However, the correlation between services shares and net profit ratios appears lower than the markup correlations displayed in Fig. 4. Indeed, the difference between the mid-1980s and the 2010s within a percentile of the markup distribution is often larger than the difference between the median and either the 25th or the 75th percentile of that distribution.

Figs. 4 and 5 suggest that part of the high markups charged by firms with services-intensive production processes is required to cover expenditure on fixed inputs and overhead costs. However, markups appear to increase by more than would be the case under zero profit conditions. Of course, some intermediate steps are missing here, particularly the relation of services cost shares to the gross profit ratio and the variable and fixed input expenditure levels. Therefore, we regress the total cost share of services on markups, TFPR, expenditure measures, and profit ratios. We vary whether within-industry or within-firm variation is used, as in Eq. (8). Results are in Table 3.

Table 3
Services expenditure cost shares and firm performance.

Dependent variable:	ln(Markup)		ln(TFPR)		ln(VCOGS)	
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Services Expenditure/Total Cost)	0.50	0.43	0.34	0.36	-0.57	-0.56
	(0.025)***	(0.028)***	(0.015)***	(0.046)***	(0.059)***	(0.046)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.36	0.80	0.96	0.83	0.24	0.92
Dependent variable:	ln(Services)		ln(Gross Profit Ratio)		ln(Net Profit Ratio)	
	(7)	(8)	(9)	(10)	(11)	(12)
ln(Services Expenditure/Total Cost)	0.67	0.68	0.25	0.24	0.02	0.02
	(0.061)***	(0.045)***	(0.006)***	(0.009)***	(0.008)**	(0.007)**
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.32	0.54	0.75	0.76	0.18	0.52

Notes: Table 3 reports output from regressions relating the total cost share of services expenditure to measures of firm performance; TFPR refers to total factor revenue productivity; VCOGS refers to the sum of labor expenditure and goods expenditure; Services refers to services expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the full sample of 73,768 observations covering the years 1985 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

High services cost shares go hand in hand with high markups (Column 1 of Table 3). Moreover, in years where firms rely more on services, they set substantially higher markups (Column 2) – a ten percent increase in the service share is associated with a five percent increase in a firm's markup. Our results imply that a firm following the trend of the median services cost share over time – an increase from 0.12 in 1985 to 0.22 in 2016 – increases its markup by about 35.83 percent. Cost structures becoming more reliant on services coincides with – and potentially requires – prices to be marked up more strongly over marginal costs. This result is not a consequence of markups being estimated under the assumption that services are overhead – Columns 1 and 2 of Table D3 in Appendix D show that estimates are near-identical if we assume that services are a fixed input of production instead.

TFPR also strongly increases with services cost shares (Columns 3 and 4 of Table 3). Recall from Eq. (6) that TFPR is defined based on a production function where services are not an input. Formally, $R_{it} = F(K_{it}, L_{it}, G_{it})TFPR_{it}$. TFPR is a measure of a firm's revenue-generating capacities, holding fixed production technology, output, and inputs. Therefore, we would expect it to increase with overhead expenditure such as advertising that can increase revenue given output. A firm following the median services cost share over the past decade would see TFPR increase by about 30 percent. If, instead, we assume that services are a fixed input in production, they enter the production function and are no longer a part of TFPR. Columns 3 and 4 of D3 in Appendix D show that the services cost share is still positively related to TFPR in that case, but that the implied increase in TFPR drops from 30 percent to about seven percent.

A high services cost share coupled with a low VCOGS cost share does not necessarily imply that a firm has low expenditure on variable inputs and high expenditure on services. For instance, if firms with high services cost shares are small in terms of input expenditure, high services shares could coincide with low levels of services expenditure. However, Columns 5 to 8 of Table 3 show that firms with high services cost shares spend less on variable inputs and more on overhead than firms with low services cost shares. Our estimates imply that a firm whose services share increases over time from 0.12 to 0.22 experiences an increase in services expenditure of roughly 57 percent, while expenditure on VCOGS decreases by about 47 percent. That cost structures rely less on variable input expenditure over time is, thus, tied to substantial increases in fixed input and overhead expenditure and substantial decreases in variable input expenditure.

The gross profit ratios of firms with high services cost shares are substantially higher than those of firms with low services cost shares, as a consequence of the last paragraphs (Column 9 of Table 2). In addition, in years where firms have higher services cost shares, they have higher gross profit ratios (Column 10). While net profit ratios are also positively related to services cost shares both within industry-year and within firm, the magnitude of this positive relation is considerably weaker than for gross profit (Columns 11 and 12). A firm that follows the median services cost share trend over the entire sample sees its gross profit ratio increase by about 20 percent, but its net profit ratio increases by a just under two percent only. Therefore, higher markups appear to mostly offset overhead costs, leaving net profit ratios only somewhat higher.

Table D4 in Appendix D reproduces Table 3 using revenue shares instead of cost shares. Results using cost and revenue shares are qualitatively similar. Higher profit ratios, TFPR, and input use are associated with higher revenue, which pushes down revenue shares relative to cost shares. Points estimates for the TFPR and profit regressions are, therefore, lower and in one instance – the within-firm net profit regression – the sign even flips. Cost shares are informative on firms' cost structures, so that the results in Table 3 investigate the relation between production technology and firm outcomes. Revenue shares, on the other hand, contain information on both production and demand, making them a less direct measure of production technology and cost structures.

Table 4
Summary statistics of ESE services shares.

variable	p(25)	p(50)	p(75)	mean	s.d.
External Labor Expenditure/Services Expenditure	0.02	0.05	0.11	0.08	0.10
Gifts Expenditure/Services Expenditure	0	0	0	0	0.02
Insurance Expenditure/Services Expenditure	0.01	0.01	0.03	0.02	0.03
Rent Expenditure/Services Expenditure	0.01	0.04	0.09	0.08	0.15
Software Expenditure/Services Expenditure	0	0	0	0.01	0.07
ESE Services Expenditure/Services Expenditure	0.08	0.14	0.24	0.18	0.19

Notes: Summary statistics for ESE services. ESE Services Expenditure bundles expenditure on all five separate components. Based on the full ESE sample of 13,959 observations covering the years 2008 to 2016. p(25), p(50), and p(75) refer to the 25th, 50th, and 75th percentile of the distribution, respectively. Mean and s.d. are the unweighted mean and standard deviation. Shares are rounded to two decimal points.

So far, our regression analysis has yet to consider the degree to which firms rely on services explicitly. Table D5 in Appendix D replicate the analyses of Table 3 on the sample of all firms in the top five percentiles of the services cost share distribution within each 2-digit-industry-year combination with at least 20 observations. While the associations are of similar sign to the corresponding full sample results, their magnitude tends to be substantially larger. For instance, a within-firm ten percent increase in the services cost share is associated with a 10.3 percent increase in its markup, a 6.3 percent increase in TFPR, and a 7.6 percent increase in the gross profit ratio. The change in the net profit ratio, on the other hand, is not significantly different from zero – i.e., even for firms that heavily rely on overhead expenditure, their use does not translate into increased profitability. One potential explanation for our results is that the type of services that firms rely on differs along the distribution of the services cost share. Therefore, in the next section, we unpack services expenditure further, relying on our survey data.

Summing up Our results suggest that substituting services expenditure for VCOGS expenditure is associated with various measures of firm performance. As the services share increases, markups and TFPR increase notably. These changes are accompanied by a decline in total expenditure on variable inputs while expenditure on fixed inputs and overhead costs increase. Consequently, gross profit ratios markedly increase. Net profit ratios only increase moderately. Therefore, a likely explanation for a substantial part of the observed markup increase is revenue generation shifting from variable-input-intensive to fixed-input-and-overhead-intensive processes.

5. Decomposing intermediates services

The ESE data allows us to study five separate components of services expenditure from 2008 onward: i) external labor, ii) gifts, iii) insurance, iv) rent, and v) software. We refer to the sum of expenditure on all five elements as ESE services expenditure and to the sample of all firms that report such information as the ESE sample. The median ESE services cost share increases over time – by roughly 25 percent between 2008 and 2016 – albeit more strongly than the services cost share – roughly eight percent over the same period. ESE services expenditure does not correspond to the services expenditure that we observe for all firms and years in our sample because two elements in the ESE survey contain both services and goods – 'energy and energy carriers' and 'raw materials and other goods and services'. As there is no information on the distribution of these items across goods and services, and most of the expenditure captured in those bundles should accrue to goods rather than services, we do not include them in our bundle of ESE services.[30]

To investigate the relative importance of the five ESE categories in overall services expenditure, we express expenditure on each ESE component as a fraction of overall services expenditure. Table 4 displays descriptive statistics on these services shares, and Figs. C.13, C.14, and C.15 in Appendix C plots percentiles of the services share distributions over time. Expenditure on gifts, insurance, and software make up a tiny fraction of total services expenditure for the vast majority of firms. On average, these items each comprise less than two percent of total services expenditure, with a median close to zero. Over time, the services shares of gifts and insurance are stable. While the median software services share is zero throughout the sample period, the 95th percentile increases from 2.3 percent in 2008 to 3.87 percent in 2016, suggesting that software has become more important in total service expenditure over time. However, as total services expenditure barely contains expenditure on gifts, insurance, or software, we conclude that these inputs play only a minor role in the secular shift towards services expenditure documented in Section 3 and ignore them in the remainder of this section.

External labor and rent each account for about eight percent of total services expenditure, on average, which means that they comprise nearly all of ESE services expenditure (itself roughly 18 percent of total services expenditure, on average). External labor consists of employees not employed directly by the firm in question. We think of these primarily as overhead costs, such as an outsourced cleaning department.[31] Rent contains rental payments for land, buildings, machinery, plants, equipment, furniture, and

[30] If we add these two items to our ESE services expenditure measure, the resulting sum is, on average, more than three times as large as the reported total services expenditure, in line with these two ESE items consisting mostly of goods.

[31] External labor that is variable is classified as goods and separately reported in the ESE survey.

Table 5
ESE input use: Substitutes and complements.

Dependent variable:	ln(External Labor/Total Cost)			
	(1)	(2)	(3)	(4)
ln(VCOGS/Total Cost)	-2.11	-2.18		
	(0.372)***	(0.171)***		
ln(Services/Total Cost)			0.94	0.96
			(0.131)***	(0.061)***
Industry×Year FE	×		×	
Firm FE & Year FE		×		×
R^2	0.19	0.73	0.22	0.74
Observations	12,945	12,945	12,945	12,945
Dependent variable:	ln(Rent/Total Cost)			
	(5)	(6)	(7)	(8)
ln(VCOGS/Total Cost)	-2.07	-1.45		
	(0.232)***	(0.177)***		
ln(Services/Total Cost)			0.88	0.68
			(0.081)***	(0.076)***
Industry×Year FE	×		×	
Firm FE & Year FE		×		×
R^2	0.21	0.81	0.23	0.81
Observations	12,586	12,586	12,586	12,586

Notes: Table 5 reports output from regressions relating the total cost shares of different inputs; VCOGS refers to the sum of labor expenditure and goods expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the full ESE sample of 13,959 observations covering the years 2008 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

vehicles and is best thought of as rental expenditure on capital. While some of these rental payment might correspond to overhead costs, by and large they consist of expenditure on a fixed input of production. Over time, the services shares of both items have increased slightly, as can be seen from Figs. C.13 and C.15 in Appendix C. Due to their importance in overall services expenditure, we next investigate whether the results from Sections 3 and 4 extend to these two types of services.

Section 3.2 established that firms substitute service for variable inputs over time.[32] The ESE data allows us to explore the sensitivity of these results to the type of services expenditure that firms make. In particular, we regress input expenditure cost shares of external labor and rent on the cost shares of VCOGS and services. Table 5 reports the results. Firms substitute both external labor and rent for VCOGS over time, and the magnitude of this relation is larger for external labor than for rent (Columns 2 and 6 of Table 5). Our results imply that a firm that follows the median VCOGS cost share between 2008 and 2016 increases its external labor cost share by about 5.39 percent and its rent cost share by 3.59 percent. Over time, an adjustment in the services cost share is accompanied by an (in percentage terms) near-identical change in the external labor cost share (Column 4). The cost shares of rent and services are also positively related but by substantially less (Column 8).

Recall that while services and variable inputs are substitutes, this is driven by goods, as services and labor appear to be complements. Table D7 in Appendix D verifies that these results also carry over to external labor and rent. In particular, external labor does not come at the cost of in-house employment, as each ten percent increase in a firm's labor cost share is associated with an increase in its external labor cost share of just under three percent. Why would an increased reliance on services coincide with a larger focus on (in-house and outsourced) labor but less focus intermediate goods? One explanation comes from servitization in manufacturing, the phenomenon that firms increasingly move away from traditional product-centered business models to offering both a product and (complementary) services (e.g., Crozet and Milet (2017)). Such a shift is accompanied by less emphasis on processing intermediate goods, and more emphasis on labor to provide additional services such as customer support.

Overall, then, our results on complementarity and substitutability in Section 3 extend to the two primary components of services expenditure observed in the ESE. Note that this does not imply anything about the substitutability of external labor and rent. Indeed, regressing the cost share of external workers on that of rent while including firm and year fixed effects results in a point estimate of 0.02 with a standard error of 0.020. In terms of cost structure, therefore, external labor and rent are two unrelated inputs that are both substituted for VCOGS over time.

In Section 4, we demonstrated that high services cost shares go hand-in-hand with high markups, high expenditure on fixed inputs and overhead, and low expenditure on variable inputs. As a result, gross profit ratios strongly increase with services cost shares, while

[32] Table D6 in Appendix D verifies that this result also holds in the ESE sample, although the magnitude of the point estimate is slightly smaller there.

Table 6
External labor and rent expenditure cost shares and firm performance.

Dependent variable:	ln(Markup)		ln(TFPR)		ln(VCOGS)	
	(1)	(2)	(3)	(4)	(5)	(6)
ln(External Labor Expenditure/Total Cost)	0.08	0.02	0.07	0.04	-0.30	-0.01
	(0.009)***	(0.007)***	(0.010)***	(0.013)**	(0.042)***	(0.013)
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.12	0.87	0.89	0.84	0.34	0.97
Observations	12,945	12,945	12,945	12,945	12,945	12,945
Dependent variable:	ln(Services)		ln(Gross Profit Ratio)		ln(Net Profit Ratio)	
	(7)	(8)	(9)	(10)	(11)	(12)
ln(External Labor Expenditure/Total Cost)	-0.16	0.04	0.01	0.02	0.02	-0.00
	(0.030)***	(0.010)***	(0.006)***	(0.003)***	(0.002)***	(0.002)
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.31	0.97	0.21	0.84	0.16	0.78
Observations	12,945	12,945	12,945	12,945	12,945	12,945
Dependent variable:	ln(Markup)		ln(TFPR)		ln(VCOGS)	
	(13)	(14)	(15)	(16)	(17)	(18)
ln(Rent Expenditure/Total Cost)	0.08	0.03	0.06	0.05	-0.20	-0.07
	(0.013)***	(0.001)***	(0.011)***	(0.012)***	(0.032)***	(0.014)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.11	0.87	0.89	0.84	0.29	0.97
Observations	12,586	12,586	12,586	12,586	12,586	12,586
Dependent variable:	ln(Services)		ln(Gross Profit Ratio)		ln(Net Profit Ratio)	
	(19)	(20)	(21)	(22)	(23)	(24)
ln(Rent Expenditure/Total Cost)	-0.06	-0.02	0.03	0.01	0.00	-0.00
	(0.021)***	(0.012)	(0.006)***	(0.003)**	(0.003)	(0.002)
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.29	0.97	0.18	0.84	0.14	0.77
Observations	12,586	12,586	12,586	12,586	12,586	12,586

Notes: Table 6 reports output from regressions relating the total cost share of external labor or rent expenditure to measures of firm performance; TFPR refers to total factor revenue productivity; VCOGS refers to the sum of labor expenditure and goods expenditure; Services refers to services expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

net profit ratios only moderately rise. Table 6 repeats this analysis with the cost share of either external labor or rent taking the place of the services cost share.

Table 6 shows that markups and TFPR increase by about two to five percent as firms increase either their external labor or rent cost share by one percent over time. As a result, the within-firm association between cost shares and gross profit ratios is very moderate for both rent and external labor. Net profit ratios do not increase at all in response to a within-firm cost share increase of rent or external labor. Moreover, the shift from expenditure on variable inputs to expenditure on fixed inputs and overhead that accompanies increases in services cost shares is absent for both external labor and rent – compare results in Tables 3 and 6. Differences in the sample period cannot explain these differences. Table D8 in Appendix D replicates Table 3 on the ESE sample and finds that the results are qualitatively and quantitatively similar. Moreover, while we have focused on the two main components of observed services, external labor and rent, similar results can be obtained using the entire bundle of ESE services expenditure instead.[33]

Summing up While cost shares of external labor and rent co-move with services cost shares, they correlate quite differently to firm outcomes. Therefore, the observed shift from expenditure on variable inputs to expenditure on fixed inputs and overhead and the resulting change in markups and profit ratios are unlikely to be explained by firms investing more in external labor, rent, software,

[33] Focusing on the other three observed ESE services components – gifts, insurance, and software – gives similar results although power is often low due to the very small fraction of firms that utilize these services. These results, and results based on the total ESE services bundle, are omitted so as not to clutter the paper with tables further.

or other services reported in the ESE. In light of recent academic work on outsourcing and investment in information technology, it is noteworthy that these items do not appear to explain our results.

6. Concluding remarks

Recent work documents a widening gap between a firm's price and its marginal costs. This paper analyzes this trend and takes a first step at looking into the likely underlying causes using data from the Belgian manufacturing sector between 1985 and 2016. Our data allows us to separate intermediate input expenditure into services and goods. This breakdown roughly corresponds to fixed and overhead (services) and variable (goods) factors of production contained in intermediates. In addition, for an economically meaningful subset of our data, we observe a further breakdown of services into several separate components, including external labor and rent.

While the COGS share of total cost is stable over time, we document an increasing services cost share, while cost shares of variable expenditure (labor and intermediates goods) decrease over time. This distinction is important if these input shares are used to measure markups across firms and time. Firms substitute services for variable inputs over time, suggesting that production technology is changing, particularly for firms that rely heavily on services. The changing cost structure of Belgian manufacturing firms is associated with changing firm performance. In particular, markups increase with services cost shares, as do gross profit ratios. Net profit ratios, that take into account services expenditure, also increase, but by substantially less than gross profit ratios. The increase in markups, therefore, appears to exceed that of a competitive firm increasing services expenditure only slightly. This suggests that a considerable part of markup increases is likely due to technological change. As none of the services components we observe – external labor, gifts, insurance, rent, software – can fully explain these trends, an important avenue for future work is identifying the types of services expenditure that drive our results.

Our results suggest that changing cost structures, which are informative on production technology, can explain part of the aggregate trends of markups and profitability. Moreover, this trend appears strikingly similar across firms and industries. As a similar breakdown of intermediate inputs exists for other countries (e.g., France), an appealing avenue for further research is to investigate the generality of our results. Of course, part of the change in markups and profitability might occur for other reasons and be orthogonal to firms' cost structure. Ultimately, two essential components are required to determine the relative importance of different channels in explaining aggregate trends: measurement of key variables and a model of firm behavior. We hope to have contributed to the former with this article and leave the latter for future work.

CRediT authorship contribution statement

Jan De Loecker: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization; **Catherine Fuss:** Resources, Project administration, Data curation; **Nathan Quiller-Doust:** Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation; **Leonard Treuren:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Data availability

The data that has been used is confidential data owned and managed by the National Bank of Belgium.

Appendix A. Data

A.1. Data sources and cleaning

This paper uses annual firm-level data from the National Bank of Belgium (NBB), covering all private manufacturing firms that have to submit their annual accounts to the Belgian authorities from 1985 to 2016. Although annual accounts (AA) are collected for (nearly) all companies located in Belgium, larger firms are required to report more information. In particular, for large firms, we observe revenue and a breakdown of intermediate input expenditure into goods and services expenditure. We limit the sample to firms reporting this breakdown, as it is the central focus of this paper.

The reporting thresholds that define whether a firm is considered large vary over our sample period. From 1985 to 1996, large firms are those that satisfy at least two of the following criteria: i) yearly mean employment of at least 50, ii) yearly revenue of at least 3.59 million euros (145 million Belgian francs (BEF)) excluding value-added taxes, iii) total assets worth at least 1.74 million euros (70 million BEF). In addition, any firm with at least 100 employees is classified as large. For the period 1996 to 2016, the revenue and total assets thresholds are nine million euros and 4.5 million euros, respectively.

The AA contain firm-level data on revenue, FTE employment, tangible fixed assets, and expenditure on labor, goods, and services. Where physical quantities are unavailable, we use deflated expenditure. Deflators on value added, investment and intermediate consumption at the 2-digit-industry level are based on published data in the National Accounts and sector classification information reported in the annual accounts database. More specifically, revenue is deflated by the value added deflator, capital stock is de-

Table A1
Industries covered in the final sample.

Division	Description
10	Manufacture of food products
11	Manufacture of beverages
12	Manufacture of tobacco products
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31	Manufacture of furniture
32	Other manufacturing
33	Repair and installation of machinery and equipment

Notes: This table lists all 2-digit industries covered by the final sample. Manufacturing covers industries 10 to 33.

flated by the gross fixed capital consumption deflator, and intermediate goods and services are both deflated by the intermediate consumption deflator. Monetary values are in 1991 units, including labor expenditure for which deflating is done at the sample level.

Each firm is allocated to a single 2-digit NACE Rev. 2 industry, which are defined in a time-consistent manner over the entire sample period using industry concordances. Table A1 in Appendix A lists all 2-digit industries that are included in the final sample. Eurostat (2008) provides a description of all NACE classifications and the conversion to other international industry classification codes.

The NBB makes a small set of corrections concerning dates in the annual accounts and annualizes the resulting data while extrapolating missing values. In addition, we drop observations for which the breakdown of intermediate inputs into services and goods is not reported and for which either inputs, input expenditure, or revenue are missing. Next, we focus on firms with at least 20 full-time equivalent employees and trim the top and bottom 0.5 percent of the distributions of the cost shares of services, goods, labor, and capital. Finally, we remove outliers by dropping markups above 50 or below 0.5 and net profit ratios below -0.5. Firms that are dropped play only a small role in the Belgian economy as our final sample contains 82.73 percent of all reported revenue in the raw data.

The final sample contains 73,768 observations covering 5,933 firms. The observation count is relatively stable across different years and does not display a clear trend over time. On average, 2,305 firms are present in a given year, ranging from 1,923 in 2016 to 2,561 in 1992. Table A2 describes how observations, revenue, and employment are distributed over the different 2-digit industries in our final sample.

The *Enquête Structurelle des Entreprises* (ESE) is an annual survey conducted by Statistics Belgium that provides a detailed breakdown of intermediate inputs. We use this data for the 2008 to 2016 period, as it is unavailable prior to 2008. Statistics Belgium separates firms into five different classes based on their number of employees, revenue, and social security status. Firms in class five, that is, firms with above 50 employees and a revenue of above eight million euros, are obligated to fill out the survey annually. Firms in other classes are subject to a rotating sample. If firms in class five do not cover at least 50% of annual activity, then the survey is supplemented with data from firms from lower classes, until the 50% threshold is reached.[34] From the ESE, we construct a bundle of services expenditure consisting of expenditure on the separately observed components (i) external labor, (ii) gifts, (iii) insurance, (iv) rent, and (v) software. The ESE sample contains 13,959 observations covering 2,702 firms (ranging from 1,311 in 2014 to 1,940 in 2012). Firms that are in the ESE data report on average 5.17 years out of a possible nine.

[34] See https://www.ejustice.just.fgov.be/cgi/article_body.pl?language=nl&caller=summary&pub_date=08-09-22&numac=2008011338 for a more detailed description (in Dutch).

Table A2
Percentage share of total revenue, employment, and observations, by 2-digit industry.

Industry	Revenue share	Employment share	Observations share	Observations
10	16.1	12.01	15.6	11,506
11	0.96	0.62	0.48	356
12	1.21	0.53	0.46	340
13	3.63	6.19	8.18	6,033
14	1.01	1.28	2.02	1,488
15	0.24	0.39	0.39	291
16	1.19	1.29	2.95	2,179
17	3.19	2.82	2.89	2,132
18	1.39	2.80	5.08	3,746
19	3.19	0.60	0.23	170
20	15.57	11.62	7.78	5,741
21	3.39	3.03	1.52	1,124
22	3.83	4.16	6.24	4,605
23	3.40	5.68	7.43	5,482
24	12.49	9.20	3.00	2,213
25	4.07	7.06	12.19	8,994
26	3.78	4.64	2.53	1,868
27	2.64	4.47	3.13	2,306
28	5.56	8.76	8.66	6,388
29	10.67	8.61	2.78	2,052
30	0.87	1.04	0.85	628
31	0.88	2.04	3.87	2,858
32	0.38	0.61	1.14	840
33	0.38	0.54	0.58	428

Notes: 2-digit-industry shares of total revenue, employment, and observations. Shares calculated as percentage of sample total. Percentage shares rounded to two decimal points. Based on the full sample of 73,768 observations covering 1985 to 2016.

A.2. Definition of variables

The following list gives the definition of key variables taken from the AA

- Revenue (R_{it}): Total revenue net of value-added taxes (VAT)
- Capital (K_{it}): Total book value of tangible fixed assets
- Labor (L_{it}): Full-time equivalent employment
- Cost of goods sold ($COGS_{it}$): Sum of expenditure on labor and intermediate inputs
- Variable cost of goods sold ($VCOGS_{it}$): Sum of expenditure on labor and goods
- Intermediate input expenditure ($P^M_{it}M_{it}$): Sum of expenditure on goods and services
- Labor expenditure ($W_{it}L_{it}$): Total labor expenditure consisting of gross wages and all other labor expenses, such as employers' mandatory social security and pension contributions
- Goods expenditure ($P^G_{it}G_{it}$): Sum of expenditure on raw materials and consumables
- Services expenditure ($P^S_{it}S_{it}$): Sum of expenditure on services and all other goods
- Production cost (PC_{it}): Sum of $0.1K_{it}$ and expenditure on labor and goods
- Total cost (TC_{it}): Sum of production costs and expenditure on services
- Gross profit ratio: The ratio of revenue to production cost
- Net profit ratio: The ratio of revenue to total cost

The following list gives the definition of key variables taken from the ESE, the total of which constitutes our complete bundle of ESE services

- External Labor Expenditure ($P^{EW}_{it}EW_{it}$): Sum of costs related to agency workers and persons placed at the disposal of the enterprise
- Gifts Expenditure ($P^{GI}_{it}GI_{it}$): Sum of costs related to gifts and donations
- Insurance Expenditure ($P^{IN}_{it}IN_{it}$): Sum of premiums for non-life insurance
- Rent Expenditure ($P^{RN}_{it}RN_{it}$): Sum of rental payments for land, buildings, machinery, plant, equipment, furniture and vehicles
- Software Expenditure ($P^{SW}_{it}SW_{it}$): Sum of expenditure on computer software

Table A3
Output elasticities and markups: median *mean* (standard deviation), by 2-digit industry.

Industry	Goods elasticity	Labor elasticity	Markup	Observations
10	0.91 *0.92* (0.04)	0.16 *0.16* (0.04)	1.44 *1.79* (2.28)	11,506
11	0.83 *0.83* (0.03)	0.22 *0.22* (0.02)	2.50 *3.12* (2.79)	356
12	0.94 *0.93* (0.05)	0.14 *0.16* (0.05)	1.46 *1.87* (1.76)	340
13	0.82 *0.81* (0.10)	0.26 *0.27* (0.09)	1.49 *1.98* (2.89)	6,033
14	0.75 *0.76* (0.16)	0.33 *0.33* (0.16)	1.38 *2.02* (3.10)	1,488
15	0.71 *0.72* (0.15)	0.39 *0.37* (0.15)	1.40 *1.47* (0.47)	291
16	0.85 *0.86* (0.07)	0.23 *0.21* (0.07)	1.45 *1.86* (2.99)	2,179
17	0.83 *0.85* (0.07)	0.23 *0.22* (0.07)	1.54 *1.72* (1.65)	2,132
18	0.62 *0.65* (0.08)	0.43 *0.40* (0.09)	1.47 *1.92* (1.87)	3,746
19	0.89 *0.84* (0.19)	0.19 *0.22* (0.15)	1.24 *2.31* (4.25)	170
20	0.85 *0.85* (0.06)	0.22 *0.23* (0.05)	1.47 *2.15* (3.56)	5,741
21	0.73 *0.72* (0.08)	0.34 *0.34* (0.07)	1.66 *2.25* (2.77)	1,124
22	0.82 *0.83* (0.08)	0.24 *0.25* (0.08)	1.57 *1.81* (1.85)	4,605
23	0.71 *0.72* (0.08)	0.34 *0.34* (0.08)	1.54 *1.86* (1.70)	5,482
24	0.83 *0.82* (0.13)	0.24 *0.25* (0.12)	1.46 *1.80* (1.43)	2,213
25	0.74 *0.73* (0.09)	0.34 *0.34* (0.09)	1.49 *2.08* (2.63)	8,994
26	0.75 *0.74* (0.11)	0.33 *0.34* (0.11)	1.55 *2.02* (2.70)	1,868
27	0.73 *0.73* (0.08)	0.35 *0.35* (0.08)	1.45 *1.74* (1.63)	2,306
28	0.71 *0.71* (0.07)	0.38 *0.37* (0.07)	1.44 *1.83* (2.14)	6,388
29	0.86 *0.84* (0.08)	0.22 *0.24* (0.08)	1.43 *1.89* (2.27)	2,052
30	0.70 *0.72* (0.15)	0.36 *0.36* (0.15)	1.47 *1.74* (0.96)	628
31	0.69 *0.71* (0.07)	0.38 *0.37* (0.07)	1.46 *1.59* (1.59)	2,858
32	0.76 *0.76* (0.09)	0.32 *0.32* (0.09)	1.38 *2.23* (3.55)	840
33	0.72 *0.73* (0.07)	0.37 *0.35* (0.07)	1.54 *2.67* (4.23)	428
Full sample	0.80 *0.79* (0.11)	0.28 *0.28* (0.11)	1.48 *1.91* (2.43)	73,768

Notes: Table A3 shows summary statistics for the output elasticities of goods and labor, and markups. For each 2-digit industry, the median, mean (in italics), and standard deviation (in brackets) are displayed. Medians, means, and standard deviations are rounded to 2 decimal points. Output elasticities are median 3-digit-industry-by-year production cost shares and markups are estimates assuming that goods are variable. Based on the full sample of 73,768 observations.

Appendix B. Classifying services

Our baseline estimates build on the assumptions that services are overhead. Therefore, they do not enter the production function or the cost shares used to estimate output elasticities – i.e., $F(K_{it}, L_{it}, G_{it})$. Throughout the main text, however, we discuss how estimation and results are impacted by instead assuming that services are a fixed input in production – i.e., $F(K_{it}, L_{it}, G_{it}, S_{it})$. This appendix explains the reasoning behind this approach in more detail. Ultimately, the services expenditure bundle appears to have characteristics of both overhead costs and expenditure on fixed inputs, and as we cannot distinguish these perfectly we highlight results from both in the main text. As discussed, our main results – that cost structures have moved away from variable inputs and towards services expenditure over time, and that this is associated with higher markups but only somewhat higher net profit ratios – are unaffected by how we classify services.

In Section 5, we explore the ESE survey data, which allows us to observe a more detailed breakdown of services expenditure. Rental expenditure closely resembles capital, and is probably best thought of as a fixed input. Most other components – such as expenditure on insurance, software, and external workers – align better with overhead costs. In addition, the sum of all ESE services expenditure covers, on average, only about a fifth of total services expenditure. Hence, it does not seem appropriate to conclude that services consists entirely of either overhead costs or expenditure on fixed inputs based on the ESE survey alone.

If services, like capital, is a fixed input that is determined dynamically by firms, we might expect its marginal revenue product to be more dispersed than that of goods as firms face (potentially firm-specific) adjustment frictions that prevent them from immediately adjusting input use to ensure that marginal revenue products equal the going input prices when faced with economic shocks. The role of such dynamic inputs in misallocation is studied in Asker et al. (2014), to which we refer for a more detailed discussion and from which we borrow the following analysis. Assume that services are an input of production, so they enter the production function. To construct output elasticities and obtain a measure of total factor revenue productivity, we assumed that technology is constant within a 3-digit-industry-by-year cell and given by a Cobb-Douglas production function. If we additionally assume that demand is isoelastic (with demand elasticity ε) and 3-digit-industry-by-year specific – $Q_{it} = P^{-\varepsilon_{st}}$ – we can obtain the logged marginal revenue product of input X ($X \in \{K, G, S\}$) as

$$MRPX_{it} = \ln\left(\theta^X_{st}\frac{\varepsilon_{st}-1}{\varepsilon_{st}}\right) + \ln(R_{it}) - \ln(X_{it}), \tag{B1}$$

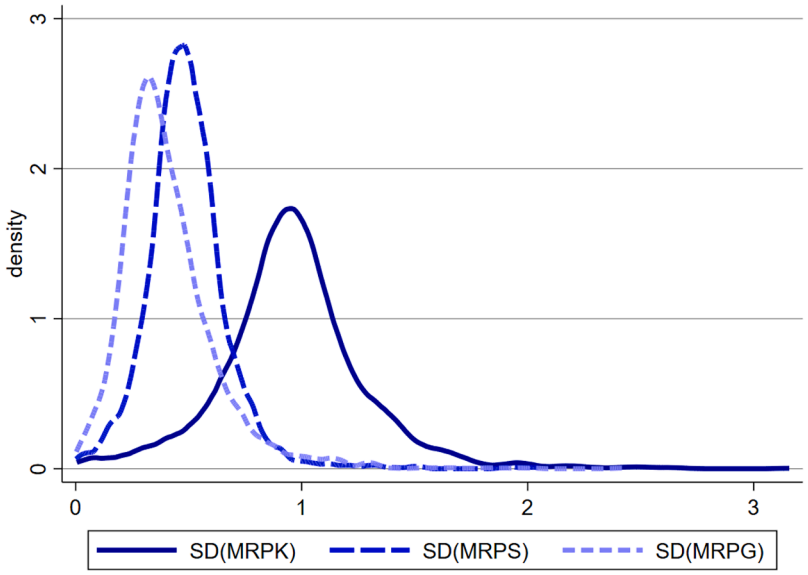


Fig. B.6. Density of 3-digit-industry-by-year standard deviations of marginal revenue products of inputs.

where the first term in brackets is the revenue elasticity of input X. Eq. B1 makes it clear that any within-3-digit-industry-by-year dispersion of input X's marginal revenue product is due to dispersion in $\ln(R_{it}) - \ln(X_{it})$. Fig. B.6 displays the distribution across different 3-digit-industry-by-year cells of the standard deviation of the marginal revenue products of capital, services, and goods. We view capital as a fixed production input that is dynamically determined, so that it is unsurprising that it's marginal revenue product is the most dispersed – $Mean(SD_{st}(MRPK_{it}) = 0.96$ and $Median(SD_{st}(MRPK_{it})) = 0.95$. Goods, on the other hand, contain variable production factors that are relatively easy to adjust. Accordingly, it has the least dispersed marginal revenue product – $Mean(SD_{st}(MRPG_{it}) = 0.41$ and $Median(SD_{st}(MRPG_{it})) = 0.37$. Services fall in between the two other inputs, although the distribution more closely resembles that of goods than of services – $Mean(SD_{st}(MRPS_{it}) = 0.49$ and $Median(SD_{st}(MRPG_{it})) = 0.48$. Assuming that services are an input of production, we have shown that they behave more like a fixed input than goods does, but less so than capital does. Again, the suggestion is that services might contain elements that are best thought of as fixed inputs, but that this is likely not be true of the entire services bundle.[35]

Finally, we investigate our markup estimates to conclude that services likely contain expenditure best characterized as overhead costs. Recall that we estimate markups as

$$\mu_{it} = \frac{Median_{st}\left(1.1 \frac{P_{it}^{G} G_{it}}{\text{total cost of production inputs}}\right) R_{it}}{P_{it}^{G} G_{it}}, \tag{B2}$$

so the only difference between markups estimated under the assumption that services are a fixed input and markups estimated treating services as overhead is the specification of the total cost of production inputs – TC_{it} under the fixed input interpretation and PC_{it} under the overhead interpretation. As total costs weakly exceed production costs that omit services, the fixed input interpretation will lead to lower markups and bias markups down if services are overhead. We, therefore, examine the fraction of markups that are estimated to be below unity in both approaches. In the overhead interpretation, markups below one occur in 5,066 instances (6.87 percent of the sample). In the fixed input interpretation, markups below unity characterize 19,518 observations (26.46 percent of the sample). While there are valid reasons why firms might occasionally sell at a price below marginal cost, and while the assumptions inherent in the cost share approach to markup estimation might cause some bias, it seem particularly unlikely that more than 25 percent of all firm-years in Belgian manufacturing sell goods at a loss. More likely, only a smaller part of services expenditure relates to inputs of the production function, while a larger part is best thought of as overhead costs.

[35] Note that this analysis does not inform us on how likely it is that services are overhead, as in that case they would not enter the production function and their marginal revenue product would not be defined unless we alter the demand function to depend on services.

Appendix C. Additional figures

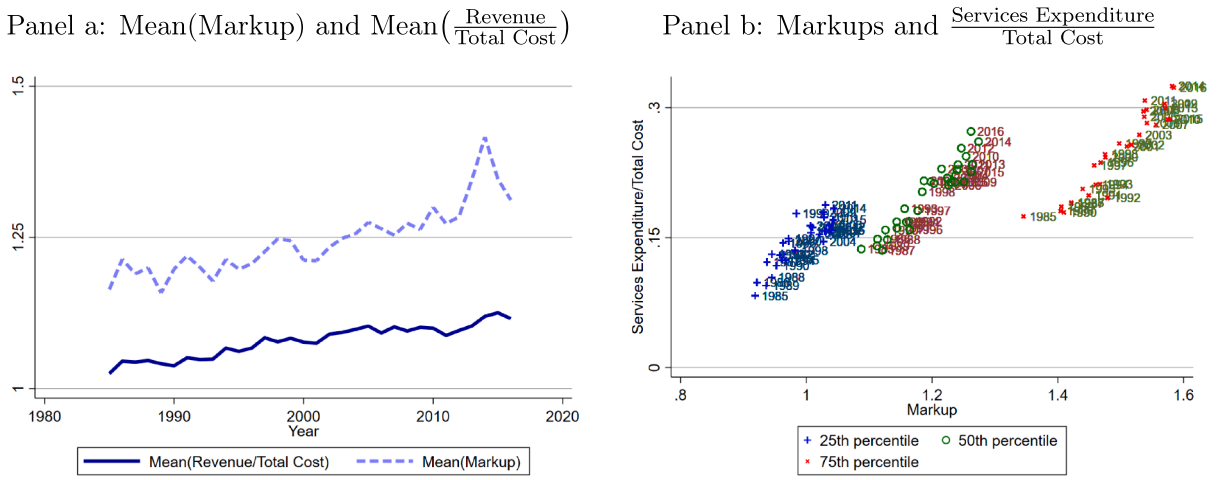


Fig. C.7. Figures assuming that services are a fixed input of production.
Notes: The revenue-weighted averages of the markup and the net profit ratio (panel b), and a replication of panel b of Fig. 4 (panel b), under the assumption that services are a fixed input and enter the production function.

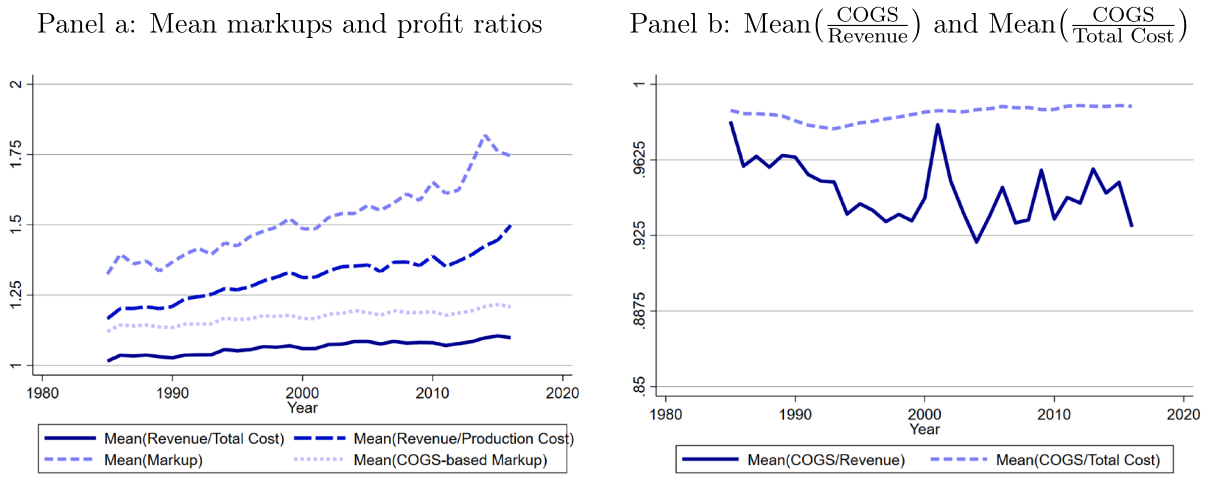


Fig. C.8. Cost-weighted averages of markups, profitability, and COGS shares, over time.
Notes: The total-cost-weighted averages of the markup (calculated assuming that either goods or COGS are variable), and the net and gross profit ratios (panel a), and the total-cost-weighted averages of the shares of COGS in revenue and total cost (panel b), over time. COGS refers to the sum of labor expenditure and intermediate input expenditure. Based on the full samples of 73,768 observations covering the years 1985 to 2016.

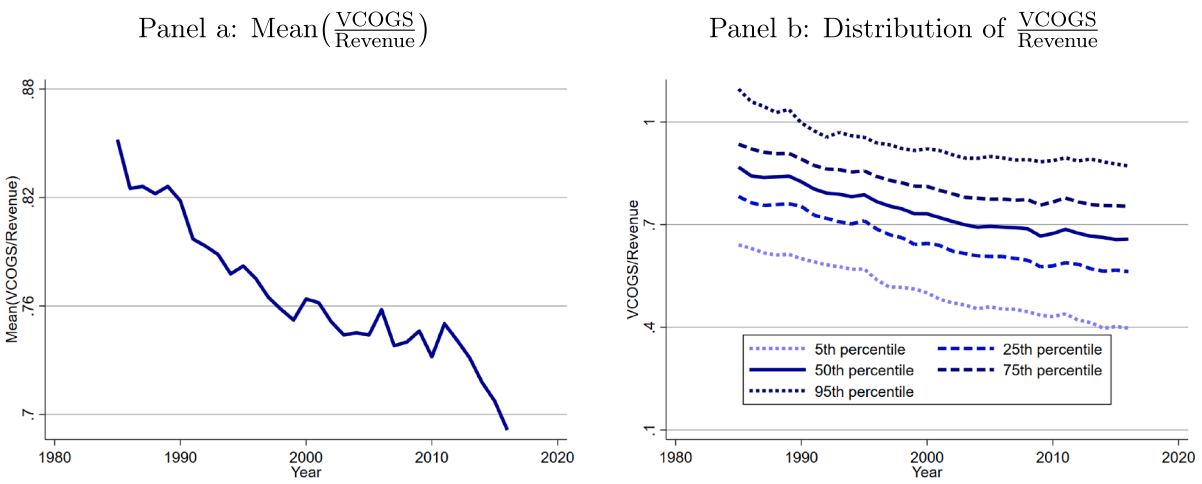


Fig. C.9. VCOGS revenue share, over time.

Notes: The revenue-weighted average (panel a), and selected percentiles from the distribution (panel b), of the share of VCOGS in revenue, over time. VCOGS refers to the sum of labor expenditure and goods expenditure. Based on the full samples of 73,768 observations covering the years 1985 to 2016.

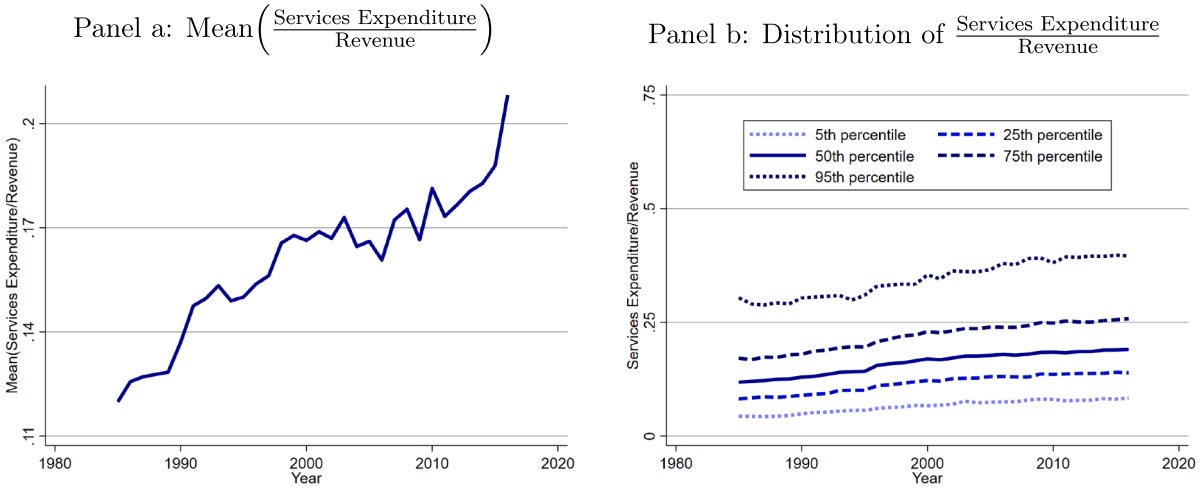


Fig. C.10. Services revenue share, over time.

Notes: The revenue-weighted average (panel a), and selected percentiles from the distribution (panel b), of the share of services expenditure in revenue, over time. Based on the full samples of 73,768 observations covering the years 1985 to 2016.

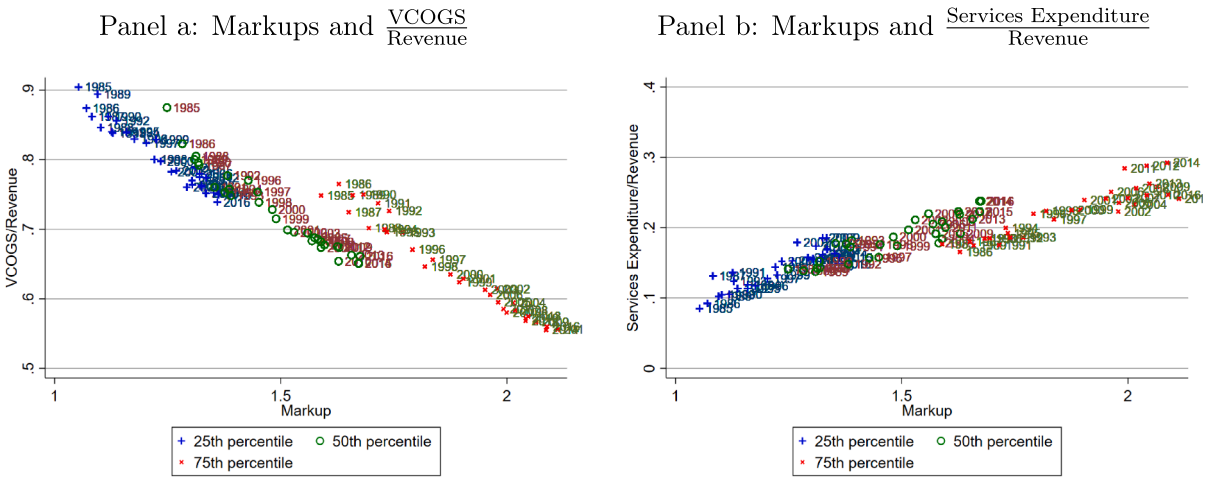


Fig. C.11. Correlation between markups and input expenditure revenue shares.
Notes: The sample for the p^{th} percentile in year t consists of all observations between the $(p-5)^{th}$ and $(p+5)^{th}$ percentile of the markup distribution in year t. Using this sample, the weighted average markup and either the weighted average VCOGS share of revenue (panel a), or the weighted average services expenditure share of revenue (panel b) are calculated. Weights are given by revenue shares.

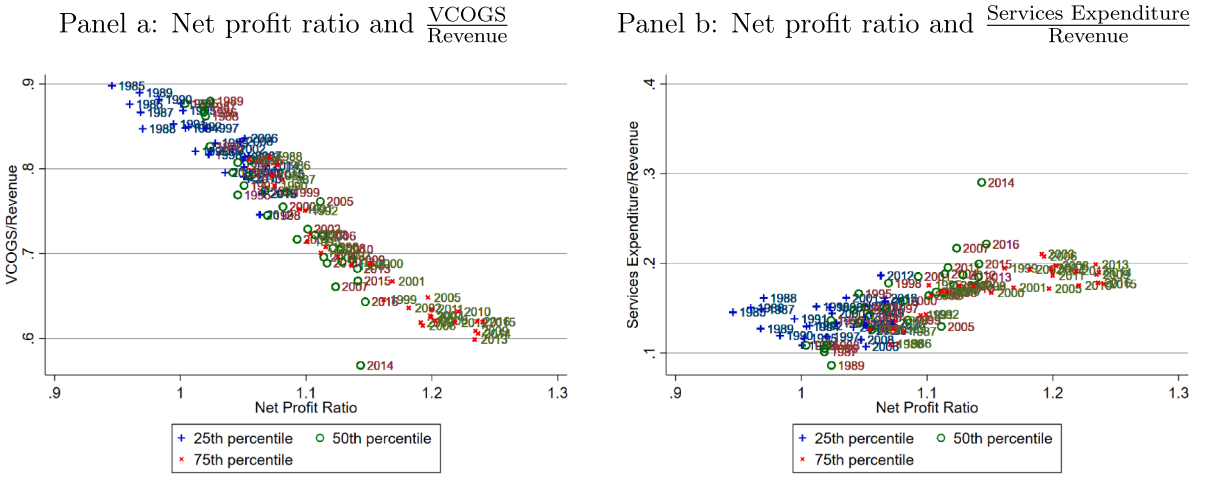


Fig. C.12. Correlation between net profit ratios and input expenditure revenue shares.
Notes: The sample for the p^{th} percentile in year t consists of all observations between the $(p-5)^{th}$ and $(p+5)^{th}$ percentile of the profit ratio distribution in year t. Using this sample, the weighted average profit ratio and either the weighted average VCOGS share of revenue (panel a), or the weighted average services expenditure share of revenue (panel b) are calculated. Weights are given by revenue shares.

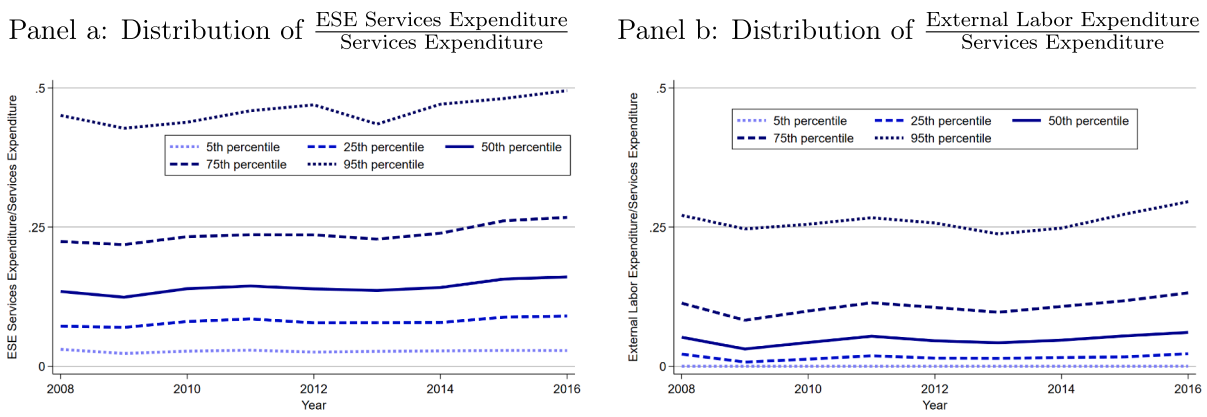


Fig. C.13. Services shares of ESE services and external labor, over time.

Notes: Selected percentile from the distributions of the share of ESE services expenditure (panel a) and external labor expenditure (panel b) in total services expenditure, over time. Based on the ESE samples of 13,959 observations covering the years 2008 to 2016.

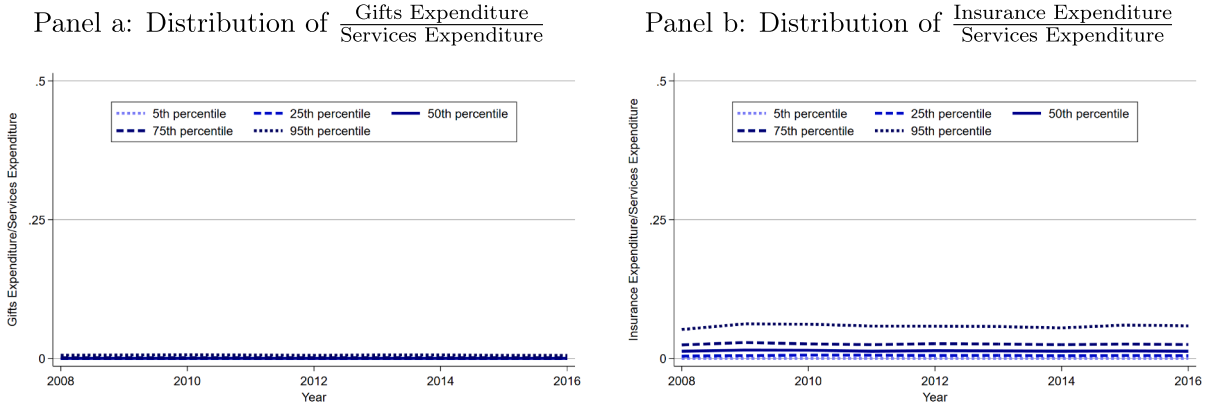


Fig. C.14. Services shares of gifts and insurance, over time.

Notes: Selected percentile from the distributions of the share of gifts expenditure (panel a) and insurance expenditure (panel b) in total services expenditure, over time. Based on the ESE samples of 13,959 observations covering the years 2008 to 2016.

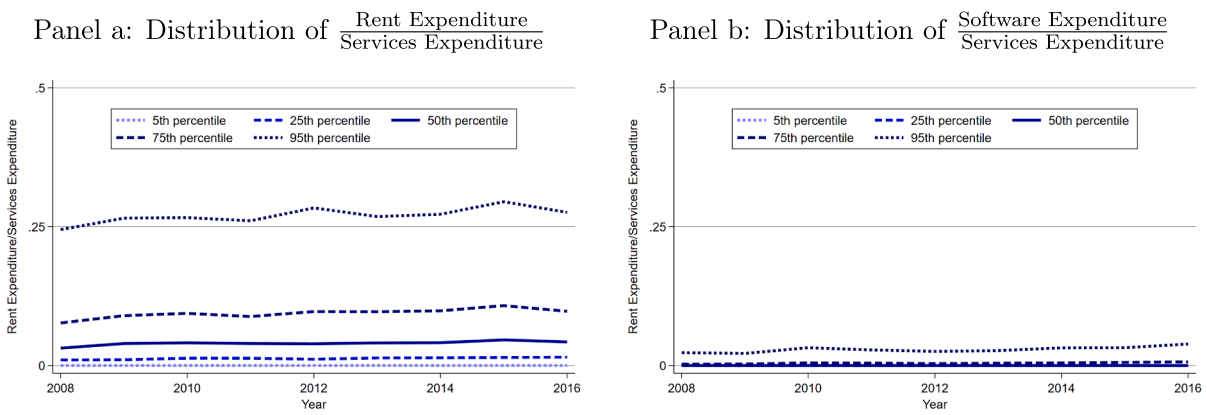


Fig. C.15. Services shares of rent and software, over time.

Notes: Selected percentile from the distributions of the share of rent expenditure (panel a) and software expenditure (panel b) in total services expenditure, over time. Based on the ESE samples of 13,959 observations covering the years 2008 to 2016.

Appendix D. Additional tables

Table D1

Input use: Substitutes and complements (revenue shares).

	Dependent variable: ln(Services Expenditure/Revenue)					
	(1)	(2)	(3)	(4)	(5)	(6)
ln(VCOGS/Revenue)	-1.07	-0.27				
	(0.125)***	(0.064)***				
ln(Labor Expenditure/Revenue)			0.32	0.27		
			(0.044)***	(0.025)***		
ln(Goods Expenditure/Revenue)					-0.52	-0.35
					(0.057)***	(0.025)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.32	0.77	0.28	0.79	0.34	0.79

Notes: Table D1 reports output from regressions relating the revenue shares of different inputs; VCOGS refers to the sum of labor expenditure and goods expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the full sample of 73,768 observations covering the years 1985 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table D2
Input use: Substitutes and complements (outliers).

	Dependent variable: ln(Services Expenditure/Total Cost)					
	(1)	(2)	(3)	(4)	(5)	(6)
ln(VCOGS/Total Cost)	-0.94	-1.03				
	(0.052)***	(0.043)***				
ln(Labor Expenditure/Total Cost)			-0.02	-0.14		
			(0.019)	(0.019)**		
ln(Goods Expenditure/Total Cost)					-0.08	-0.14
					(0.012)***	(0.017)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.95	0.97	0.77	0.85	0.79	0.86

Notes: Table D2 reports output from regressions relating the total cost shares of different inputs; VCOGS refers to the sum of labor expenditure and goods expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the reduced sample of 3,914 observations, which contains only firms that are in the top 5% of the services cost share distribution for each 2-digit-industry-by-year combination with at least 20 observations, covering the years 1985 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table D3
Services expenditure cost shares and firm performance if services are a fixed input of production.

Dependent variable:	ln(Markup)		ln(TFPR)	
	(1)	(2)	(3)	(4)
ln(Services Expenditure/Total Cost)	0.50	0.41	0.09	0.08
	(0.025)***	(0.028)***	(0.013)***	(0.042)*
Industry×Year FE	×		×	
Firm FE & Year FE		×		×
R^2	0.34	0.79	0.96	0.81

Notes: Table D3 reports output from regressions relating the total cost share of services expenditure to markups and TFPR under the assumption that services are a fixed input of production and, therefore, enter the production function; TFPR refers to total factor revenue productivity; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the full sample of 73,768 observations covering the years 1985 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table D4
Services expenditure revenue shares and firm performance.

Dependent variable:	ln(Markup)		ln(TFPR)		ln(VCOGS)	
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Services Expenditure/Revenue)	0.41	0.25	0.25	0.24	-0.49	-0.50
	(0.016)***	(0.020)***	(0.018)***	(0.038)***	(0.061)***	(0.042)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.27	0.77	0.95	0.83	0.23	0.92
Dependent variable:	ln(Services)		ln(Gross Profit Ratio)		ln(Net Profit Ratio)	
	(7)	(8)	(9)	(10)	(11)	(12)
ln(Services Expenditure/Revenue)	0.69	0.56	0.16	0.05	-0.06	-0.14
	(0.053)***	(0.047)***	(0.014)***	(0.013)***	(0.017)***	(0.014)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.32	0.92	0.37	0.68	0.21	0.58

Notes: Table D4 reports output from regressions relating the revenue share of services expenditure to measures of firm performance; TFPR refers to total factor revenue productivity; VCOGS refers to the sum of labor expenditure and goods expenditure; Services refers to services expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the full sample of 73,768 observations covering the years 1985 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table D5
Services expenditure cost shares and firm performance (outliers).

Dependent variable:	ln(Markup)		ln(TFPR)		ln(VCOGS)	
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Services Expenditure/Total Cost)	1.47	1.03	1.33	0.63	-0.95	-0.78
	(0.242)***	(0.069)***	(0.185)***	(0.212)***	(0.445)**	(0.141)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.57	0.92	0.86	0.86	0.51	0.95
Dependent variable:	ln(Services)		ln(Gross Profit Ratio)		ln(Net Profit Ratio)	
	(7)	(8)	(9)	(10)	(11)	(12)
ln(Services Expenditure/Total Cost)	0.89	1.00	0.77	0.76	-0.02	0.01
	(0.443)*	(0.143)***	(0.063)***	(0.060)***	(0.045)	(0.059)
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.55	0.95	0.66	0.80	0.51	0.71

Notes: Table D5 reports output from regressions relating the total cost share of services expenditure to measures of firm performance; TFPR refers to total factor revenue productivity; VCOGS refers to the sum of labor expenditure and goods expenditure; Services refers to services expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the reduced sample 3,914 observations, which contains only the firms who are in the top 5% of the services cost share distribution for each 2-digit-industry-by-year combination with at least 20 observations, covering the years 1985 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table D6
Input use: Substitutes and complements (ESE sample).

Dependent variable:	ln(Services Expenditure/Total Cost)					
	(1)	(2)	(3)	(4)	(5)	(6)
ln(VCOGS/Total Cost)	-2.54	-2.27				
	(0.097)***	(0.070)***				
ln(Labor Expenditure/Total Cost)			0.37	0.20		
			(0.041)***	(0.047)***		
ln(Goods Expenditure/Total Cost)					-0.71	-0.59
					(0.059)***	(0.042)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.80	0.97	0.31	0.91	0.50	0.94

Notes: Table D6 reports output from regressions relating the total cost shares of different inputs; VCOGS refers to the sum of labor expenditure and goods expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the full ESE sample of 13,959 observations covering the years 2008 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table D7
ESE input use: Substitutes and complements (additional results).

Dependent variable:	ln(External Labor/Total Cost)			
	(1)	(2)	(3)	(4)
ln(Labor Expenditure/Total Cost)	0.60	0.26		
	(0.092)***	(0.130)*		
ln(Goods Expenditure/Total Cost)			-0.69	-0.58
			(0.138)***	(0.067)***
Industry×Year FE	×		×	
Firm FE & Year FE		×		×
R^2	0.19	0.73	0.17	0.73
Observations	12,945	12,945	12,945	12,945
Dependent variable:	ln(Rent/Total Cost)			
	(5)	(6)	(7)	(8)
ln(Labor Expenditure/Total Cost)	0.62	0.59		
	(0.052)***	(0.076)***		
ln(Goods Expenditure/Total Cost)			-0.75	-0.62
			(0.071)***	(0.068)***
Industry×Year FE	×		×	
Firm FE & Year FE		×		×
R^2	0.22	0.81	0.20	0.80
Observations	12,586	12,586	12,586	12,586

Notes: Table D7 reports output from regressions relating the total cost shares of different inputs; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the full ESE sample of 13,818 observations covering the years 2008 to 2016; Standard errors clustered at the 2-digit-industry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table D8
Services expenditure cost shares and firm performance (ESE sample).

Dependent variable:	ln(Markup)		ln(TFPR)		ln(VCOGS)	
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Services Expenditure/Total Cost)	0.64	0.63	0.50	0.48	-0.94	-0.73
	(0.038)***	(0.042)***	(0.029)***	(0.061)***	(0.083)***	(0.075)***
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.44	0.90	0.93	0.84	0.36	0.97
Dependent variable:	ln(Services)		ln(Gross Profit Ratio)		ln(Net Profit Ratio)	
	(7)	(8)	(9)	(10)	(11)	(12)
ln(Services Expenditure/Total Cost)	0.37	0.58	0.32	0.33	0.03	0.03
	(0.086)***	(0.071)***	(0.015)***	(0.014)***	(0.017)*	(0.013)**
Industry×Year FE	×		×		×	
Firm FE & Year FE		×		×		×
R^2	0.30	0.97	0.53	0.87	0.14	0.76

Notes: Table D8 reports output from regressions relating the total cost share of services expenditure to measures of firm performance; TFPR refers to total factor revenue productivity; VCOGS refers to the sum of labor expenditure and goods expenditure; Services refers to services expenditure; All regressions include an unreported constant term; Industry×Year FE refers to 3-digit-industry-by-year fixed effects; Based on the full ESE sample of 13,959 observations covering the years 2008 to 2016; Standard errors clustered at the 2-digit-idustry level; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

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