Wage markups and buyer power in intermediate input markets[*]

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February 2023

Abstract

A rapidly growing literature suggests that monopsony power is common in US labor markets. I examine whether this result generalizes to Europe, where collective bargaining agreements characterize labor markets. I use Dutch firm-level manufacturing data from 2007 to 2018, together with an efficient bargaining model and revenue function estimation. Wages are typically above the marginal revenue contribution of employees. This is not in line with monopsonistic labor markets but precisely what is expected when employees have bargaining power and can extract rents from their employers. In addition, I provide evidence of buyer power in intermediate input markets and show that firms that underpay their input suppliers on the margin set higher wage markups. This suggests that firms share rents generated in intermediate input markets with their employees. Firm-time-specific rent sharing elasticities indicate that firms increase wages on average by 0.22 percent following a 1 percent increase in quasi-rents per employee.

Keywords: Monopsony; Rent sharing; Buyer power; Revenue function estimation

JEL Codes: D43; J31; J42; J50; L10

[*]I thank Dan Ackerberg, Eric Bartelsman, Filippo Biondi, Jan De Loecker, Katharina Erhardt, Nadine Hahn, Paul Heidhues, Matthias Mertens, Michael Rubens, Tobias Salz, Jo Seldeslachts, Joel Stiebale, Jo Van Biesebroeck, Frank Verboven, and seminar participants at DICE, KU Leuven, and the 2021 EARIE (Bergen), 2021 CAED (Coimbra), 2022 IIOC (Boston), 2022 EEA (Milan), and 2022 JEI (Las Palmas) conferences for useful comments and discussions. Results based on calculations using non-public microdata from Statistics Netherlands (CBS). This research is funded by the Open Data Infrastructure for Social Science and Economic Innovations (ODISSEI) in the Netherlands (`www.odissei-data.nl`). Remaining errors are my own.

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1 Introduction

A rapidly growing literature suggests that monopsonistic labor markets are the norm in the United States, allowing firms to mark down wages relative to the marginal revenue product of labor, which leads to misallocation and reduces welfare (e.g., Yeh et al. (2022); Berger et al. (2022); Lamadon et al. (2022)).[1] These findings have led to a surge of policy proposals.[2] Unlike in the US, European labor markets are characterized by collective bargaining agreements that could cause firms to share rents with their employees, eliminating monopsony concerns. Determining whether monopsony results translate to European labor markets is of first-order policy concern and is, therefore, the first aim of this paper.

Buyer power in intermediate input markets is also documented by an emerging literature (e.g., Morlacco (2020); Rubens (2021), Avignon and Guigue (2022)). When firms are not wage takers in the labor market, buyer power in other input markets can influence wages. However, studies of imperfectly competitive labor markets typically ignore imperfections in other input markets. The second aim of this paper is to fill this gap by studying intermediate input market imperfections and their relation to wages.

In this paper, I study imperfect competition in labor markets and buyer power in intermediate input markets in Dutch manufacturing from 2007 to 2018. Collective bargaining agreements are central to Dutch labor markets, while intermediate input markets are fairly concentrated and rely heavily on imports. I choose this setting because Dutch labor markets are representative of western European labor markets, and because buyer power has been documented in comparable intermediate input markets in France (Morlacco, 2020).

I develop a simple theoretical framework where firms bargain with collectively organized workers in the labor market and potentially possess buyer power in the market for intermediate inputs. In this setting, wages are marked up above the marginal revenue product of labor. In contrast, when firms have monopsony power, wage markdowns are expected. Likewise, if firms have buyer power in the market for intermediates, intermediate input prices are marked down relative to the marginal revenue product of intermediates. Finally, the extent of the wage markup depends positively on the rents a firm generates. As buyer power increases rents, firms with more buyer power should pay higher wages, all else equal.

I estimate the input wedges of labor and intermediate inputs to test these theoretical predictions. An input wedge is the ratio of an input's marginal revenue product to its price. I show that input wedges can be expressed as the revenue elasticity of an input divided by its expenditure share in revenue. Akin to Petrin and Sivadasan (2013), I estimate a revenue function using a control function approach to recover revenue elasticities of labor

[1] Manning (2021) and Card (2022) survey the recent monopsony literature.

[2] See the Department of Justice's 2016 Antitrust Guidance for Human Resource Professionals, the Federal Trade Commission's 2018 hearing on Multi-Sided Platforms, Labor Markets and Potential Competition (Hearing #3, October 15–17), and calls by academics to reform antitrust practice concerning labor markets (e.g., Naidu et al. (2018); Marinescu and Posner (2019)).

and intermediate inputs.[3] In contrast, the US-based monopsony results of Yeh et al. (2022) are based on labor wedges identified using the production approach.

The production approach is the prevalent approach to identifying labor wedges. It relies on production function estimation and requires the existence of a variable input that is frictionlessly adjustable and for which firms are price takers.[4] This literature tends to select intermediate inputs – often referred to as "materials" – as this variable input. I show that this approach underestimates the labor wedge if firms have buyer power in the market for intermediate inputs. As buyer power might be a concern in the Dutch setting I study, the production approach is not suitable. The main advantage of my identification strategy is that it allows for buyer power in all input markets.

I find that wage markups are prevalent in Dutch manufacturing, covering more than 75 percent of all observations. At the median, wages are marked up by 16 percent over the marginal revenue product of labor. This is not in line with monopsony power, which would result in wage markdowns as observed in US manufacturing by Yeh et al. (2022), but is in line with employees using their bargaining power to extract rents from firms. In contrast, intermediate input wedges suggest that buyer power for intermediates is common in Dutch manufacturing. The median intermediates price markdown is 15 percent. This finding is in line with Morlacco (2020), who finds evidence of buyer power for imported intermediate inputs in French manufacturing.

The labor wedge distribution and the intermediate input wedge distribution show substantial dispersion. This dispersion is not caused by variation over time, suggesting that adjustment frictions do not play an important role. Within-industry differences, rather than between-industry differences, are the primary driver of input wedge variation, implying that firm-specific factors shape variation in wage markups more than industry-specific ones. I show that within-industry wage markup variation is largely unrelated to the revenue-generating abilities of employees but can be explained by wage variation. In addition, firms that underpay their input suppliers on the margin set higher wage markups. The higher a firm's intermediate input price markdown, the higher its wage. The data, therefore, support the hypothesis that the distribution of wage markups is shaped not by worker ability but by firms sharing rents generated in the intermediate input market with their employees.

To quantify rent sharing, I estimate the firm-level responsiveness of wages to rents. In my efficient bargaining model, firms bargain about wages and employment, consistent with the Dutch setting where employee associations trade off wage increases with unemployment. In this setting, firms act as if they are wage takers facing the employees' outside option as the

[3]See Olley and Pakes (1996), Levinsohn and Petrin (2003), and Ackerberg et al. (2015).

[4]Applications are in Lu et al. (2019), Mertens (2021, 2022), Caselli et al. (2021), Brooks et al. (2021), Yeh et al. (2022), and in papers that estimate measures closely related to the labor wedge based on the marginal revenue product of labor and the wage (e.g., Mertens (2020); Dobbelaere et al. (2020); Dobbelaere and Wiersma (2020)).

going wage – they set the marginal revenue product of labor equal to the employees' outside option. Relative bargaining power between employers and employees then determines how much of the firm's rents are captured by employees in the form of wages exceeding their outside option. These insights allow me to use revenue function estimates to identify the employees' outside option. Rent sharing elasticities are obtained by comparing actual wages to implied outside options.

I show that the elasticity of wage with respect to a firm's quasi-rents can be written as a Lerner index wage markup: the ratio of wage minus the marginal revenue product of labor to the wage. The standard approach in the rent sharing literature is to regress wages on a measure of rents and several controls (see Card et al. (2018) for a survey). This method delivers an average of the underlying firm-specific rent sharing elasticities. In addition, as both the employees' and the firms' outside option are typically unobserved, instruments for a firm's rents that do not also shift the outside options are required. In contrast, my approach recovers firm-time-specific elasticities using an efficient bargaining model and revenue function estimation.

I find that firms pay their employees on average 0.22 percent more following a 1 percent increase in quasi-rents per employee. The distribution of elasticities is right skewed, with wages increasing by less than 0.5 percent following a 1 percent increase in quasi-rents per employee in 95 percent of all cases and increasing by less than 0.1 percent in roughly 25 percent of all cases. The mean elasticities I report are in line with, but slightly below, the rent sharing elasticities reported in Van Reenen (1996) and Kline et al. (2019). In addition, I show that the rent sharing elasticity I obtain using a standard regression approach is comparable to the mean of the firm-time specific elasticities.

The main implication of this paper is that concerns about widespread monopsony power are unlikely to be warranted in European labor markets characterized by collective bargaining agreements. The second implication is that researchers should be careful when identifying labor market imperfections by restricting imperfections in other input markets. Specifically, in my Dutch sample, using the prevalent production approach to identify the labor wedge would substantially bias estimates of the labor wedge and ignore the connection between the two input markets. The third implication of this paper is that there exists substantial variation in rent-sharing elasticities, which can not be entirely identified by regressing wages on a measure of rents. This paper shows how an efficient bargaining model and revenue function estimation allow consideration of these implications

Key results in this paper require estimates of revenue elasticities of labor and intermediate inputs. A firm's revenue function depends on primitives of demand and supply, each potentially containing unobserved determinants. Identification of revenue functions, therefore, potentially requires strong assumptions on which unobservables are relevant and how they evolve over time. I show that all key results are robust to a host of alternative approaches to obtaining revenue elasticities. In particular, all key results remain valid when ignoring revenue function estimation altogether and simply calibrating a single revenue elasticity for each input. The reason is that my results are driven by variation of revenue shares of input expenditure, which are observed, and not by variation of revenue elasticities.

This paper contributes to three different strands of literature. First, the literature on monopsony power.[5] Yeh et al. (2022) estimate plant-level labor wedges for US manufacturing from 1976 to 2014 and, in line with monopsony power, find that most plants have wage markdowns. In Germany, a considerable number of firms are characterized by wage markdowns, although substantially less than in the US. These wage markdowns are concentrated in firms setting high average wages (Mertens, 2021) and are markedly less likely to occur where collective bargaining agreements cover employees (Dobbelaere et al., 2020). In line with the current paper, these findings suggest that wage markdowns are unlikely to occur when collective bargaining agreements are central to labor markets. Finally, wage markdowns are found to substantially decrease labor shares in China and India (Brooks et al., 2021), and Germany (Mertens, 2022).[6]

The second strand of literature related to this paper studies rent sharing. An extensive literature regresses wages on a measure of rents and controls to obtain an average rent sharing elasticity (see Card et al. (2018) for a recent survey). I contribute by instead relying on revenue function estimation and an efficient bargaining model to identify firm-time-specific rent sharing elasticities. Several papers provide evidence of rent sharing based on production function estimation. Dobbelaere and Mairesse (2013) classify the majority of French manufacturing firms as operating in labor markets characterized by efficient bargaining.[7] Caselli et al. (2021) report sizeable wage markups in French manufacturing and show that these wage markups decline in response to Chinese import competition. Finally, Card and Cardoso (2022) report a 20 percent wage markup over sectoral wage floors in Portugal, a country also characterized by high collective bargaining coverage.

The third strand of related work is an emerging literature on buyer power in intermediate input markets. Morlacco (2020) finds evidence of buyer power for imported intermediate inputs in French manufacturing. Rubens (2021) finds that ownership consolidation in Chinese cigarette manufacturing has increased intermediate input price markdowns by 30 percent. A fundamental difficulty in this literature is that prices of intermediate inputs are typically unobserved. This prevents the current paper from making detailed inferences on the origins of buyer power. Input prices are observed by Avignon and Guigue (2022), who show that

[5] I focus on papers estimating labor wedges using the production approach. Other common approaches include estimating labor supply elasticities and relating labor market concentration to wage measures. Manning (2021) and Card (2022) survey the monopsony literature.

[6] Several papers study the relation between decreasing protectionism and monopsony power (e.g., Lu et al. (2019); Mertens (2020); Dobbelaere and Wiersma (2020)). Results depend heavily on the country, and the particular deregulation studied.

[7] See also Crépon et al. (2005) and Dobbelaere and Mairesse (2018). These papers jointly estimate markups in output markets and imperfections in labor markets.

French dairy manufacturers have buyer power in the market for raw milk. Atalay (2014) does not directly study buyer power, but does find dispersion in materials' prices within narrowly defined industries producing relatively homogeneous goods in the US, and shows that within-supplier markup differences can explain part of this dispersion.

This paper contributes to the aforementioned articles by considering both labor and intermediate input market imperfections. The production approach identifies labor wedges by ruling out buyer power in another input market. I show that using this approach to study Dutch manufacturing would overestimate the extent of wage markups and rule out buyer power for intermediates. My primary contribution is permitting buyer power for both labor and intermediates. This allows me to study imperfections in both input markets as well as their relation.

The remainder of this paper proceeds as follows. In Section 2, the theoretical framework and the Dutch setting on which it is based are introduced. Section 3 outlines the empirical approach to identifying input wedges and the data. Section 4 provides the results and robustness checks, followed by concluding remarks in Section 5.

2 Theoretical framework

This section presents the theoretical framework and the Dutch institutional setting. I introduce a simple model that links a firm's optimality conditions for labor and intermediate inputs to input wedges. An input wedge is the ratio of an input's marginal revenue product to its price. The model provides an interpretation of these wedges and several empirical hypotheses which are explored in this paper.

2.1 Setting

In the Netherlands, employees' compensation and labor market legislation are primarily determined by collective bargaining and dialogue between federations of employee associations, firms, and, occasionally, the government. Collective agreements are central to Dutch labor markets. Collective bargaining coverage in the Netherlands in 2016 was 78.6 percent, compared to 11.5 percent in the US (OECD, 2019a).[8] High collective bargaining coverage characterizes all western European labor markets and is the main difference between labor markets in the United States and Europe.[9]

Bargaining is an institutional feature of Dutch labor markets that is supported by the

[8]The collective bargaining coverage is the share of all employees whose terms of employment are governed by at least one collective agreement. The 2016 OECD average is 32.4 percent.

[9]OECD countries for which bargaining coverage was at least 70 percent in 2016 are Austria, Belgium, Denmark, Finland, France, Iceland, Italy, the Netherlands, Norway, Portugal, Slovenia, Spain, and Sweden (OECD, 2019a).

central government. Each year, firms and associations of employees meet to set guidelines for the subsequent wage adjustments and other outcomes such as mandatory social security contributions (Visser, 2016). Collective agreements apply automatically to all workers employed by firms involved in a particular agreement, regardless of whether those employees are members of an employee association (Hijzen et al., 2019). Unionization rates and union membership status are, therefore, no longer directly tied to collective bargaining coverage. This has allowed coverage to remain stable and high while unionization rates decreased rapidly the past 30 years.[10]

The Netherlands has a "two-level" bargaining system. Bargaining at the sector level sets wage floors, while bargaining at the firm level determines wages and employment. Collective agreements at the sector level specify various pay scales determined by factors such as seniority and job description. Firms can and do form their own agreements with employee associations, creating firm-level variation in collective agreements within industries. In addition, firms usually have some discretion when allocating employees to pay scales and awarding premiums, ensuring that collective agreements act primarily as wage floors. Bargaining in most of western Europe is organized similarly, and a robust result from the literature is that actual wages tend to exceed wage floors substantially (e.g., Cardoso and Portugal (2005); Card et al. (2014); Bhuller et al. (2022)).[11]

Low unemployment and high minimum wages characterize the Dutch labor market. In 2016, the real annual minimum wage in the Netherlands was 55.24 percent higher than the real annual minimum wage in the US. Compared to Germany, the concomitant percentage differences was only 6.77 (OECD, 2019b).[12] Unemployment as a percentage of the labor force increased following the financial crisis of 2007-2008, but remained relatively low at on average 5.3 percent throughout the sample period (OECD, 2019c).

Collective agreements are absent in the Dutch intermediate input market, so interactions between firms and their input suppliers are bilateral. Intermediate input markets are fairly concentrated and Dutch firms frequently rely on imports. Dutch imports totaled 75.16 percent of GDP in 2015, compared to 15.4 percent in the US.[13] In 2018, more than 80

[10]Decreasing unionization rates have forced unions to rely less on members' contributions to finance their operations. For instance, from 2019 to 2020, the largest Dutch employee association maintained a constant budget while seeing contributions from private firms and the government increase at the expense of members' contributions. See `https://www.fnv-magazine. nl/fnv-jaarverslag-2020`.

[11]The 1982 Wassenaar agreement between the leading employee association and employer representatives set the stage for decentralization of collective bargaining over wages and other labor market outcomes. This decentralization allowed firms to deviate from national or industry-level collective agreements by increasing the scope for firm-level bargaining. Under "semi-binding law", deviations from higher-level agreements can be specified in written agreements between firms and their employees (Hijzen et al., 2019).

[12]Real annual minimum wages are computed by converting statutory minimum wages into a common hourly and annual pay period and then converting the sums into a common currency unit (USD) using Purchasing Power Parities (PPPs) for private consumption expenditure.

[13]Obtained from `https://data.worldbank.org/indicator/NE.IMP.GNFS.ZS?most_`

percent of Dutch imports accrued to either manufacturing or wholesale and retail trade, with manufacturing imports exceeding 100 billion (CBS, 2019b, p.69). According to the OECD, low business dynamism characterizes Dutch manufacturing and a relatively large share of business is concentrated in larger firms.[14]

Two main differences emerge between input markets in the US and the Netherlands. First, while in the US, relations between firms and their input suppliers are primarily bilateral. In the Netherlands, firms interact mainly with employee associations in the labor market. Second, sellers and buyers in input markets are mainly domestic in the US, while intermediate input suppliers are often foreign firms in the Netherlands. In French manufacturing, Morlacco (2020) finds evidence of buyer power for imported intermediate inputs. Therefore, a suitable theoretical framework should incorporate the collective nature of Dutch labor markets while simultaneously allowing – but not imposing – firms to have buyer power in intermediate input markets.

2.2 Model

To model the key characteristics of the Dutch labor market, I rely on the efficient bargaining setting of McDonald and Solow (1981).[15] In this setting, employee associations have bargaining power and capture part of the surplus generated by firms. I allow firms to have finite input supply elasticities in the market for intermediate inputs. This allows for – but does not impose – buyer power in the intermediate input market.

Firm i's production function at time t is given by

$$Q_{it} = F_{it}^{Q}(K_{it}, L_{it}, M_{it})\Omega_{it}^{Q}, \tag{1}$$

where K_{it}, L_{it}, and M_{it} are, respectively, a firm's capital, labor, and intermediate inputs, and Ω_{it}^{Q} is Hicks-neutral total factor productivity. The production function is assumed to be twice differentiable with respect to its arguments, with $\frac{\partial Q_{it}}{\partial x} > 0$ and $\frac{\partial^2 Q_{it}}{\partial x^2} < 0$ for $x \in \{K_{it}, L_{it}, M_{it}\}$. Inverse demand is given by

$$P_{it}(Q_{it}) = F_{it}^{P}(Q_{it})\Omega_{it}^{P}, \tag{2}$$

where Ω_{it}^{P} is a demand shock. $P_{it}(Q_{it})$ is assumed to be twice differentiable with respect to quantity, with $\frac{\partial P_{it}}{\partial Q_{it}} < 0$. The profit of firm i at time t is given by

$$\Pi_{it} = R_{it}(Q_{it}) - P_{it}^{K}K_{it} - W_{it}L_{it} - P_{it}^{M}(M_{it})M_{it}, \tag{3}$$

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[14] "Larger firms" are defined as firms with 50+ employees, and Dutch manufacturing is compared to manufacturing in a group of EU countries. See OECD (2021) for details.

[15] Efficient bargaining models are standard in the rent sharing literature and have been used before to model labor markets in western European manufacturing (e.g., Dobbelaere and Mairesse (2013)).

where $R_{it}(Q_{it}) = P_{it}(Q_{it})Q_{it}$ is revenue, P^K_{it} is the user cost of capital, W_{it} the wage, and $P^M_{it}(M_{it})$ the price of intermediate inputs. I assume that $\frac{\partial R_{it}}{\partial x} > 0$ and $\frac{\partial^2 R_{it}}{\partial x^2} < 0$ for $x \in \{K_{it}, L_{it}, M_{it}\}$.[16]

In the labor market, a firm's wage and employment result from bargaining with an association of employees. The association maximizes

$$U(L_{it}, W_{it}) = L_{it}(W_{it} - \bar{W}_{it}), \tag{4}$$

where $\bar{W}_{it} > 0$ is the outside option of the association's workers.[17] Equation (4) is standard in the literature on rent sharing and captures the notion that the employee association puts weight on both employment and wages (Card et al., 2018). If bargaining fails, employees are assumed to obtain their outside option. If the employee association has any bargaining power at all, therefore, $W_{it} > \bar{W}_{it}$. Profit if bargaining fails is denoted by $\bar{\Pi}_{it} > 0$. Therefore, firm profit should exceed $\bar{\Pi}_{it}$ if firm i has bargaining power. Following the literature, $\bar{W}_{it}$ and $\bar{\Pi}_{it}$ are assumed to be independent of W_{it} and L_{it}.

By modeling bargaining as a single interaction between firms and employee associations, I abstract from the two-level bargaining that occurs in practice. Unfortunately, data limitations ensure that I can not distinguish the wage floors resulting from sectoral bargaining from wages and employment resulting from bargaining at the firm level. I, therefore, follow Card et al.'s (2014) approach to modeling two-level bargaining in Italy and represent the negotiation process as a single efficient bargaining game between a firm and an employee association. I interpret results as measuring the sum of wage premiums received by workers, including those resulting from firm-level deviations from sectoral wage floors.[18]

I assume that labor, wages, and intermediate inputs can be adjusted each period. Not all sectoral collective agreements are adjusted yearly so this assumption can be questioned for labor and wages. In western Europe, the majority of firms adjust wages each year, and wages tend to substantially exceed sectoral wage floors (e.g., Bhuller et al. (2022)).[19] These findings suggest that the firm-level tier of bargaining is sufficiently flexible to overcome sector-level rigidities. In line with this, Caloia et al. (2021) show that the staggered setting of collective

[16] Positive first derivatives of the revenue function require that marginal revenue is positive, as for all inputs x we have $\frac{\partial R_{it}}{\partial x} = \frac{\partial R_{it}}{\partial Q_{it}}\frac{\partial Q_{it}}{\partial x}$ and $\frac{\partial Q_{it}}{\partial x} > 0$ by assumption. $\frac{\partial^2 R_{it}}{\partial x^2} < 0$ requires $\frac{\partial^2 P_{it}}{\partial Q_{it}^2}$ to either be negative, or positive but not too large, as $\frac{\partial^2 R_{it}}{\partial x^2} = \frac{\partial R_{it}}{\partial Q_{it}}\frac{\partial^2 Q_{it}}{\partial x^2} + \frac{\partial^2 R_{it}}{\partial Q_{it}\partial x}\frac{\partial Q_{it}}{\partial x}$ and $\frac{\partial^2 R_{it}}{\partial Q_{it}\partial x} = \frac{\partial Q_{it}}{\partial x}(2\frac{\partial P_{it}}{\partial Q_{it}} + \frac{\partial^2 P_{it}}{\partial Q_{it}^2}Q_{it})$. A simple example where all assumed properties hold is an iso-elastic demand curve together with a Cobb-Douglas production function.

[17] This is typically thought of as a firm-level average of employees' "unemployment compensation benefits, but should really include all the other contributions to the standard of living that would not be received if workers were employed by the bargaining firm"(McDonald and Solow, 1981, p.899).

[18] Alternatively, one could think of the employees' outside option being shifted by the sectoral wage floor and my theoretical framework as firm-level bargaining where sectoral outcomes are taken as given.

[19] Based on a survey covering 15 countries, Fabiani et al. (2010) show that about 75 percent of all firms adjust wages at least once a year.

agreements does not materially affect firm-level employment in the Netherlands. Therefore, treating labor and wages as variable appears reasonable. I focus on the firm's two variable inputs and assume that capital is predetermined.[20]

The generalized Nash-bargaining solution to the bargaining process between the firm and the employee association solves

$$\max_{L_{it},M_{it},W_{it}} (L_{it}(W_{it}-\bar{W}_{it}))^{\phi_{it}}(R_{it}(Q_{it})-P^K_{it}K_{it}-W_{it}L_{it}-P^M_{it}(M_{it})M_{it}-\bar{\Pi}_{it})^{1-\phi_{it}}, \tag{5}$$

where ϕ_{it} denotes the bargaining power of the employee association ($0<\phi_{it}<1$), which is taken as given by the firm.[21] I allow – but do not impose – bargaining power to be firm-specific.

The first-order condition with respect to W_{it} is

$$W_{it}=\bar{W}_{it}+\frac{\phi_{it}}{1-\phi_{it}}\left(\frac{R_{it}(Q_{it})-P^K_{it}K_{it}-W_{it}L_{it}-P^M_{it}(M_{it})M_{it}-\bar{\Pi}_{it}}{L_{it}}\right), \tag{6}$$

and the first-order condition with respect to L_{it} is

$$W_{it}=MRPL_{it}+\phi_{it}\left(\frac{R_{it}(Q_{it})-P^K_{it}K_{it}-MRPL_{it}L_{it}-P^M_{it}(M_{it})M_{it}-\bar{\Pi}_{it}}{L_{it}}\right), \tag{7}$$

where $MRPL_{it}=\frac{\partial R_{it}}{\partial Q_{it}}\frac{\partial Q_{it}}{\partial L_{it}}$, the marginal revenue product of labor. Combining first-order conditions (6) and (7) shows that $MRPL_{it}=\bar{W}_{it}$, which implies that the firm's optimal input selection results in the same revenue product as the input choices of a firm operating in a perfectly competitive labor market facing wage $\bar{W}_{it}$. This insight will allow me to identify bargaining power and rent sharing elasticities later on.

The optimality conditions given in equations (6) and (7) can be related to the labor wedge. Denote the labor wedge by

$$\gamma^L_{it}=\frac{MRPL_{it}}{W_{it}}. \tag{8}$$

Define a firm's quasi-rents as $QR_{it}=R_{it}(Q_{it})-P^K_{it}K_{it}-\bar{W}_{it}L_{it}-P^M_{it}(M_{it})M_{it}-\bar{\Pi}_{it}$, which are positive whenever a firm engages in bargaining. A firm's quasi-rents represent the surplus to be divided between the firm (profit in excess of the firm's outside option) and its employees (wages in excess of the employees' outside option). From first-order conditions (6) and (7) it is then clear that

$$W_{it}-MRPL_{it}=\phi_{it}\frac{QR_{it}}{L_{it}}, \tag{9}$$

[20] Within a period, $P^K_{it}K_{it}$ represents the yearly payment flow of predetermined capital – shaped, for instance, by depreciation. Card et al. (2014) study a two-period efficient bargaining model with dynamic capital formation.

[21] I follow the rent sharing literature and leave endogenizing bargaining power for future work as this would greatly complicate the model and detract from the main contributions of this paper.

which shows that $W_{it} > MRPL_{it}$, or, equivalently, that $\gamma_{it}^{L} < 1$. Wages are marked up relative to the marginal revenue product of labor – wage markups occur. Equation (9) states that the extent of the wage markup depends on the bargaining power of the employee association and the quasi-rents per employee.

In the market for intermediate inputs, I allow for buyer power by assuming that $P_{it}^{M}(M_{it})$ is continuous and monotonically increasing in M_{it}, and that the supply elasticity of intermediate inputs, $(\varepsilon_{it}^{M})^{-1} = \frac{\partial P_{it}^{M}}{\partial M_{it}} \frac{M_{it}}{P_{it}^{M}}$, is positive but finite ($0 < (\varepsilon_{it}^{M})^{-1} < \infty$). This approach nests the competitive case in the limit as $(\varepsilon_{it}^{M})^{-1}$ approaches 0. The first-order condition of (5) with respect to M_{it} is

$$MRPM_{it} = P_{it}^{M}(M_{it})(\frac{\varepsilon_{it}^{M}+1}{\varepsilon_{it}^{M}}), \tag{10}$$

where $MRPM_{it} = \frac{\partial R_{it}}{\partial Q_{it}} \frac{\partial Q_{it}}{\partial M_{it}}$, the marginal revenue product of intermediate inputs. Equation (10) states that when the intermediates supply elasticity is finite, a wedge is driven between the marginal revenue product of intermediates and their price. Denote this intermediate input wedge by

$$\gamma_{it}^{M} = \frac{MRPM_{it}}{P_{it}^{M}}. \tag{11}$$

Equation (10) and $0 < (\varepsilon_{it}^{M})^{-1} < \infty$ imply that $\gamma_{it}^{M} > 1$. When the intermediate input wedge is above unity, the price of intermediates is marked down relative to their marginal revenue product – intermediate input price markdowns occur. The extent of the markdown depends on the elasticity of intermediate input supply. The less elastic is supply, the larger the intermediates markdown.

My approach to modeling intermediate input markets does not impose buyer power and does not require taking a stand on the origins of buyer power. This prevents me from having to make strong assumptions on unobservables and generates testable predictions that hold in a wide variety of models.[22] However, the lack of data on supplier networks and input prices implies that I can not identify the sources of buyer power. By focusing on the measurement and description of buyer power and the relation between labor markets and intermediate input markets, this paper sets a first step that future work on buyer power for intermediate inputs can build on.

My theoretical framework makes three main predictions regarding input wedges. First, we should expect wage markups – labor wedges below unity – given that collective bargaining agreements are prevalent in Dutch manufacturing. Second, if buyer power exists in the intermediate input market, we should find intermediate input price markdowns – wedges above unity. Finally, labor wedges and intermediate input wedges should be negatively

[22] In Appendix C, I give several examples of models where the intermediate input wedge captures the extent of buyer power.

related. Firms will exercise buyer power only if it increases quasi-rents and the extent of a wage markup depends on these quasi-rents. The following section outlines the empirical approach I use to investigate these predictions. Below, I first discuss the generality of this simple model.

While standard in the rent sharing literature, my theoretical framework abstracts from a more general bargaining setting with many employee associations and firms. Using more sophisticated bargaining models and allowing for adjustment frictions would substantially increase the notational complexity without altering the main predictions or the empirical analysis. The critical insight is that when employees have bargaining power, they will capture a share of their employer's quasi-rents leading to wage markups.

Note that not all firms are expected to have wage markups. Firms will only participate in bargaining if this leads to a weakly higher profit than their outside option. Firms with access to a sufficiently large competitive or monopsonistic labor market need not rely on an employee association to purchase labor. Likewise, when a firm with monopsony power bargains with an employee association, both wage markups and wage markdowns are possible outcomes, depending on the relative bargaining power of the two players (Falch and Strøm, 2007). Labor wedges should, therefore, not be expected to be below unity for all firms. However, given that collective bargaining agreements cover roughly 80 percent of Dutch employment, wage markups are expected to characterize most firms.

When inputs are not homogeneous, the input wedges introduced in this section are still informative. I model both labor and intermediate inputs as homogeneous goods because I do not observe input heterogeneity in my data, as is the case for most datasets on balance sheets and income statements such as Worldscope and Orbis. In reality, labor is heterogeneous, with high-skilled employees generally receiving higher wages and generating more revenue than low-skilled employees. In addition, intermediate inputs are typically a bundle comprising several inputs such as raw materials and energy. The input wedges introduced in equations (8) and (11) can be expressed as weighted averages of the wedges of the different input types, with weights that depend on revenue elasticities.[23] Therefore, the labor wedge should be interpreted as the average labor wedge across all labor markets the firms is active in, and likewise for the intermediate input wedge. Mertens (2021) provides a detailed theoretical underpinning of the "average input-wedge" interpretation of homogeneous input wedges.

3 Empirical approach

This section presents the empirical approach used to obtain input wedges and test key predictions of the theoretical model discussed in Section 2. Identification of input wedges is based

[23]For example, assume that there are two types of labor, indexed by $L1$ and $L2$. Equation (12) and $\frac{W_{it}L_{it}}{R_{it}} = \frac{W_{it}^{L1}L_{it}^{L1}}{R_{it}} + \frac{W_{it}^{L2}L_{it}^{L2}}{R_{it}}$ together imply that $\frac{\theta_{it}^{L}}{\gamma_{it}^{L}} = \frac{\theta_{it}^{L1}}{\gamma_{it}^{L1}} + \frac{\theta_{it}^{L2}}{\gamma_{it}^{L2}}$.

on revenue elasticities and is introduced in Section 3.1. Section 3.2 outlines the estimation of revenue elasticities, while Section 3.3 presents the data and descriptive statistics.

3.1 Identifying input wedges

Multiplying equation (8) by $\frac{L_{it}R_{it}}{L_{it}R_{it}}$ and equation (11) by $\frac{M_{it}R_{it}}{M_{it}R_{it}}$ gives

$$\gamma_{it}^{L} = \frac{\theta_{it}^{L}}{LS_{it}}, \text{ and } \gamma_{it}^{M} = \frac{\theta_{it}^{M}}{MS_{it}} \tag{12}$$

where $\theta_{it}^{L} = \frac{\partial R_{it}}{\partial L_{it}}\frac{L_{it}}{R_{it}}$ and $\theta_{it}^{M} = \frac{\partial R_{it}}{\partial M_{it}}\frac{M_{it}}{R_{it}}$ are the revenue elasticities of labor and intermediate inputs, LS_{it} is the labor share of revenue $\frac{W_{it}L_{it}}{R_{it}}$, and MS_{it} is the intermediate input share of revenue $\frac{P_{it}^{M}M_{it}}{R_{it}}$. Equation (12) requires firms to be active in both input markets and inputs to be substitutable, in line with the theoretical framework.[24] Input shares of revenue are observed in the data while revenue elasticities need to be estimated as they are not observed. Before discussing how I estimate revenue elasticities, I first compare my approach to other approaches to estimating input wedges.

The identification approach used in this paper is closely related to Petrin and Sivadasan (2013), who estimate a revenue function to obtain marginal revenue products of materials and electricity and compare these to industry-specific input price indices.[25] In contrast, equation (12) relies on an input's revenue elasticity and revenue share. My approach sidesteps problems that arise when input expenditure is deflated with an industry-wide price index but input prices are firm-specific.[26] Also related are papers that assume industry-specific input prices and use dispersion of calibrated marginal revenue products to study misallocation (e.g., Hsieh and Klenow (2009)).

In contrast, a rapidly growing literature estimates the labor wedge (e.g. Lu et al. (2019); Mertens (2021, 2022); Caselli et al. (2021); Brooks et al. (2021): Yeh et al. (2022)), or closely related measures based on the marginal revenue product of labor and the wage (e.g., Mertens (2020); Dobbelaere et al. (2020); Dobbelaere and Wiersma (2020)) using an approach relying on output elasticities and first-order conditions from cost minimization. This production approach uses insights from the markup estimation methodology of De Loecker and Warzynski (2012) to identify γ_{it}^{L}.

To understand the production approach to labor wedge estimation, first denote a firm's

[24]For measuring input wedges when inputs are perfect complements, I refer to Rubens (2021).

[25]Petrin and Sivadasan (2013) are primarily interested in estimating a production function to identify an alternative labor wedge – the value of the marginal product of labor divided by the wage. In the case of competitive output markets, their measure is identical to the labor wedge discussed in this paper.

[26]Recently, Hashemi et al. (2022) suggest that researchers use revenue elasticities to identify input wedges. I provide one approach to doing this in practice.

markup of price over marginal cost by $\mu_{it} = \frac{P_{it}}{\lambda_{it}}$. For any input V_{it}, let

$$\mu_{it}(V_{it}) = \frac{\tilde{\theta}^V_{it}}{P^V_{it} V_{it}/R_{it}}, \tag{13}$$

where $\tilde{\theta}^V_{it}$ is the output elasticity of input V_{it} and P^V_{it} is its price. Under the assumptions that V_{it} is frictionlessly adjustable, firms are price takers in the market for V_{it}, and firms select V_{it} to minimize their conditional cost function, De Loecker and Warzynski (2012) show that $\mu_{it}(V_{it}) = \mu_{it}$.[27] The choice of V_{it} is crucial in recovering the true markup μ_{it}. If the required assumptions on V_{it} do not hold, $\mu_{it}(V_{it})$ is a joint measure of μ_{it} and imperfections in the input market for V_{it}, so that $\mu_{it} \neq \mu_{it}(V_{it})$. This insight has led the production literature to estimate the labor wedge by comparing markup estimates obtained using different inputs as V_{it}. Most recent work attempts to identify the labor wedge by comparing $\mu_{it}(L_{it})$ to $\mu_{it}(M_{it})$. In particular,

$$\frac{\mu_{it}(L_{it})}{\mu_{it}(M_{it})} = \frac{\tilde{\theta}^L_{it} P^M_{it} M_{it}}{\tilde{\theta}^M_{it} W_{it} L_{it}} = \frac{\theta^L_{it}/LS_{it}}{\theta^M_{it}/MS_{it}} = \frac{\gamma^L_{it}}{\gamma^M_{it}}, \tag{14}$$

where the second equality follows from $\frac{\partial R_{it}}{\partial x} = \frac{\partial R_{it}}{\partial Q_{it}} \frac{\partial Q_{it}}{\partial x}$ for $x \in \{L_{it}, M_{it}\}$. If intermediate inputs are frictionlessly adjustable, and firms are price takers in the intermediates market, profit maximization implies that $MRPM_{it} = P^M_{it}$, so that $\gamma^M_{it} = 1$ and equation (14) identifies the labor wedge. In general, however, the production approach obtains the labor wedge relative to the wedge of a different input, in this case intermediate inputs. Applying the production approach in the Dutch context is problematic. Due to the institutional setting discussed in Section 2.1, I do not want to *a priori* rule out buyer power in the intermediate input market by assuming that $\gamma^M_{it} = 1$. A particularly attractive feature of my approach is that it does not require a frictionlessly adjustable input for which firms are price takers to identify input wedges. Therefore, I can investigate the relation between input market imperfections in labor markets and intermediate input markets instead of focusing only on labor markets.[28]

3.2 Estimating revenue elasticities

Identifying input wedges using equation (12) requires estimating revenue elasticities. Several approaches to estimating revenue functions exist, each with their own assumptions. This

[27] The conditional cost function refers to the static cost function conditional on other choice variables of the firm, which are potentially determined by a dynamic maximization problem.

[28] An alternative is to give up identifying the labor wedge and instead use equation (14) to identify the labor wedge relative to the intermediate input wedge. For instance, Morlacco (2020) identifies the wedge of imported intermediates relative to the wedge of domestic intermediates. Another approach, also taken in Morlacco (2020), is to make parametric assumptions on demand and competition and then use calibration to obtain a measure of μ_{it} so that the imported intermediates wedge can be backed out of the relative wedge equation.

section outlines the control function approach I use to generate revenue elasticities. In Section 4.4, I show that my results are robust to several alternative approaches to obtaining revenue elasticities. Appendix B contains a more detailed description of the estimation routine outlined below.

Like Petrin and Sivadasan (2013), I use insights from the literature on production function estimation to identify revenue elasticities. Note that I observe revenue, but not output, so that revenue function estimation is not plagued by the output price bias that would occur when deflated revenue is used in the place of output when estimating a production function (Klette and Griliches, 1996; De Loecker and Goldberg, 2014). Using revenue elasticities to identify input wedges, therefore, sidesteps strong identification concerns known for related ratio estimators based on output elasticities – particularly markups (Bond et al., 2021; De Ridder et al., 2022).[29]

Consider the revenue function of firm i at time t

$$R_{it} = F_{it}(K_{it}, L_{it}, M_{it})\Omega_{it}, \tag{15}$$

where Ω_{it} is Hicks-neutral revenue productivity which is potentially known to the firm at time t, but unobserved by the econometrician. As revenue results from multiplying quantity (1) and inverse demand (2), the key assumption made to ensure that revenue is given by equation (15) is that $F^P_{it}(F^Q_{it}(K_{it}, L_{it}, M_{it})\Omega^Q_{it})$ is multiplicatively separable in $F^Q_{it}(K_{it}, L_{it}, M_{it})$ and Ω^Q_{it}. This ensures that a single term that enters (15) multiplicatively contains all demand and supply shocks: $\Omega_{it} = F^P_{it}(\Omega^Q_{it})\Omega^P_{it}$.[30]

Taking logs and allowing for log-additive mean-zero deviations from planned revenue, ϵ_{it}, gives

$$r_{it} = f_{it}(k_{it}, l_{it}, m_{it}; \theta) + \omega_{it} + \epsilon_{it}, \tag{16}$$

where lowercase letters denote the natural logarithm of the concomitant uppercase letter and θ is a vector containing coefficients. The main challenge to identifying θ is controlling for unobserved (by the econometrician) revenue productivity captured in ω_{it}. If a firm's inputs at time t are at least partially determined by decisions made after the firm observes ω_{it} – which is clearly the case in the theoretical framework introduced in Section 2.2 – estimates of the revenue elasticities can be biased. A similar problem has long been recognized in the literature on production function estimation (Marschak and Andrews, 1944).

I use the control function approach, due to Olley and Pakes (1996) and Levinsohn and Petrin (2003), to deal with the correlation of unobserved revenue productivity and input choices.[31] A static input demand equation, demand for intermediate inputs, is used to

[29] An alternative solution to the output price bias is explicitly modeling the demand side (e.g., De Loecker (2011)).

[30] This holds, for instance, if $P_{it}(Q_{it}) = Q_{it}^{-\frac{1}{\epsilon}}\Omega^P_{it}$.

[31] See also Ackerberg et al. (2015) and Gandhi et al. (2020).

control for ω_{it},

$$m_{it} = m_d(\omega_{it}, k_{it}, l_{it}, \mathbf{x}_{it}^m; \delta^m), \tag{17}$$

where d is a 2-digit NACE industry, $\mathbf{x}_{it}^m$ contains additional control variables such as the firm's wage and 4-digit NACE industry intermediate input share, and δ^m contains all coefficients. Inverting equation (17) result in a control for ω_{it} based on observables which can be substituted into equation (16) under the "scalar unobservable" assumption – the assumption that revenue productivity ω_{it} is the sole unobservable in equation (17). In addition, $m_{it}(\cdot)$ is assumed to be one-to-one in ω_{it}. Note that revenue productivity ω_{it} potentially contains price variation due to demand shocks in output markets. Therefore, controlling for such price variation is unnecessary to satisfy the scalar unobservable assumption.[32]

Intermediate input demand can be derived from first-order condition (10) if one is willing to make parametric assumptions on a firm's demand, production function, and inverse intermediates supply. For expository purposes, consider a time-invariant Cobb-Douglas production function and an iso elastic demand so that the revenue function in equation (1) is given by $R_{it} = K_{it}^{\theta^K} L_{it}^{\theta^L} M_{it}^{\theta^M} \Omega_{it}$. Assuming inverse intermediates supply is iso elastic and given by $P_{it}^M = M_{it}^{(\varepsilon_{it}^M)^{-1}}$, the first-order condition of intermediate inputs in equation (10) can be rewritten to provide an expression for intermediates demand

$$M_{it} = \left(\frac{\varepsilon_{it}^M}{1+\varepsilon_{it}^M} \theta^M K_{it}^{\theta^K} L_{it}^{\theta^L} \Omega_{it} \right)^{\frac{1}{1+(\varepsilon_{it}^M)^{-1}-\theta^M}}, \tag{18}$$

which shows that satisfying the scalar unobservable assumption depends crucially on controlling for the intermediate input supply elasticity, in addition to capital and labor. This is done by including the firm's intermediate input share in $\mathbf{x}_{it}^m$. The intermediate input share controls for buyer power in a wide variety of models, as explained in Appendix C.

If the assumptions on demand, production, and intermediates supply are relaxed, the main point stands: satisfying the scalar unobservable assumption requires intermediate input demand to depend on other inputs and the supply elasticity of intermediate inputs.[33] Crucially, it is not necessary to control for bargaining power ϕ_{it}. Bargaining power affects intermediate input demand through its effect on labor, but not directly.

[32]The one-to-one assumption rules out adjustment frictions in intermediate inputs that are so severe that demand for intermediates does not respond to changes in revenue productivity. The main idea behind the control function approach is that the control, here intermediate inputs, can pin down unobserved revenue productivity.

[33]For instance, consider using a translog revenue function instead of a Cobb-Douglas revenue function. The key difference is that revenue elasticities are now firm-time-specific. However, revenue elasticity variation across firms and time is entirely due to difference in input use, so that including capital and labor in equation (17), in addition to a control for the intermediate input supply elasticity, is sufficient to satisfy the scalar unobservable assumption.

I use a translog revenue function, which results in firm-time specific revenue elasticities and is given by

$$f_d(k_{it}, l_{it}, m_{it}) = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_{kk} k_{it}^2 + \beta_{ll} l_{it}^2 + \beta_{mm} m_{it}^2 + \beta_{kl} k_{it} l_{it} + \beta_{km} k_{it} m_{it} + \beta_{lm} l_{it} m_{it}, \tag{19}$$

where d indicates the 2-digit NACE industry at which the revenue function is estimated and the revenue elasticities are given by $\theta_{it}^x = \frac{\partial f_d(\cdot)}{\partial x_{it}}$, where $x \in \{k, l, m\}$. Note that the translog revenue function does not restrict revenue returns to scale and allows for a flexible elasticity of substitution compared to a standard CES revenue function. A translog revenue function would result, for instance, if a firm's production function is translog and its demand is iso-elastic. Alternatively, equation (19) can be seen as a second-order approximation to an unspecified revenue function.

While I observe the number of full-time equivalent employees, I use deflated intermediate input expenditure and the deflated book value of capital in place of intermediate inputs and capital. If firm-level input prices differ from the input-specific 2-digit industry level deflators, and these differences correlate with input choices, estimates of the revenue elasticities will be biased. The input price bias is especially relevant for intermediate inputs, as the revenue elasticity of intermediates is needed to construct its input wedge, and firm-specific buyer power could create within-industry input price differences.[34]

To control for within-industry input price differences, I use as control function

$$b_{it} = b_d((1, k_{it}, l_{it}, m_{it}) \times \mathbf{x}_{it}^b; \delta^b), \tag{20}$$

where the notation indicates that inputs enter b_d only interacted with the control variables in $\mathbf{x}_{it}^b$ – due to the translog specification – and δ^b contains all coefficients. Following De Loecker et al. (2020), I control for price variation due to unobserved quality differences by using market shares and 4-digit NACE industry indicators. Location-based input price variation is controlled for by including indicator variables for the NUTS1 region where the firm is located. See De Loecker et al. (2016) for the theoretical underpinnings of this input price control function.

To control for within-industry intermediate input price differences stemming from buyer power, I include a firm's 4-digit NACE industry intermediate input share in $\mathbf{x}_{it}^b$. Intermediate input shares control for intermediate input price variation in a wide class of models of buyer power. Examples are given in Appendix C. Note that input price biases only occur if input price variation around the 2-digit industry-specific deflators exists. Therefore, models of buyer power with a single input price as equilibrium outcome do not produce an input price bias – for example, a Cournot-style input market for intermediates. Finally, note that $b_{it}(\cdot)$

[34] Input price biases are well known but mostly ignored in production function estimation. See De Loecker and Syverson (2022) for a review of the literature.

can partially control for input price variation even if it is misspecified so that its inclusion is always preferred (De Loecker et al., 2016).

To identify coefficients θ, I use a two-step estimation approach based on Ackerberg et al. (2015). In the first step, log revenue is regressed on a polynomial in the arguments of equations (19), (20), and the inverse of equation (17), $\omega_{it} = m_d^{-1}(k_{it}, l_{it}, m_{it}, \mathbf{x}_{it}^m; \delta^m)$.[35] This first step is not meant to identify any coefficients, but rather to separate observed revenue into planned revenue and a revenue shock: $r_{it} = \hat{r}_{it} + \hat{\epsilon}_{it}$. This is important as I need $\hat{\epsilon}_{it}$ to correct revenue shares when constructing the input wedges. Revenue shares need to be corrected as $R_{it}(\cdot)\exp(\epsilon_{it})$ is observed in the data, but firms base their decisions on planned revenue $R_{it}(\cdot)$. This is done by replacing the revenue shares in equations (12) by $\hat{LS} = \frac{W_{it}L_{it}}{R_{it}/\exp(\epsilon_{it})}$ and $\hat{MS} = \frac{P_{it}^M M_{it}}{R_{it}/\exp(\epsilon_{it})}$.

In the second step, I use as first-order Markov law of motion of revenue productivity

$$\omega_{it} = g_d(\omega_{it-1}; \delta^g) + \xi_{it}, \tag{21}$$

where ξ_{it} is a mean zero revenue productivity shock, $g_d(\cdot)$ a stochastically increasing function, and δ^g contains all coefficients. Using $\omega_{it} = \hat{r}_{it} - f_{it}(\cdot;\theta) - b_{it}(\cdot;\delta^b)$ together with the law of motion of revenue productivity allows me to obtain an estimate of the revenue productivity shock, $\hat{\xi}_{it}$, conditional on the still to be estimated coefficients.[36] Estimates are based on the following moment conditions

$$\mathbb{E}(\xi_{it}\mathbf{Z}_{it}) = 0, \tag{22}$$

where $\mathbf{Z}_{it}$ includes terms in $g_d(\cdot)$, a second-order polynomial in k_{it} and l_{it}, and interactions of contemporaneous capital and labor with all lagged inputs. The full unbalanced panel is used, and separate revenue functions are estimated for each 2-digit NACE industry. Estimates of revenue elasticities are reported in Table B1 of Appendix B.

Estimating a revenue function comes with several challenges, particularly concerning the treatment of unobserved revenue productivity. Equation (15) posits a Hicks-neutral revenue productivity term, while equation (21) states that revenue productivity evolves according to a first-order Markov process. These requirements are significant and, in particular, place strong restrictions on the underlying demand and productivity shocks. One solution is to specify particular demand and production functions. Akin to Petrin and Sivadasan (2013), assuming that $F(\cdot)^Q$ in equation (1) is a translog function and that demand is iso elastic, $P_{it}(Q_{it}) = Q_{it}^{-\frac{1}{\epsilon}}$, would alleviate concerns regarding the treatment of revenue productivity. To ensure that my results hold more generally, robustness to alternative ways to obtain

[35] I use a third-degree polynomial in all variables except for indicator variables and time trends, which are added linearly.

[36] I approximate $g_d(\cdot)$ by a third-degree polynomial and $b_d(\cdot)$ by a second-degree polynomial in all their arguments except indicator variables and time trends, which are added linearly.

revenue elasticities is crucial. Section 4.4 shows that my results are robust to, among other things, moments based on different timing assumptions, estimating the revenue function at the 4-digit industry instead of the 2-digit industry level, estimating year-by-2-digit industry revenue functions, and calibrating sample-wide revenue elasticities so all variation is driven by revenue shares.

3.3 Data and descriptive statistics

I construct a yearly firm-level dataset covering Dutch manufacturing firms with at least one employee over the period 2007 to 2018, using non-public data obtained from Statistics Netherlands (CBS).[37] I combine data from the "General Firm Registry" (ABR) and the "Financial Statistics of Non-financial Firm" (NFO). These two yearly firm-level datasets use as primary sources registries from the Dutch Chamber of Commerce, the Dutch tax authority, and the Dutch Ministry of Finance. The ABR and NFO aim to document the universe of all non-financial firms located in the Netherlands. The ABR contains yearly data on each firm's full-time equivalent (FTE) employment, the 4-digit NACE industry in which the firm is active, and the location of the firm's headquarters. The NFO contains yearly balance sheets and income statements from which I obtain revenue, the total expenditure on labor and intermediate inputs, the book value of capital, and earnings before interest and taxes (EBIT).

The CBS routinely controls quality by contacting firms when reporting errors are suspected. In addition, I remove outliers and observations that report internally inconsistent statistics. I further restrict the sample to firm-year observations with sufficient information to construct labor and intermediate input wedges. In particular, only observations with positive revenue, capital, intermediate input expenditure, and at least one FTE employee on the payroll are included. The final sample consists of 21,293 firms for a total of 121,057 firm-year observations. Appendix A provides a detailed overview of all variables and the sample selection procedure. Table A2 presents a breakdown of observations by year and 2-digit NACE industry.

I use total labor expenditure to construct my labor compensation variable, as total labor expenditure captures a firm's labor cost more accurately than employees' net or gross salary. In the absence of labor market imperfections other than taxes, firms can be expected to equalize the marginal revenue product of labor and the per-employee variable expenditure on labor, not the marginal revenue product of labor and take-home wage of the employee. With slight abuse of terminology, I refer to labor expenditure as "wages" in order to remain in line with the broader academic literature, which refers to total labor expenditure in this

[37] Under certain conditions, these data are accessible for research. See https://www.cbs.nl/en-gb/our-services/customised-services-microdata for details.