Economics Department
University of Southampton
Southampton SO17 1BJ, UK

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Market Power and Income Distribution: Lessons from Hybrid Industrial-Labour Economics

Jian Tong (University of Southampton) and **Carmine Ornaghi** (University of Southampton)

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Market Power and Income Distribution: Lessons from Hybrid Industrial-Labour Economics*

Jian Tong† Carmine Ornaghi‡

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Abstract

Over the recent decades, the income gap between capital and labour has widened, a shift accompanied by an increase in dominant firms' market power. To understand the underlying causes of this phenomenon, we construct a hybrid industrial-labour economics model that integrates imperfect competition in both product and labour markets, which underpins a post-neoclassical theory of income distribution, going beyond equation of input price to marginal productivity, and capturing rent-sharing mechanisms more generally. We also develop a novel empirical method for estimating production function, markup and markdown powers, which we apply to a panel of UK manufacturing firms. Our method is based on the factor-cost-share approach á la Solow (1957), but applied only to the competitive fringe firms that have little market power, designed for achieving unbiased estimation. Our analyses attribute the root cause of dispersion in market power to the large disparity in firms' productivity, which we show, left to persist and entrench, will lead to both income inequity and inefficiency. Our research underscores the importance of addressing market power concentration and entrenchment in order to promote equitable and efficient economic growth.

Keywords: firm heterogeneity, inequality, multifactor productivity, market powers, markup, markdown, oligopsony, rent sharing, income distribution, estimation of production function, identification method

JEL Classification: D21, D33, D43, D6, E24, J2, J3, L4

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†J.Tong@soton.ac.uk., Department of Economics, University of Southampton, Southampton, SO17 1BJ, UK.

‡C.Ornaghi@soton.ac.uk, Department of Economics, University of Southampton, Southampton, SO17 1BJ, UK.

1 Introduction

Over the recent decades, capital income has grown much faster than labour income in most developed market economies, where stagnant wages[1] have not kept pace with firms' rising profits among value added (Elsby *et al.* 2013, Karabarbounis and Neiman 2014). This macroeconomic trend has been associated with the rise of superstar firms (Autor *et al.* 2020) and an increase in the market power of firms at the top of the dispersed market power distribution (De Loecker *et al.* 2020). The presence of dispersion and concentration of market power[2] seems to challenge the conventional view that inequity is the price to pay for sustained efficiency.[3] To understand the causes of these secular trends and ascertain whether they contradict this view, we construct a hybrid industrial-labour economics model that integrates imperfect competition in both product and labour markets, which underpins a post-neoclassical theory of income distribution,[4] going beyond equation of input price to marginal productivity, and capturing rent-sharing mechanisms more generally.[5] The model uncovers the mechanisms that translate rising dispersion in firms' productivity and competitiveness into rising market power concentration, and falling aggregate labour income shares. We show that rising market power concentration, left to persist and entrench, can lead to both income inequity and inefficiency. Furthermore, the model lays the theoretical foundation for a novel and simple empirical method able to jointly estimate firms' production function and market powers.

Our study provides a unifying framework to examine a number of phenomena observed in different streams of literature. First, the influential paper by Autor *et al.* (2020) highlights the role of dominant frontier firms – the so-called superstar firms – in the fall of the labour share. The defining characteristic of the superstar firms is their superiority in productive efficiency relative to their laggard rivals, resulting in above-average profit margins and below-average labour income shares.[6] This calls for a refocusing of attention from market concentration to

[1] Although the term wage stagnation often means a lack of growth in the real wage rate (e.g., Acemoglu and Autor 2011), it more specifically refers to the phenomenon of real wage growth falling below the potential indicated by the growth rate of labour productivity (see, e.g., Mishel 2012, Bivens and Mishel 2015). The ILO and OECD (2015, page 2) go even further in suggesting a causal connection: "A falling labour share often reflects more rapid growth in labour productivity than in average labour compensation, and an increase in returns to capital relative to labour."

[2] By the phrase 'market power concentration' we want to capture the fact that dominant firms have high values of overall market power index, as well as heavier weights, such as market shares of value added, which are used in computing weighted average of market power at aggregate levels. Large dispersion of market power distribution then implies high weighted average of market power, as well as high concentration of the market share weights.

[3] The conventional way of looking at the static inefficiency caused by market power is to focus on deadweight loss. When market power distribution is dispersed and skewed towards a few powerful firms (e.g., superstar firms), it becomes another source of static inefficiency. Unlike the situation of monopoly by a single efficient firm, the coexistence of dominant firms and inefficient rivals leads to productive/technological inefficiency. When both sources are taken into account, the sacrifice of static efficiency could outweigh the gain in dynamic efficiency of the Schumpeterian type (i.e., market power as reward for innovation). We elaborate this view in Section 5.

[4] The neoclassical theory of distribution, which denies distributional inequity based on the assumption that each factor of production is paid according to its marginal productivity, relies on the implausible assumption of perfect competition in all markets.

[5] The inclusion of variation in rent-sharing mechanisms is dictated by evidence in the data.

[6] The superiority of superstar firms' productivity, say, measured by value added per worker, does not imply that the rise of superstar firms with expansion of their product market shares, say, measured in terms of value added shares, causes the weighted average of productivity in industry or economy-wide aggregation to increase, in contrast to the increase of weighted average of market share (i.e., product market concentration), because the weight for aggregating the former is employment share, different from the weight used for aggregating the former, which is value added share. Therefore the efficiency implication of the rise of superstar firms is not necessarily positive. See Philippon (2019) for more discussion on the welfare and efficiency implications of the rise of superstar firms.

the dispersion of firms' productivity and competitiveness, a defining feature of our analysis.[7]

Second, the equally important paper by De Loecker *et al.* (2020) documents how aggregate markups have increased over the last few decades, driven by the rising dispersion of firms' markups. However, estimation of markups (equivalently, the Lerner index) can either over- or under-estimate firms' overall market power depending on the power of wage markdowns and whether the rent-sharing mechanism involves collective bargaining.[8] In this paper, we propose two new measures of overall market power that supersede the familiar Lerner index by capturing the effects of wage markdown power and rent-sharing institutions.

Third, rent sharing between firms and their employees has long been a central theme in labour economics. For example, the 'declining worker power' hypothesis proposed by Stansbury and Summers (2020) argues that the weakening of unionisation and collective wage bargaining power of workers in the US in recent decades has led to a redistribution of economic rents from labour to capital owners. The various rent-sharing mechanisms formalised in the literature can be broadly grouped into two main streams: (i) bargaining (bilateral monopoly), related to either search frictions or costs of hiring, training and firing, and (ii) imperfect competition in the labour market caused by a finitely elastic firm-specific labour supply function. The first stream also includes[9] models that focus on collective bargaining and unionisation, such as efficient bargaining (McDonald and Solow 1981) and 'right-to-manage' bargaining (Nickell and Andrews 1983). The second stream includes the theory of monopsony power in the labour market[10] (see Manning 2003, 2011 and 2021).[11] For example, Card *et al.* (2018) develop a monopsonistic competition model, where the source of firms' wage markdown power is heterogeneity across employees in their valuation of jobs at different firms (causing finite elasticity of labour supply with respect to wages), while the inability of firms to discriminate against such worker heterogeneity empowers workers to rent share.

[7] While high inequality in distribution of market share, say, in terms of value added share, can cause concentration, the converse is not true. A small number of homogenous/symmetric firms in a market leads to high concentration, but no dispersion and inequality in the market share distribution.

[8] See Tortarolo and Zarate (2020), Mertens (2022) and Traina (2022) for examples of joint estimation of markups and markdowns. Previous work that has employed the production function approach to investigate imperfect competition in both product and labour markets includes Bughin (1996), Crépon *et al.* (2002), Dobbelaere (2004) and Dobbelaere and Mairesse (2013).

[9] Burdett and Mortensen (1998) model a labour market with search frictions, wage posting, and on-the-job search. This line of research does not involve collective bargaining. Gouin-Bonenfant (2022) studies the relationship between firm productivity dispersion and labour share along these lines, abstracting from product market power.

[10] The term 'monopsony', which literally means 'single buyer', was coined by Joan Robinson (1933). It is also loosely used to refer to the market power of a small number of buyers, although the more accurate word would be oligopsony. We employ the latter in this paper, which covers the special case of monopsony.

[11] Empirically, there is long-standing evidence that, contrary to the standard view of perfectly competitive labour markets, the labour supply functions faced by individual firms are less than perfectly elastic (Boal and Ransom 1997, Ashenfelter *et al.* 2010, Manning 2011). Recent cross-industry studies also show that firms operating in more concentrated markets exercise greater wage markdown power, to the detriment of workers in terms of suppressed or stagnating wages (Azar, Marinescu and Steinbaum 2019, Benmelech *et al.* 2018). Berry *et al.* (2019, page 57) highlight certain limitations that arise in both new and classic work in the field of industrial organisation: "A main difficulty in this area is that most of the existing studies of monopsony and wages ... proceed to estimate regressions of wages on measures of concentration ... studies like this may provide some interesting descriptions of concentration and wages, but are not ultimately informative about whether monopsony power has grown and is depressing wages." The authors also call for more detailed industry-specific studies to establish the causal relation in imperfect competition in labour markets. In-depth industry-specific investigations have increased in recent years, and trace the root causes of wage markdown power to economic primitives, such as imperfectly elastic market-level or firm-level labour supply function (Azar, Berry and Marinescu 2019, Kroft *et al.* 2021).

Finally, understanding the institutional determination of the make-or-buy decision and the vertical boundary of the firm has been a key objective in the theory of the firm since Coase (1937). Williamson (1979) and Grossman and Hart (1986) show that vertical integration is an organisational solution to the *ex post* bilateral monopoly (hold-up) problem linked to sunk relationship-specific investment. Grossman and Hart (1986) further show that vertical integration does not eliminate the hold-up (bilateral monopoly) problem, but replaces an internal hold-up problem between the firm's asset owner(s) and employee(s) for a potential external hold-up problem between the firm and an external supplier.[12] For firms that use both labour and intermediate goods as flexible inputs, the make-or-buy choice is closely linked to the decision regarding substitution between labour and intermediate inputs. Indeed, producing more in-house and buying less from external suppliers means employing more labour in-house to produce. Thus the make-or-buy decision is related to the demand for labour, which is affected by labour market imperfect competition and rent-sharing institutions, including collective bargaining and bilateral monopoly. The formal institutional theory of the firm *à la* Grossman and Hart (1986) and the efficient bargaining model of McDonald and Solow (1981) both apply the Nash bargaining solution to (partial) equilibrium analysis, allowing firms' objectives to depart from pure profit maximisation.[13]

Building on the above literature, we develop a hybrid industrial-labour economics model of imperfect competition, with different labour market rent-sharing mechanisms, ranging from oligopsony to bilateral monopoly involving two types of collective bargaining. Our theory shows that a firm's gross profit margin and gross profit share of value added are suitable measures of overall market power (thus superseding the well-known Lerner index). We model the strategic interaction between competing firms' output and make-or-buy decisions and show that such interaction can propagate the dispersion in firms' short-run multi-factor productivity into the dispersion in firms' market power. By allowing the coexistence of dominant firms and competitive fringe firms that behave like neoclassical price-takers, our model maintains an interesting continuity with the neoclassical theory. This insight enables us to propose a novel and simple empirical identification method, based on the factor cost share approach, *á la* Solow (1957), but applied only to the competitive fringe firms, which have little market power. In Section 4, we use our novel approach to estimate the annual joint distributions of short-run productivity, markup, markdown, overall market power indices and the value-added share of labour in a panel of UK manufacturing firms for 2003-2019.

Main Findings. For ease of exposition, Table 1 summarises the names and notations of the key variables, and what they measure. Our hybrid industrial-labour economics theory shows that, under the empirically validated

[12] According Grossman and Hart's (1986) theory, asset ownership gives the owner residual control rights over the assets, and thus strengthens the owner's bargaining position in the bilateral monopoly situation. An independent asset-owning input supplier should have a stronger bargaining position than the firm's own employees who do not own the assets they use for production. This may explain why the firm prefers vertical integration to separation.

[13] Without such institutional insights, a purely technology-based theory of purely profit maximising firms have to explain make-or-buy decisions primarily by complicated shapes of production functions.

Table 1: Key variables of interest

Name	Notation	Remark
Hicks technology coefficient (short-run)	A	Unobservable short-run multi-factor productivity
A proxy measure of A	Λ	Λ tracks A: $\Lambda = \frac{P}{(p_X)^{\theta_X}} A$; can be estimated
Product price	P	Unobservable
Intermediate input price	p_X	Unobservable
Output elasticity of intermediate input	θ_X	Can be estimated
Output elasticity of labour	θ_L	Can be estimated
Elasticity of scale (short-run)	$\theta_X + \theta_L$	$\theta_X + \theta_L = 1$ means constant returns to scale
Value added per worker	ω	A proxy for short-run productivity A
Gross profit margin	δ	An overall market power index
Marginal cost	MC	Unobservable
Markup power (Lerner) index	ρ	$\rho = \frac{P-MC}{P}$, $\frac{1}{1-\rho} = \frac{P}{MC}$ is markup; can be estimated
Marginal revenue product of labour	$MRPL$	Can be estimated
Wage	w	
Wage markdown power index	χ_L	$\chi_L = \frac{MRPL-w}{w}$; can be estimated
Labour share of variable cost	ψ_L	A measure of input mix/make-or-buy decision
Labour share of value added	ν_L	A measure of income distribution
Gross profit/capital share of value added	ν_K	A measure of income distribution, $\nu_K + \nu_L \equiv 1$

assumption of constant returns to scale (CRS) for the short-run production function, both the gross profit margin δ and gross profit share of value added ν_K are increasing functions of the markup power (Lerner) index ρ as well as the wage markdown power index χ_L. This finding suggests δ and ν_K are consistent measures of overall market power (superseding ρ), irrespective of how markup and markdown powers interact, or whether the labour market rent-sharing mechanism involves collective bargaining.[14] Furthermore, we show that ν_K outperforms δ as a measure of overall market power because it is more suitable to aggregate weighted averages across industries. The fact that ν_K is a suitable measure of both overall market power and income distribution at the firm level indicates the deep connection between the two theoretical concepts.

Our panel data on UK manufacturing firms reveal large firm heterogeneity within a typical four or five-digit SIC-code industry along the following key dimensions: (1) value added per worker ω, (2) gross profit margin δ, (3) value added share of labour or capital, ν_L or ν_K. (4) proxy measure of short-run productivity, Λ.[15] (5) variable cost share of labour ψ_L. Figures 1 and 2 visualise the dispersion in all four dimensions (1) - (4) in two different years. They also show resemblance respectively between ω and Λ, and between δ and ν_K. Our theory and empirical analysis show that the dispersion in firms' short-run multi-factor productivity A, which we approximately measure by Λ, is a root cause of the dispersion along each of the dimensions (1) - (3). Furthermore, the dispersion in (5) reflects a key structural difference in labour market rent-sharing institutions ranging from

[14] The empirically validated constant returns to scale (CRS) hypothesis also ensures that δ is not affected by short-run technology/production-function features of decreasing or increasing returns of scale.

[15] See Table 1 for the definition of Λ. Note that the discrepancy between theoretical variable A and Λ is caused by unobservability of prices of product and intermediate input.

oligopsony to two types of collective bargaining mechanisms, which is captured by the sign of the wage-markdown power index χ_L.

We additionally show that large dispersion in firms' overall market power distribution has a static productive inefficiency implication, beyond the conventional focus on deadweight loss. We argue that this additional source of static inefficiency, in combination of evidence of slowdown of productivity growth (see for example, Coyle and Mei 2022), warrants a radical reassessment of the view that static efficiency loss is a necessary evil to achieve dynamic efficiency gains. Our analysis makes clear that prolonged, rank-persistent[16] and excessive[17] dispersion in the distributions of δ, ν_K and A (as measured by Λ) leads to both income inequity and inefficiency, not a trade-off between them. Accordingly, addressing concentration and entrenchment of market power is necessary to promote equitable and efficient economic growth.[18]

Finally, our work provides the theoretical underpinnings for a novel approach to estimate production function and firms' market power in both product and labour markets. Our theory shows that for the competitive fringe firms, the variable cost share of labour, ψ_L, is equal to and thus identifies the industry-specific output elasticity of labour, θ_L. It also shows that competitive fringe firms can be used as a benchmark for measuring the wage-markdown power of all types of firms since they have (approximately) zero wage-markdown power. A striking finding of our empirical analysis is that the non-fringe firms in an industry have values of ψ_L diverging from θ_L in both directions, implying that the broadly defined markdown power index χ_L systematically has both positive and negative values. Since χ_L measures how the wage w departs from the marginal revenue product of labour ($MRPL$) in general, the result $\chi_L > 0$ is consistent with oligopsony, $\chi_L = 0$ matches the right-to-manage bargaining model *à la* Nickell and Andrews (1983), and $\chi_L < 0$ corresponds to the efficient bargaining model *à la* McDonald and Solow (1981). Accordingly, we introduce three different labour market rent-sharing (RS) types: RS type I for $\chi_L > 0$, RS type II for $\chi_L \approx 0$, and RS type III for $\chi_L < 0$. In our dataset of UK manufacturing firms with five or more employees, the RS types I, II and III account for, respectively, 20%, 11% and 70%.[19] Both theoretically and empirically we find that the extent of firm-level wage stagnation decreases as RS type increases; that is, collective bargaining enhances workers' bargaining power and mitigates (though does not eliminate) wage stagnation. This shows the importance of understanding the role of collective bargaining in wage determination and income distribution. Our analysis also underlines the implication of ignoring the

[16] The words 'prolonged' and 'rank-persistent' refer respectively to persistence of dispersion of the distribution over time, and persistence of identities of top-ranking firms among the distribution over time. The former is a necessary condition of the latter, but not conversely.

[17] The excess is defined based on the slowness of productivity growth. Ever since Schumpeter (1934, 1942) economists have been familiar with the idea that, to some extent, expected market power rents provide incentives for firms to invest and innovate. This view implies that too much competition is not compatible with innovation and productivity growth. The presence of both slowness of productivity growth and market power concentration, however, highlights the opposite possibility of excessive market power and insufficient competition, which cannot be justified as necessary for spurring productivity growth.

[18] The point that economic growth marred by wage stagnation is both inequitable and inefficient is further elaborated in Section 5.

[19] The sum exceeds 100% because of accumulation of rounding-up errors.

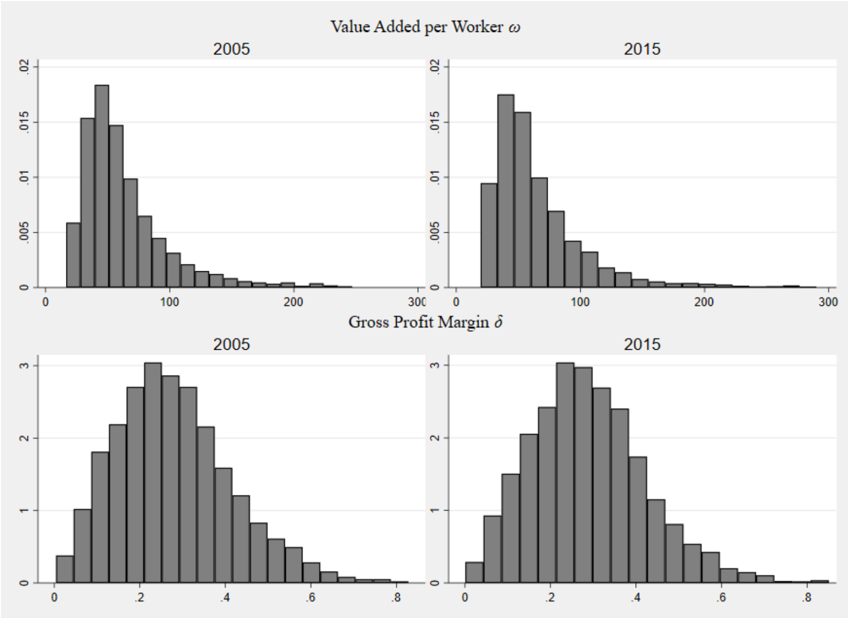

Figure 1: Histograms of Value Added per Worker ω, and Gross Profit Margin δ

structural differences in rent-sharing institutions for estimation of production function[20] as well as for empirical analysis of market power.[21]

Contribution to Literature. First, our model of imperfect competition in both product and labour markets enables us to develop a post-neoclassical theory of income distribution that goes beyond equation of input price to marginal productivity, and captures rent-sharing mechanisms more generally. This allows us to contribute to the global debate on the causes of the secular decline in the labour share of GDP by identifying the common root of the dispersions of market power and the labour share of value added, as well as the rise of market power and the fall of labour share at aggregate levels.[22] We show that the dispersion in firms' short-run productivity distribution is the common root cause.[23] A number of researchers argue that a major cause of the fall in labour

[20] This is because when the difference between labour market rent-sharing types is ignored, their differential effects are typically explained as features of production functions, such as non-neutral technological change (Doraszelski and Jaumandreu, 2018, 2019; Raval, 2023a, 2023b; Zhang, 2019), or returns to scale, leading to biases in the estimation of elasticity of scale. We elaborate the latter point in Section 4.2.2. The interaction between the direction of technology and labour market rent sharing is a fascinating topic explored by Acemoglu and Johnson (2023). These authors emphasise that the direction of technological change, e.g., whether it is biased towards automation and surveillance over workers' behaviour, is a socially constructed choice, rather than determined by nature.

[21] The market power analysis that ignores this structural difference is similar to assuming that RS type II is the universal labour market institutional setting, for which $\chi_L = 0$ holds. Such analysis, however, has some difficulty in explaining wage differentials across firms, and may resort to skill differentials and skill-biased technological changes for explanation. Card *et al.* (2018), however, show that cross-firm wage differentials cannot be fully explained by the skill level variation. Skill level differences do not feature in our analysis for reasons of parsimony and data limitation.

[22] Technically, these refer to the increase of weighted average of market power above its unweighted mean, as well as to the suppression of the weighted average of labour share below its unweighted mean.

[23] Gouin-Bonenfant (2022) examines the relationship between the dispersion of firms' productivity and the dispersion in their labour shares based on an on-the-job search model, allowing between-firm competition in the labour market. While he too attributes the suppression of weighted labour share to the dispersion in productivity, he focuses on labour market search-friction rather than collective bargaining and product market power. Kehrig and Vincent (2021) provide a micro-level empirical analysis of the decline in labour share, and find evidence that productivity dispersion is a driver. They furthermore note that high-productivity low-labour-share

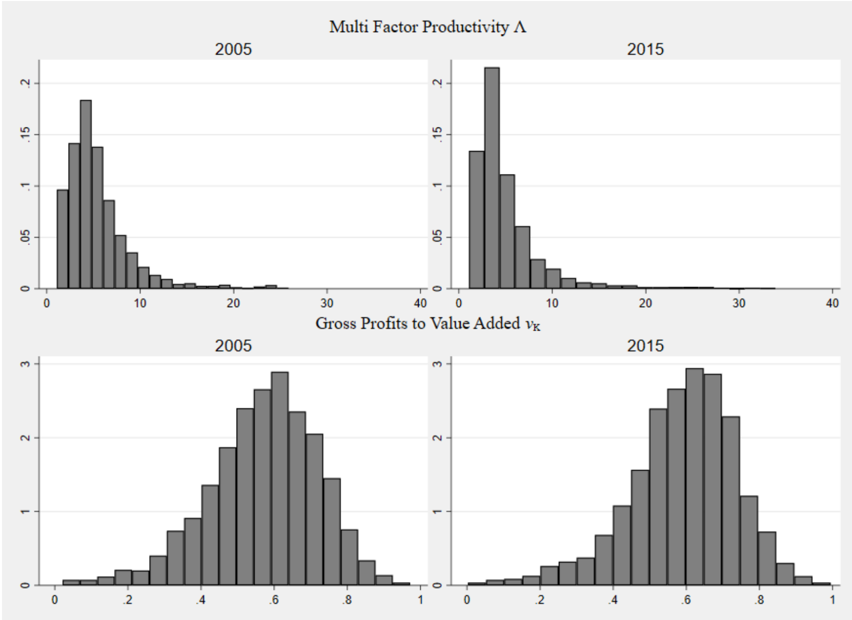

Figure 2: Histograms of (proxy measure of) Short-run MFP Λ, and Gross Profit Share of Value Added ν_K

share is the substitution of capital for labour, though they differ in the specific mechanisms involved. For example, Karabarbounis and Neiman (2014) point to a secular decline in the prices of capital goods. Elsby *et al.* (2013) underline offshoring of the labour-intensive component of the U.S. supply chain. Doraszelski and Jaumandreu (2018) meanwhile suggest that the substitution is caused by labour-augmenting (biased) technological change. Our novel approach to study the substitution between labour and (flexible) capital consists of investigating how labour market imperfect competition and rent-sharing institutions affect the substitution between labour and intermediate input, without relying on complicated shapes of production functions for purely technological explanations.[24] Our line of research follows and extends the work by De Loecker *et al.* (2020) and Autor *et al.* (2020) in connecting the dispersions of firms' market power and income distribution, and their aggregate effects. The extension provides a unifying model for better understanding of the overall market power, covering both product and labour markets, as well as systematic micro-founded metrics for measuring the state of competition, productivity and income distribution.

Second, we add to the broad literature on the labour market imperfect competition and rent sharing, originated with the work of Robinson (1933) on labour market monopsony. Our hybrid industrial-labour economics model encompasses both product-price markup and broadly defined wage-markdown powers. Furthermore, our analysis

establishments enjoy a product price premium relative to their competitors. Our contribution complements this work on attributing the root cause to productivity dispersion by enriching the underlying mechanisms, covering both markup power and broadly defined markdown power, and allowing for different types of labour market rent sharing.

[24] Although our analysis does not feature fixed capital explicitly, our explanation is consistent with the hypothesis that technological change in recent decades has been characterised with bias toward fixed capital, particularly of the intangible type, against variable inputs, a trend that tends to favour superstar firms.

captures the strategic interaction between heterogeneous competing firms, featuring the coexistence of dominant superstar firms and competitive fringes. Our model features joint-input production with labour and intermediate inputs, and thus enables us to investigate the determination of substitution of flexible capital for labour. We show that the broadly defined wage markdown power is a determinant of firms' flexible input mix. From its origin (Robinson, 1933), the labour market rent sharing literature recognised that labour market institutions, such as trade union and collective bargaining, could counter firms' monopsonistic wage-setting power by imposing a wage floor/minimum wage restriction (also see Nickell and Andrews 1983). The efficient bargaining model of McDonald and Solow (1981) explicitly introduced the Nash bargaining solution to model a bilateral monopoly situation. Following Crépon *et al.* (2005), we extend McDonald and Solow's (1981) single input model to joint-input production with both labour and intermediate input, and thus capture the determination of the flexible input mix in a bilateral monopoly. Our structural estimation of workers' quasi-rent share parameter shows that the efficient bargaining mechanism, by imposing floors to both wage and labour-intermediate input ratio, increases workers' quasi rent share relative to both oligopsony, and the wage floor mechanism, confirming our theoretical predictions.

Third, our study intersects with the literature on estimating production function and market powers. The novel idea implemented here is to estimate the short-run production function using the factor (cost) share method pioneered by Solow (1957), but applied only to competitive fringe firms for environments with an imperfectly competitive input market. For this, we first show theoretically that under the constant returns to scale (CRS) hypothesis for the short-run production function, the gross profit margin δ is a consistent measure of overall market power, superior to the conventional Lerner index (or markup) because it is robust to any variation in labour market rent-sharing mechanisms. We then use this index δ to empirically identify the competitive fringe firms as those with profit margin close to zero. After using the competitive fringe firms to recover the output elasticities of the short-run production function, we follow Hall (1988) to estimate markup power index[25], as well as to estimate wage markdown power index, and a proxy measure of short-run multi-factor productivity. As an integral part of this methodology, we structurally estimate the scale elasticity to validate the CRS hypothesis. The advantage of our methodology are two-fold. First, it avoids the well-known problem of not observing firm-level output and input quantities and prices,[26] and is therefore applicable to large-scale micro panel data sets. Second, the theoretical underpinning of the identification strategy is straightforward, and therefore easy to interpret.[27]

Our fourth contribution is to use short-run multi-factor productivity (SMFP) at the firm level as a novel

[25] Our approach is therefore related to the work of Bughin (1996), Crépon *et al.* (2002), Dobbelaere (2004), De Loecker and Warzynski (2012) and Dobbelaere and Mairesse (2013), all of whom have, in various ways, advanced the production approach.

[26] See Gandhi *et al.* (2020) and Bond *et al.* (2022) for the non-identification problems that arise in estimating production function parameters in the absence of firm-level product or input price data.

[27] Similar to Doraszelski and Jaumandreu (2013), our identification of the (short-run) production function takes advantage of the parametric specification, e.g., the Cobb-Douglas functional form, which reduces data requirement relative to non-parametric approaches.

measure of productivity for static analysis. The SMFP aims to capture the residual product unexplained by flexible labour and intermediate input, thus including the contribution from fixed capital stock, both tangible and intangible. In contrast, the familiar notion of total factor productivity (TFP) captures the residual product unexplained by flexible labour and intermediate input, and the directly measurable part of fixed capital stock. We model SMFP theoretically by Hicks technology coefficient in the short-run production function, which we are able to partially measure, and also approximate with value added per worker, gross profit margin, or gross profit share of value added. The advantages of using SMFP, instead of TFP, for static analysis are two-fold. First, the fixed capital stocks are treated as predetermined (i.e., sunk and costly to adjust) and exogenous for the analysis of short-run decisions, even though the fixed capital stocks are endogenous for the long-run decisions.[28] In contrast, the notion of TFP is confounding the short and long runs, as well as mixing up the predetermined and endogenous for short-run analysis. The second advantage is that our analysis avoids reliance on problematic measurements of fixed capital stocks of heterogeneous qualities, which include intangibles.

Finally, we contribute to the institutional theory of the firm by both analysing the make-or-buy decision and modelling firms whose objectives are not purely to maximise profits, such as in efficient bargaining, formalised with Nash bargaining solution. Specifically, we apply the incomplete contract theory of the firm *à la* Grossman and Hart (1986) to explain the connection between the preference of in-house production of flexible inputs to outsourcing and efficient bargaining in bilateral monopoly. We argue that the firms that prefer in-house production are likely to have made relationship-specific investments *ex ante* – e.g., in an innovation that necessitates specialised intermediate inputs or labour, which cannot be replaced from perfectly competitive markets, leading to *ex post* bilateral monopoly situations. Since the ownership of the firm's assets strengthens the firm's owners' bargaining position, they therefore prefer to replace an internal bilateral monopoly relation vis-à-vis employees, who don't control the assets, for a potential external hold-up problem vis-à-vis an independent supplier, who owns the relevant productive assets (see Section 4.2.1).

The remainder of the paper is organised as follows. Section 2 introduces the canonical Joint Oligopoly-Oligopsony Model, derives the basic equations of market power, and explores their implications for input mix (i.e., make-or-buy decision) and estimation of production function. Section 3 studies wage determination in three types of labour market rent-sharing mechanisms, ranging from oligopsony to two types of bilateral monopoly (collective bargaining), and analyses the effects of market power on wage stagnation and income distribution. Section 4 presents our empirical analyses. Section 5 discusses policy implications and Section 6 concludes. All proofs are given in Appendix.

[28] This demarcation is inspired by the endogenous sunk cost literature in game-theoretic IO, particularly the work of Sutton (1991, 1998). In the typical stage-game models, fixed/sunk cost decisions are made in an early stage, and become predetermined and exogenous for the analysis of later stage subgames.

2 The Joint Oligopoly Oligopsony Model

A novelty of the Joint Oligopoly Oligopsony Model (JOOM) is to capture imperfect competition in both labour and product markets between firms of dispersed productivity, ranging from dominant frontier (superstar) firms to the competitive fringes. While the canonical model features Cournot quantity competition in the product market and wage posting competition in the labour market, we note that the main results (given in Theorem 2) generalise more widely (see Appendix B, and Theorem 5 in Section 3).

Let each firm $i \in \{1, \cdots, n\}$ face finitely elastic upward-sloping residual labour supply function $L_i(\mathbf{w})$, which depends on the posted wage vector $\mathbf{w} \equiv (w_1, \cdots, w_n)$. The firm specific supply elasticity $\epsilon_{Li} \equiv \frac{\partial L_i(\mathbf{w})}{\partial w_i} \frac{w_i}{L_i(\mathbf{w})} < \infty$, implies imperfect competition in labour market, and also satisfies: (i) $\frac{\partial \epsilon_{Li}}{\partial w_i} < 0$, (ii) $\frac{\partial \epsilon_{Li}}{\partial w_j} > 0$. Property (i) means a high-paying (and large) employer faces more inelastic labour supply and departs further from price-taker behavior. Property (ii) implies the firm specific labour supply becomes more elastic as a rival firm pays higher wage (and employs more workers). This underlies strategic interaction in labour market competition.

Let the product market demand system be described by $p_i = P_i(\mathbf{q})$, where p_i and $P_i(\mathbf{q})$ are the product price and residual inverse demand function for firm i, which depend on output vector $\mathbf{q} \equiv (q_1, \cdots, q_n)$. Each firm's residual demand elasticity, $\epsilon_i \equiv -\frac{1}{\frac{\partial P_i(\mathbf{q})}{\partial q_i} \frac{q_i}{P_i(\mathbf{q})}} < \infty$, is finite, and has the following properties: (iii) $\frac{\partial \epsilon_i}{\partial q_i} < 0$, (iv) $\frac{\partial \epsilon_i}{\partial q_j} > 0$. Property (iii) implies that large firm faces more inelastic demand and departs further from price-taker behavior. Property (iv) means the residual demand becomes more elastic as a rival firm produces more. These properties are satisfied by many commonly used models, such as linear demand functions and homogeneous good market with constant price elasticity of demand.

Central to our analysis is the notion of short-run production function, denoted by $F_i(x_i, l_i)$, where x_i is the intermediate input (or flexible capital), and l_i is flexible labour input. $F_i(x_i, l_i)$ depends on the fixed (tangible and intangible) capital, which is not explicitly modelled in the static setting, as it can only be changed in the long-run. Instead, we assume $F_i(x_i, l_i) = A_i f(x_i, l_i)$, where A_i is the predetermined Hicks technology coefficient, which is a simple way to capture the short-run multi-factor productivity (SMFP).[29]

Let the market for intermediate input be perfectly competitive with constant price p_X. The conditional short-run profit maximisation problem is:

$$\max_{q_i, x_i, w_i, q_i \leq F_i(x_i, L_i(\mathbf{w}))} \pi_i(\mathbf{q}, \mathbf{w}, x_i) = \underbrace{P_i(\mathbf{q})\, q_i}_{R_i} - \underbrace{[w_i L_i(\mathbf{w}) + p_X x_i]}_{C_i},$$

[29] We deliberately choose the term SMFP to differentiate from the familiar notion of total factor productivity (TFP) because fixed capital is not an argument of the short-run production function. SMFP is a residual of output unexplained by flexible labour and intermediate input, and it captures the contribution of all forms of fixed capital (including knowledge capital intangible or embodied in physical capital) some of which are notoriously difficult to measure directly. The catch-all variable SMFP measures their overall effect. Also, SMFP is more relevant than TFP to a firm's short-run competitiveness.

where R_i and C_i respectively denote revenue and cost. The Nash equilibrium of the game is such that all firms conditionally maximise their gross profits.

2.1 Definitions of Marginal Cost and Market Power Indices

In the standard Cournot model, the definition of marginal cost can be trivially derived. This is not the case for our canonical JOOM, where the definition of marginal cost has to be derived from the primitive short-run production function through Nash equilibrium analysis.

Denote the Lerner index, a standard measure of markup power, by $\rho_i \equiv \frac{p_i - MC_i}{p_i}$, and the wage markdown power index by $\chi_{Li} \equiv \frac{MRPL_i - w_i}{w_i}$, where MC_i and $MRPL_i$ denote marginal cost and marginal revenue product of labour, with their definitions derived from solving the following Lagrangian maximisation problem:

$$\max_{q_i, x_i, w_i, \lambda_i} \mathfrak{L}_i = \underbrace{P_i(\mathbf{q})\, q_i}_{R_i} - \underbrace{[w_i L_i(\mathbf{w}) + p_X x_i]}_{C_i} - \lambda_i \left[q_i - F_i\left(x_i, L_i(\mathbf{w})\right)\right], \tag{1}$$

as summarised by the lemma below.

Lemma 1 *At each Nash equilibrium point, the Lagrangian multiplier λ_i equals both the marginal revenue and marginal cost, i.e.,*

$$\lambda_i = MR_i \equiv \frac{\partial R_i}{\partial q_i} = MC_i \equiv \frac{\partial C_i}{\partial q_i}. \tag{2}$$

The markup and markdown power indices ρ_i and χ_{Li} satisfy the following equations:

$$\rho_i = \frac{p_i - \lambda_i}{p_i}, \tag{3}$$

$$\chi_{Li} = \frac{\lambda_i \frac{\partial F_i(x_i, L_i(\mathbf{w}))}{\partial l_i} - w_i}{w_i}. \tag{4}$$

Eq. (2) - (4) derive the definitions of marginal revenue, marginal cost, Lerner index and the markdown power index. The gross profit margin δ_i is our potentially[30] preferred candidate index of overall market power. It is defined by:

$$\delta_i \equiv \frac{p_i - AVC_i}{p_i} \equiv \frac{p_i q_i - VC_i}{p_i q_i}, \tag{5}$$

where AVC_i and VC_i respectively denote average variable cost and variable cost. Note that δ_i is also the producer surplus to revenue ratio.

[30] Later we will introduce gross profit share of value added, which can supersede δ_i as a preferred index for particular purposes.

2.2 Basic Equations of Market Powers

We aim to find an index of overall market power that, differently from the Lerner index, is robust to how the markup and markdown powers interact. For this purpose we analyse the interaction between markup and markdown powers, and how this affects the gross profit margin. The results are summarised by the following theorem:

Theorem 2 *For the joint oligopoly-oligopsony model (JOOM), the markup and markdown power indices ρ_i and χ_{Li} satisfy the following basic equations:*

$$\frac{1}{1-\rho_i} = \frac{\theta_{Xi}}{\phi_{Xi}}, \tag{6}$$

$$\rho_i + (1+\chi_{Li})\frac{\phi_{Li}}{\theta_{Li}} = 1, \tag{7}$$

where $\phi_{Xi} \equiv \frac{p_X x_i}{p_i F_i}$ and $\phi_{Li} \equiv \frac{w_i L_i}{p_i F_i}$ are respectively the revenue shares of intermediate input and labour, and $\theta_{Xi} \equiv \frac{\partial F_i(x_i, L_i(\mathbf{w}))}{\partial x_i}\frac{x_i}{F_i}$ and $\theta_{Li} \equiv \frac{\partial F_i(x_i, L_i(\mathbf{w}))}{\partial L_i}\frac{L_i}{F_i}$ are respectively the output elasticities of intermediate input and labour. The effects of ρ_i and χ_{Li} on δ_i are captured by the basic equation below:

$$\delta_i = \rho_i + \frac{\theta_{Li}(1-\rho_i)\chi_{Li}}{(1+\chi_{Li})} + (1-\theta_{Li}-\theta_{Xi})(1-\rho_i), \tag{8}$$

implying δ_i is an increasing function of both ρ_i and χ_{Li}, with $\frac{\partial \delta_i}{\partial \rho_i} = \frac{\theta_{Li}}{1+\chi_{Li}} + \theta_{Xi} > 0$, $\frac{\partial \delta_i}{\partial \chi_{Li}} = \frac{\theta_{Li}(1-\rho_i)}{(1+\chi_{Li})^2} > 0$. Furthermore, if the short-run production functions $F_i(x_i, l_i)$ have constant returns to scale, i.e., $\theta_{Xi} + \theta_{Li} = 1$, then the gross profit margin δ_i has the following properties:

$$\delta_i = \rho_i + \frac{\theta_{Li}(1-\rho_i)\chi_{Li}}{1+\chi_{Li}}, \tag{9}$$

$$\delta_i = 0 \text{ if } \rho_i = \chi_{Li} = 0, \tag{10}$$

$$\delta_i = \rho_i \text{ if } \chi_{Li} = 0. \tag{11}$$

The constant returns to scale (CRS) hypothesis used in Theorem 2 is a necessary and sufficient condition for the results in eq. (9) - (11). We note that the term $(\theta_{Xi} + \theta_{Li})$ is the elasticity of scale. The following equation shows how the parameters of the Cobb-Douglas production function can be decomposed into A_i, α and $(\theta_{Xi} + \theta_{Li})$:

$$F_i(x_i, l_i) = A_i x_i^{\theta_X} l_i^{\theta_L} = A_i \left(x_i^{\alpha} l_i^{1-\alpha}\right)^{\theta_X+\theta_L}, \tag{12}$$

where $\alpha \equiv \frac{\theta_X}{\theta_X+\theta_L}$, with $\theta_X = \alpha$ and $\theta_L = 1-\alpha$ for $\theta_X + \theta_L = 1$. Constant/decreasing/increasing returns to scale (CRS/DRS/IRS) corresponds to $\theta_X + \theta_L =$ or $<$ or > 1. Given its importance for our analysis, in Section 4.2.2 we structurally estimate the elasticity of scale $(\theta_X + \theta_L)$ and validate the CRS hypothesis: $\theta_X + \theta_L = 1$.

The Lerner index ρ_i (or the markup $\frac{p_i}{\lambda_i} \equiv \frac{1}{1-\rho_i}$) has conventionally been used as a sufficient measure of firm's (overall) market power. However, recent advancement of research on imperfect competition in labour market has exposed its limitation. Both market power indices (ρ_i, χ_{Li}) are necessary to measure how the firm's pricing in product and labour markets departs from the benchmarks of price-taking behaviour. The analysis we present in the following sections makes clear that neither of these indices in isolation is generally adequate to measure a firm's relative competitiveness vis-à-vis its rivals. For example, when $\rho_i > 0$ and $\chi_{Li} > 0$, either of the indices underestimates the firm's relative competitiveness. If $\rho_i > 0$ and $\chi_{Li} < 0$ then ρ_i overestimates it.

Theorem 2 shows that δ_i is an increasing function of both ρ_i and χ_{Li}, and it measures the net departure of firm's pricing behaviour from the price-taking benchmarks. Interestingly, under the CRS hypothesis δ_i is an extension of ρ_i: for if $\chi_{Li} = 0$ then $\delta_i = \rho_i$; if $\chi_{Li} \neq 0$ then δ_i captures how labour market rent sharing affects the overall market power which is not captured by ρ_i. From data and measurement point of view, δ_i, unlike (ρ_i, χ_{Li}), has the additional appeal that it can be measured directly. In Section 3.4, we show the close relationship between the gross profit share of value added ν_K and δ, and discuss when ν_K can supersede δ as a measure of overall market power.

In the following two sections, we investigate the effect of wage markdown power on the substitution pattern of flexible inputs (Section 2.3), and we show how the substitution pattern of the competitive fringe firms can inform the estimation of common production function parameters (Section 2.4).

2.3 Markdown Power, Substitution of Flexible Inputs and Make-or-Buy Decision

Our short-run production function captures the technological possibility of substitution of intermediate input for labour. The input mix decision is closely related to the make-or-buy decision since firms that choose to make part of the intermediate input in-house need to employ more labour. The variable cost share of labour, $\psi_{Li} \equiv \frac{w_i l_i}{p_X x_i + w_i l_i}$, can be used to measure the state of the firm's make-or-buy decision. The standard profit maximisation assumption implies cost minimisation, which is sufficient for our results about substitution of flexible inputs.[31] In the JOOM, the wage markdown power of a firm provides an incentive to substitute intermediate input for labour, which a price-taking firm in the labour market lacks. That is, in comparison with a wage-taking firm, a firm with wage markdown power is inclined to "buy" in its make-or-buy decision. The following theorem captures this insight.

Theorem 3 *Let the short-run production function in the JOOM be $F_i(x_i, l_i) = A_i x_i^{\alpha} l_i^{1-\alpha}$ for all $i \in \{1, \cdots, n\}$, and firms i and i' in the JOOM be such that $\chi_{Li} \geqslant \chi_{Li'} = 0$, then*

$$\psi_{Li} = \frac{1-\alpha}{1+\alpha\chi_{Li}} \leqslant \psi_{Li'} = 1 - \alpha. \tag{13}$$

[31] The results given in this section can be extended to non-profit maximising firms that engage in collective wage bargaining, which are treated in Section 3.3.

Furthermore, the expenditure ratio between intermediate input and labour is:

$$\frac{p_X x_i}{w_i l_i} = \frac{\alpha}{1-\alpha} + \frac{\alpha}{1-\alpha}\chi_{Li}, \tag{14}$$

which is equivalent to

$$\chi_{Li} = \frac{1-\alpha}{\alpha}\left(\frac{1}{\psi_{Li}} - \frac{1}{1-\alpha}\right) = \frac{1-\alpha}{\alpha}\frac{p_X x_i}{w_i l_i} - 1, \tag{15}$$

and the markup power index is given by

$$\rho_i = 1 - \frac{\phi_{Li}}{\alpha}\frac{p_X x_i}{w_i l_i} = 1 - \frac{\phi_{Xi}}{\alpha}. \tag{16}$$

Finally, for given α, there exists a proxy measure of A_i, defined by the following identities:

$$\Lambda_i \equiv \frac{(w_i)^{1-\alpha}}{\phi_{Li}\left(\frac{p_X x_i}{w_i l_i}\right)^{\alpha}} \equiv \frac{p_i}{(p_X)^{\alpha}} A_i. \tag{17}$$

In comparison with a rival who does not have wage markdown power, a firm tends to have lower labour share of variable cost. In terms of the theory of the firm, wage markdown power is a novel determinant of the make-or-buy decision. This implies that each firm's variable cost share of labour ψ_L (a measure of the state of the make-or-buy decision) can inform its wage markdown power χ_L. Eq. (14) predicts that the input expenditure ratio $\frac{p_X x_i}{w_i l_i}$ and ψ_{Li} depend on wage markdown power index χ_{Li} (given that $\frac{p_X x_i}{w_i l_i} \equiv \frac{1}{\psi_{Li}} - 1$). If there is substantial dispersion in χ_{Li} among firms in an industry, then eq. (14) and (15) predict substantial dispersion in $\frac{p_X x_i}{w_i l_i}$ and ψ_{Li}. Thus, $\frac{p_X x_i}{w_i l_i}$ (and equivalently ψ_{Li}) can be used for identifying χ_{Li} if the parameter α has been identified. Similarly, ϕ_{Li} and $\frac{p_X x_i}{w_i l_i}$ can be used to pin down ρ_i and Λ_i if α has been identified. The first identity in eq. (17) defines Λ_i. The second shows how Λ_i is related to and can serve as a proxy measure of A_i, as Λ_i tracks the unobservable A_i proportionally, with an unobservable coefficient $\frac{p_i}{(p_X)^{\alpha}}$. The usefulness of Λ_i for empirical analysis is demonstrated in Section 4.4.

To sum up, Theorem 3 lays the theoretical foundation for a novel method for estimating production function, including parameter α and a proxy measure of A_i, and market power indices ρ_i and χ_{Li}. The next section deals with the linchpin of this new methodology which is the identification of technology parameter α.

2.4 A Novel Factor Share Approach for Estimating Production Function

Eq. (15) is useful to guide the measurement of both the technology parameter α and the markdown power index χ_{Li}. The key idea here is to estimate α using the competitive fringe firms with no market power, and then compute χ_{Li} for the other firms in our dataset.

Theoretically, we define firm j as a competitive fringe firm in a given industry if $\chi_{Lj} = \rho_j = 0$. The notion of competitive fringe firm is useful for the estimation of parameter α because for such a firm

$$\alpha = 1 - \psi_{Lj} \text{ and } \frac{\alpha}{1-\alpha} = \frac{p_X x_j}{w_j l_j}.$$

By eq. (11) of theorem 2, a competitive fringe firm necessarily has $\delta_j = 0$. For quantitative and empirical analysis, we use the weaker condition $\delta_j \approx 0$. Operationally, we approximately identify as competitive firms those with values of δ in the interval $[\delta_{\min}, \delta_{\min} + 0.05]$, where $\delta_{\min}$ denotes the minimum value of δ in the industry. We further identify as the "representative" competitive fringe firm the one with the median[32] value of ψ_L among all those competitive fringe firms, and then we estimate α based on this "representative". That is,

$$\alpha = 1 - median \left\{ \psi_{Lj} : \delta_{\min} \leq \delta_j \leq \delta_{\min} + 0.05 \right\}, \tag{18}$$

Once α is estimated, we can estimate χ_{Li}, ρ_i and Λ_i for each firm in the industry. This novel approach for estimating the production function parameter α, the markdown power index χ_L, the Lerner index ρ, and the proxy measure of short-run MFP Λ is implemented in Section 4.2.1 with a panel data set containing UK manufacturing firms. Here, importantly, we make a general remark that the data requirement for implementing this method is modest: it does not require observation of prices and quantities of output and intermediate inputs. It is sufficient to observe revenue, total expenditure on flexible inputs, cost and employment of (ideally flexible) labour, which are a common feature of data sets reporting accounting information.[33]

Based on this method, the broadly defined wage markdown power index χ_{Li} is calculated by

$$\chi_{Li} = \frac{\frac{p_X x_i}{w_i l_i}}{median \left\{ \frac{p_X x_j}{w_j l_j} : \delta_{\min} \leq \delta_j \leq \delta_{\min} + 0.05 \right\}} - 1. \tag{19}$$

Eq. (19) implies that χ_{Li} is positive (negative) when firm i has a labour cost share above (below) the median labour cost share of the fringe firms. This suggests that the firm pays its employees less (more) than their marginal revenue product of labour, and it is inclined toward buy (make) in the make-or-buy decision. The theoretical underpinning of the the systematic differences in the signs of χ_{Li}, and their relation to labour market rent-sharing mechanisms are discussed in Section 3.

[32] The median is preferred to the mean as a measure of central location because only the median gives invariant results regardless whether we estimate α or $\frac{\alpha}{1-\alpha}$ as the basis. Even so, we have done robustness check on our results (confirmative, unreported) using the specification with the mean.

[33] In contrast, the prevalent econometric method of estimating production function, such as the control function approach (Olley and Pakes 1996, Levinsohn and Petrin 2003, Ackerberg *et al.* 2015), requires data on input and output quantities, which are not available from typical accounting data. As highlighted by Bond *et al.* (2021), this problem with data availability may cause further problems of bias or non-identification for the estimation of markups (see De Loecker and Warzynski 2012, De Loecker *et al.* 2020).

3 Rent-Sharing Mechanisms and Wage Determination

The relationship between heterogenous productivity and differential wages across firms has attracted a lot of interest in labour economics. Recent works have increasingly recognised that labour market is not perfectly competitive, ranging from oligopsony to collective bargaining, and there are quasi rents to be shared between firms and their employees (see Card *et al.* 2018, Crépon *et al.* 2005). In this section, we show how the hybrid industrial-labour economics model can enrich our understanding of the relationship between productivity and wage at the firm level.

We start by observing that the oligopsony model (OL), the wage floor model (WF) and the efficient bargaining model (EB) together form a partition of all possible relations between wage (W) and marginal revenue product of labour ($MRPL$), as they predict the following three mutually exclusive possibilities: $W < MRPL$ (OL), $W = MRPL$ (WF) and $W > MRPL$ (EB).[34] Interestingly, competitive fringe firms lie in the common boundary of these three subsets, thus representing a point of continuity among these three models. Sections 3.1, 3.2 and 3.3 below analyse wage determination in, respectively, the canonical JOOM (OL), wage floor model (WF) and the efficient wage bargaining model (EB), which correspond to RS types I, II and III, empirically defined in Section 4. Finally, section 3.4 shows that the basic equations from Theorem generalise to the unifying model, and investigates the common root cause of firms' overall market power and income distribution between labour and firms' gross profit.

3.1 Canonical JOOM

The canonical JOOM features a Cournot oligopoly product market, an oligopsony labour market, and Cobb-Douglas short-run production functions $F_i(x_i, l_i) = A_i x_i^{\alpha} l_i^{1-\alpha}$. We follow Card *et al.* (2018) to model a heterogeneous job market with wage posting, and firm-specific labour supply function:

$$L_i(\mathbf{w}) = \mathcal{L}\frac{(w_i - b)^{\beta} a_i}{\sum_{j=1}^{n} (w_j - b)^{\beta} a_j}, \tag{20}$$

where $\mathcal{L}$ is the aggregate labour supply, b is the outside option/benefit, a_i is the firm specific amenity parameter, and parameter β measures the toughness of wage competition, with $\beta \to \infty$ representing perfect competition, and $\beta = 0$ representing independent monopsonies. The term $\frac{(w_i-b)^{\beta} a_i}{\sum_{j=1}^{n}(w_j-b)^{\beta} a_j}$ is the logit probability for a worker to work for firm i given the wage vector $\mathbf{w}$. The elasticity of firm-specific labour supply is:

$$\epsilon_{Li} \equiv \frac{\partial L_i(\mathbf{w})}{\partial w_i}\frac{w_i}{L_i(\mathbf{w})} = \frac{\beta(1 - s_{Li}) w_i}{w_i - b}, \tag{21}$$

[34] This observation has been inspired by Dobbelaere and Mairesse (2013).

where $s_{Li} \equiv \frac{L_i(\mathbf{w})}{\mathcal{L}}$ is the labour market share of firm i, with $\lim_{s_{Li}\to 1} \epsilon_{Li} = 0$. Notice that $\lim_{\beta\to\infty} \epsilon_{Li} = \infty$, consistent with that β is the toughness of wage competition parameter. The following partial derivatives (i) $\frac{\partial \epsilon_{Li}}{\partial w_i} = \frac{-\beta \frac{\partial s_{Li}}{\partial w_i}\left(1-\frac{b}{w_i}\right)-\beta(1-s_{Li})\frac{b}{w_i^2}}{\left(1-\frac{b}{w_i}\right)^2} < 0$, with $\lim_{w_i\to b} \epsilon_{Li} = \infty$, (ii) $\frac{\partial \epsilon_{Li}}{\partial w_j} > 0$, and (iii) $\frac{\partial \epsilon_{Li}}{\partial b} > 0$, indicate that (i) large and high wage employers face more inelastic residual labour supplies, (ii) a rise of a rival firm's wage raises the residual labour supply elasticity, and (iii) an increase in outside option/benefit raises every firm's labour supply elasticity.

In the canonical JOOM, profit maximisation implies: $\chi_{Li} \equiv \frac{MRPL_i - w_i}{w_i} = \frac{1}{\epsilon_{Li}}$. Substituting this into eq. (21) results in the following wage determination equation:

$$w_i = \frac{b}{1+\beta(1-s_{Li})} + \frac{\beta(1-s_{Li})}{1+\beta(1-s_{Li})} MRPL_i, \tag{22}$$

with $b \leq w_i \leq MRPL_i$. Eq. (22) shows that the profit maximising wage w_i is a weighted average of the outside option b and the marginal revenue product of labour $MRPL_i$, with respective weights $\frac{1}{1+\beta(1-s_{Li})}$ and $\frac{\beta(1-s_{Li})}{1+\beta(1-s_{Li})}$. For $s_{Li} \to 0$, the weights become constant, and w_i tracks $MRPL_i$ linearly. This limiting result is consistent with the monopsonistic competition labour market literature (see Card *et al.* 2018), indicating that the JOOM is more general than the monopsonistic competition model. The generality is clearly needed to capture the dominance of superstar firms, and dispersion of market power between the superstar and the competitive fringe firms.

In empirical analysis, the variable $MRPL_i$ is typically replaced by the value added per worker $\omega_i \equiv \frac{p_i q_i - p_X x_i}{l_i}$. Accordingly, for Cobb-Douglas production function $F_i(x_i, l_i) = A_i x_i^{\alpha} l_i^{1-\alpha}$, w_i can be expressed as weighted average of b and ω_i:[35]

$$w_i = \frac{1}{1+\beta(1-s_{Li})(1-\alpha(1-\rho_i)(1+\chi_{Li}))} b + \frac{(1-\alpha)(1-\rho_i)\beta(1-s_{Li})}{1+\beta(1-s_{Li})(1-\alpha(1-\rho_i)(1+\chi_{Li}))} \omega_i, \tag{23}$$

with $\frac{\partial w_i}{\partial \omega_i} > 0$, $\frac{\partial^2 w_i}{\partial \omega_i \partial s_i} < 0$, $\frac{\partial^2 w_i}{\partial \omega_i \partial \rho_i} < 0$ and $\frac{\partial^2 w_i}{\partial \omega_i \partial \chi_i} > 0$. For competitive fringe firms, with $s_{Li} \to 0$, $\rho_i \to 0$ and $\chi_{Li} \to 0$, the coefficient on ω_i approaches to $\frac{\beta(1-\alpha)}{1+\beta(1-\alpha)}$. It is of interest to observe that this coefficient depends both on the technology parameter of output elasticity of labour $(1-\alpha)$, and on the toughness of wage competition parameter β. In Section 4.3 we structurally estimate parameters $(1-\alpha)$ and β from wage regressions.

3.2 Wage Floor Model

We now consider the following wage floor model inspired by Robinson (1933) and Nichell and Andrews (1983). Suppose the employee union sets a wage floor $\bar{w}_i$. The firm has the "right-to-manage" and maximises profit

[35] Note the following intermediate steps: $\omega_i = p_i A_i \left(\frac{x_i}{l_i}\right)^{\alpha} - p_X \left(\frac{x_i}{l_i}\right)$, $MRPL_i = (1-\alpha)(1-\rho_i) p_i A_i \left(\frac{x_i}{l_i}\right)^{\alpha}$, implying: $MRPL_i = (1-\alpha)(1-\rho_i)\left(\omega_i + \frac{1-\psi_{Li}}{\psi_{Li}} w_i\right)$ and $MRPL_i = (1-\alpha)(1-\rho_i)\left(\omega_i + \frac{\alpha}{1-\alpha}(1+\chi_{Li}) w_i\right)$.

subject to the wage floor constraint, resulting in labour demand curve intersecting the labour supply curve L_i^S at the kink point $\left(\bar{w}_i, L_i^S\left(\bar{w}_i\right)\right)$, with $\chi_i = 0$ for $w_i = \bar{w}_i$ and $l_i \leq L_i^S\left(\bar{w}_i\right)$; and $\chi_i = \frac{1}{\epsilon_{Li}}$ for $w_i > \bar{w}_i$ and $l_i > L_i^S\left(\bar{w}_i\right)$. Let $L_i^D\left(\bar{w}_i\right)$ denote the conditional profit-maximising demand of labour by the firm. The model assumes that the union is committed to labour market clearing. Thus $\bar{w}_i$ equates $L_i^D\left(\bar{w}_i\right)$ and the firm specific labour supply $L_i^S\left(\bar{w}_i\right)$, with $\frac{\partial L_i^S(\bar{w}_i)}{\partial \bar{w}_i} > 0$. The labour market clearing equation implies

$$\frac{d\bar{w}_i}{dA_i} = \frac{\frac{\partial L_i^D(\bar{w}_i)}{\partial A_i}}{\frac{\partial L_i^S(\bar{w}_i)}{\partial \bar{w}_i} - \frac{\partial L_i^D(\bar{w}_i)}{\partial \bar{w}_i}} > 0 \text{ if } \frac{\partial L_i^D\left(\bar{w}_i\right)}{\partial \bar{w}_i} < 0 \text{ and } \frac{\partial L_i^D\left(\bar{w}_i\right)}{\partial A_i} > 0. \tag{24}$$

Eq (24) implies that, under the plausible assumptions that $\frac{\partial L_i^D(\bar{w}_i)}{\partial \bar{w}_i} < 0$ and $\frac{\partial L_i^D(\bar{w}_i)}{\partial A_i} > 0$, more productive firms tend to pay higher wages.

In the current model $\chi_{Li} \equiv \frac{MRPL_i - w_i}{w_i} \leq \frac{1}{\epsilon_{Li}}$ holds. Substituting this inequality into (21), we obtain:

$$w_i \geq \frac{b}{1+\beta\left(1-s_{Li}\right)} + \frac{\beta\left(1-s_{Li}\right)}{1+\beta\left(1-s_{Li}\right)} MRPL_i. \tag{25}$$

The profit maximising wage w_i weakly exceeds a weighted average of the outside option b and the marginal revenue product of labour $MRPL_i$, with respective weights being $\frac{1}{1+\beta(1-s_{Li})}$ and $\frac{\beta(1-s_{Li})}{1+\beta(1-s_{Li})}$.

For the current model with the Cobb-Douglas production function $F_i\left(x_i, l_i\right) = A_i x_i^{\alpha} l_i^{1-\alpha}$, inequality (25) and $\chi_i = 0$ imply:

$$w_i \geq \frac{1}{1+\beta\left(1-s_{Li}\right)\left(1-\alpha\left(1-\rho_i\right)\right)} b + \frac{\left(1-\alpha\right)\left(1-\rho_i\right)\beta\left(1-s_{Li}\right)}{1+\beta\left(1-s_{Li}\right)\left(1-\alpha\left(1-\rho_i\right)\right)} \omega_i. \tag{26}$$

The weak inequality (26) holds with equality for $\rho_i = 0$ and $s_{Li} = 0$. Furthermore, for competitive fringe firms with $\delta_i \to 0$ and $s_{Li} \to 0$, the coefficient on ω_i approaches to $\frac{\beta(1-\alpha)}{1+\beta(1-\alpha)}$, the same as for RS type I, thus showing the continuity of OL and WF at the point of $\delta_i \to 0$.

3.3 Efficient Bargaining Model

In this section we follow Crépon *et al.* (2005) to extend the single-input efficient bargaining model *à la* McDonald and Solow (1983) to joint-input production with labour and intermediate input.

Suppose the workers collectively bargain with the firm over both the level of employment l_i and wage w_i, with the preference to maximise worker surplus $l_i\left(w_i - b\right)$, where b is the reservation wage. The firm's preference is to maximise short-run profit $R_i - w_i l_i - p_X x_i$ (i.e., producer surplus), where $R_i = P_i\left(\mathbf{q}\right) q_i$ is the firm revenue, and $q_i = F_i\left(x_i, l_i\right)$ is the output determined by the production function. Therefore the objective of *de facto* joint decision by the firm and workers departs from profit maximisation.[36] The outcome is formalised by the Pareto

[36] The interpretation of this may go beyond merely collective bargaining. It may involve some form of worker participation or co-determination in corporate governance.

efficient (extended) Nash bargaining solution, which solves the following maximisation problem:

$$\max_{w_i, l_i, x_i} \left[l_i \left(w_i - b\right)\right]^{\eta_i} \left[R_i - w_i l_i - p_X x_i\right]^{1-\eta_i},$$

where $\eta_i \in [0,1]$ is the workers' bargaining power coefficient. If η_i is treated as a free parameter then the locus of the solution to the above maximisation problem forms the contract curve, or the set of Pareto efficient outcomes, and hence the name 'efficient bargaining'. The first order conditions include:

$$\frac{\partial R_i}{\partial x_i} = p_X, \tag{27}$$

$$w_i = b + \frac{\eta_i}{1-\eta_i} \frac{R_i - w_i l_i - p_X x_i}{l_i}, \tag{28}$$

$$w_i = \frac{\partial R_i}{\partial l_i} + \frac{\eta_i}{1-\eta_i} \frac{R_i - w_i l_i - p_X x_i}{l_i}. \tag{29}$$

In the analysis of this model we extend the definition of marginal cost to

$$MC_i \equiv \frac{p_X}{\frac{\partial F_i}{\partial x_i}}. \tag{30}$$

This is the ratio between changes of cost and output caused by an infinitesimal change of input dx_i, evaluated at the conditionally optimal level of x_i. The definition maintains the familiar equality between marginal revenue and marginal cost as a necessary condition for optimal output level. To see this, note that from $\frac{\partial R_i}{\partial x_i} = \frac{\partial R_i}{\partial q_i} \frac{\partial F_i}{\partial x_i}$ and eq. (27), it follows that $MR_i \equiv \frac{\partial R_i}{\partial q_i} = \frac{p_X}{\frac{\partial F_i}{\partial x_i}} = MC_i$, i.e., marginal revenue equals marginal cost. The definitions of markup and markdown power indices $\rho_i \equiv 1 - \frac{MC_i}{P_i}$ and $\chi_{Li} \equiv \frac{MRPL_i - w_i}{w_i}$ apply to the current extension of the JOOM.

Proposition 4 *The efficient bargaining model satisfies the following equations:*

$$\frac{\partial R_i}{\partial x_i} = b, \tag{31}$$

$$w_i = (1-\eta_i)\, b + \eta_i \omega_i, \tag{32}$$

$$\chi_{Li} = \frac{\eta_i (b - \omega_i)}{\eta_i \omega_i + (1-\eta_i)\, b} \leqslant 0. \tag{33}$$

For the Cobb-Douglas production function $F_i(x_i, l_i) = A_i x_i^{\alpha} l_i^{1-\alpha}$, the input mix $\frac{l_i}{x_i}$ is a constant given by

$$\frac{l_i}{x_i} = \frac{1-\alpha}{\alpha} \frac{p_X}{b}. \tag{34}$$

Recall that the (extended) Nash bargaining solution is Pareto efficient and therefore (ω_i, l_i) is on the contract curve. The precise location on the contract curve is determined by the bargaining power parameter η_i. The analysis so far does not tell us how η_i is determined, therefore leaves η_i as a free parameter. Hereafter, we use the Cobb-Douglas production function, the information contained in the labour supply function and the bargaining solution to show the determination of η_i in the close vicinity of $\delta_i = 0$, i.e., among approximately competitive fringe firms.[37]

We begin by reinterpreting the extended Nash bargaining solution not as the employee union getting involved in daily operational decisions of the firm, but imposing two restrictions on the wage and employment. The first is the wage floor constraint: $w_i \geq b + \eta_i (\omega_i - b)$. The second is the labour input floor constraint (a 'feather-bedding' or 'manning' rule): $\frac{l_i}{x_i} \geq \frac{1-\alpha}{\alpha}\frac{p_X}{b}$, which is invariant to A_i.[38] This rent-sharing mechanism can then be reinterpreted as if the firm is a profit maximiser who faces these two constraints. In comparison to the WF model, the union has one more instrument, which can be used to quote a higher wage floor without inducing the firm to substitute intermediate input for labour. The firm is free to choose to reduce both labour and intermediate input, but this is suboptimal.

For the current model, $\chi_{Li} = \frac{MRPL_i - w_i}{w_i} \leq \frac{1}{\epsilon_{Li}}$ for arbitrary value of $\beta > 0$. Inequality (25) also holds, and we can apply the relations $1 + \chi_{Li} = \frac{MRPL_i}{w_i} = \frac{b}{w_i}$ to it to derive the following inequalities:

$$\begin{aligned} 1 &\geq \frac{1}{1+\beta(1-s_{Li})\left(1-\alpha(1-\rho_i)\frac{b}{w_i}\right)}\frac{b}{w_i} + \frac{(1-\alpha)(1-\rho_i)\beta(1-s_{Li})}{1+\beta(1-s_{Li})\left(1-\alpha(1-\rho_i)\frac{b}{w_i}\right)}\frac{\omega_i}{w_i}, \\ w_i &\geq \frac{1+\alpha(1-\rho_i)\beta(1-s_{Li})}{1+\beta(1-s_{Li})}b + \frac{(1-\alpha)(1-\rho_i)\beta(1-s_{Li})}{1+\beta(1-s_{Li})}\omega_i. \end{aligned}$$

Since the second inequality above holds for arbitrary value of β, it also holds for the limit $\beta \to \infty$, implying

$$w_i \geq \alpha(1-\rho_i)b + (1-\alpha)(1-\rho_i)\omega_i, \tag{35}$$

with equality holding if $\rho_i = 0$.

For inequality (35), as $\rho_i \to 0$ the coefficient on ω_i converges to the output elasticity of labour $(1-\alpha)$.[39] This shows an important difference between WF and EB: for the former the coefficient on ω_i converges to $\frac{\beta(1-\alpha)}{1+\beta(1-\alpha)}$, which is smaller than $(1-\alpha)$ if $\beta < \frac{1}{\alpha}$.

Table 2 summarises the different predictions about wage determination between RS type I and II (on one side)

[37] In general, the determinants of η_i include the revenue function $R_i(q_i)$, the labour supply function $L_i(w_i)$, and firm short-run productivity parameter A_i.

[38] This constraint is binding when profit is maximised, resulting in eq. (34). The result of fixed input ratio looks as if the underlying short-run production function is Leontief, rather than Cobb-Douglas. This example shows that if the labour market rent-sharing institution is ignored and the observed input ratio is entirely attributed to features of the production function, then the estimation of the production function is biased by the effect of labour market rent-sharing mechanism.

[39] This characterises the limit of worker's quasi rent share for firms with market power as $\omega_i \to b$. For competitive fringe firms with $w_i = \omega_i = b$, $w_i = (1-c_i)b + c_i\omega_i$ for any $c_i \in [0,1]$, that is c_i is indeterminate.

and type III (on the other side). The parameters α and β will be structurally estimated from wage regressions in Section 4.3.

Table 2: Predictions of Models

RS type	Model of RS mechanism	Labour rent share for $\delta \to 0$
I	Oligopsony (OL)	$\frac{\beta(1-\alpha)}{1+\beta(1-\alpha)}$
II	Wage Floor (WF)	$\frac{\beta(1-\alpha)}{1+\beta(1-\alpha)}$
III	Efficient Bargaining (EB)	$(1-\alpha)$

Note: $(1-\alpha)$ is output elasticity of labour, and $\beta \in [0, \infty)$ measures toughness of wage competition.

3.4 Market Powers, Income Distribution and Root Cause of Inequality

In this section we first show that the results stated in Theorem 2 extend to the current general model. We will then analyse the common root cause of firms' overall market power and income distribution.

Theorem 5 (Extension Theorem) *Let the labour market rent-sharing mechanisms in the extended joint oligopoly-oligopsony model either be the oligopsony model (OL), or the wage floor model (WF) or the efficient bargaining model (EB). Let marginal cost MC_i be defined by eq. (30). All results of Theorem 2, i.e., eq. (6) - (11)) apply to this extended model.*

As shown above, the gross profit margin δ_i is not only a measure of a firm's overall market power, but also reflects a firm's relative competitiveness, defined as the ability to sustain profitability against the competitive pressure exerted by rival firms. Since δ_i also measures the producer surplus ratio to revenue, it is a key variable in the standard (Marshallian style) welfare analysis.

Define $\nu_{Li} \equiv \frac{\phi_{Li}}{\phi_{Li}+\delta_i}$ and $\nu_{Ki} \equiv \frac{\delta_i}{\phi_{Li}+\delta_i} \equiv \frac{\delta_i}{1-\phi_{Xi}}$ as the value added shares of labour and capital (gross profit) respectively. Obviously

$$\nu_{Li} \equiv \frac{\phi_{Li}}{1-\phi_{Xi}}, \nu_{Ki} \equiv \frac{1-\phi_{Xi}-\phi_{Li}}{1-\phi_{Xi}}, \nu_{Li} + \nu_{Ki} \equiv 1.$$

Define $\psi_{Li} \equiv \frac{\phi_{Li}}{\phi_{Xi}+\phi_{Li}}$ ($\psi_{Xi} \equiv \frac{\phi_{Xi}}{\phi_{Xi}+\phi_{Li}}$) as the variable cost share of labour (and intermediate input), and recall $\omega_i \equiv \frac{p_i q_i - p_X x_i}{l_i}$ as the value added per worker[40].

Theorem 6 *The labour share of value added ν_{Li} can be expressed as functions of variables w_i and ω_i as well as δ_i and ψ_{Li} by the following identities:*

$$\nu_{Li} \equiv 1 - \nu_{Ki} \equiv \frac{w_i}{\omega_i} \equiv \frac{1}{1 + \frac{\delta_i}{1-\delta_i}\frac{1}{\psi_{Li}}}, \;\; \textit{with} \; \frac{\partial \nu_{Li}}{\partial \delta_i} < 0, \frac{\partial \nu_{Li}}{\partial \psi_{Li}} > 0, \frac{\partial \nu_{Ki}}{\partial \psi_{Li}} < 0. \quad (36)$$

[40] More precisely this is value added per unit of labour. Here we adopt the term value added per worker, which is commonly used in the empirical literature on rent sharing (Card *et al.*, 2018).

Additionally, the relationship between ψ_{Li} and χ_{Li} (see eq. (15)) implies

$$\nu_{Li} = \frac{1}{1 + \frac{\alpha}{1-\alpha}\frac{\delta_i}{1-\delta_i}(1+\chi_{Li})}, \ \textit{with} \ \frac{\partial \nu_{Li}}{\partial \delta_i} < 0, \frac{\partial \nu_{Li}}{\partial \chi_{Li}} < 0. \tag{37}$$

Furthermore,

$$\nu_{Ki} \equiv 1 - \nu_{Li} = \frac{1}{1 + \frac{1-\alpha}{\alpha}\frac{1-\delta_i}{\delta_i}\frac{1}{1+\chi_{Li}}}, \ \textit{with} \ \frac{\partial \nu_{Ki}}{\partial \delta_i} > 0, \frac{\partial \nu_{Ki}}{\partial \chi_{Li}} > 0, \frac{\partial \nu_{Ki}}{\partial \alpha} > 0. \tag{38}$$

$$\nu_{Ki} = 0 \ \textit{iff} \ \delta_i = 0; \nu_{Ki} = 1 \ \textit{iff} \ \delta_i = 1. \tag{39}$$

Finally, the relationships between δ_i, ν_{Ki} and parameter α are determined by:

$$\delta_i = \frac{1}{1 + \frac{1-\nu_{Ki}}{\nu_{Ki}}\frac{\alpha(1+\chi_{Li})}{1-\alpha}}, \ \textit{with} \ \frac{\partial \delta_i}{\partial \nu_{Ki}} > 0, \frac{\partial \delta_i}{\partial \chi_{Li}} < 0, \frac{\partial \delta_i}{\partial \alpha} < 0. \tag{40}$$

Eq. (36) - (38) show that the gross profit margin δ, by definition, is a key determinant of labour share of value added ν_L and the gross profit share of value added share ν_K. An increase of overall market power index δ means lower value of ν_L and higher value of ν_K. The wage markdown power index χ_L and labour cost share ψ_L also affect ν_L and ν_K. Since χ_L and ψ_L measure the state of make-or-buy decision, then this decision must also affect the firm's internal distribution of value added between labour and capital. Furthermore, given that the sign of χ_L also captures labour market rent-sharing institutions, then these institutions must affect firms' internal income distribution between labour and capital, e.g., collective bargaining enhances workers' bargaining power. Eq. (38) and (39) show that ν_K is increasing in δ, with $\nu_K = 0$ iff $\delta = 0$, and $\nu_K = 1$ iff $\delta = 1$. This means that ν_K can substitute δ as a suitable overall market power index.[41] The fact that δ is the ratio between gross profit to revenue and ν_K is the ratio between gross profit to value added makes ν_K preferable to δ for purpose of aggregation to industry, sector and the whole economy, in the form of weighted averages. To see this, consider that the sum of value added of all firms in an economy is the GDP, and the economy-wide weighted average of ν_K is simply the ratio between the sum of gross profits and the GDP. In contrast, the economy-wide weighted average of δ is the ratio of the sum of gross profits to the sum of revenues. Here, unlike the GDP, the denominator is not a meaningful aggregate economic variable as it suffers from the double counting problem. Additionally, ν_K, like ν_L, is a perfect measure of income distribution. Thus ν_K combines measures of both market power and income distribution, and therefore makes the relationship between them transparent.[42]

[41] Note: $\nu_K = 0$ if $\rho = \chi_L = 0$. Consequently, ν_K, like δ, can also be used for identification of competitive fringe firms.

[42] The reason why we do not replace ν_K for δ entirely as a dominant measure of overall market power lies in the vital roles of δ in Theorem 2 and in the validation of the CRS hypothesis (in Section 4.2.2).

Eq. (40) shows that if we take ν_K, χ_L and α as independent variables that control for, respectively, firm productivity, labour market institution and technology, then the gross profit margin δ is an increasing function of ν_K, and it is a decreasing function of the technology/production function parameter α. The relation with α can be explained intuitively as follows. Higher value of α means firms in the industry are induced to use more intermediate input for production. Fix the level of gross profit π and ν_K in the equation: $\delta = \frac{\pi}{\pi/\nu_K + p_X x}$, then higher value of α implies higher value of intermediate input expenditure $p_X x$ and lower value of δ.

The next proposition shows that each of variables ω, ν_K and δ can be used as a proxy for the unobservable productivity for they all have variable A as a common determinant. The proposition also identifies factors that may affect their suitability as proxies, which need to be controlled for.

Proposition 7 *For Cobb-Douglas production function $F_i(x_i, l_i) = A_i x_i^{\alpha} l_i^{1-\alpha}$, the following equations and identities hold:*

$$\omega_i = A_i p_i [1 - \alpha(1 - \rho_i)] \left(\frac{x_i}{l_i}\right)^{\alpha}, \ \text{with} \ \frac{\partial \omega_i}{\partial A_i} > 0, \tag{41}$$

$$\nu_{Ki} = 1 - \frac{p_X \frac{\psi_{Li}}{1-\psi_{Li}} \left(\frac{x_i}{l_i}\right)^{1-\alpha}}{A_i p_i [1 - \alpha(1 - \rho_i)]}, \ \text{with} \ \frac{\partial \nu_{Ki}}{\partial A_i} > 0, \tag{42}$$

$$\delta_i = 1 - \frac{p_X \left(\frac{x_i}{l_i}\right)^{1-\alpha}}{A_i p_i (1 - \psi_{Li})}, \ \text{with} \ \frac{\partial \delta_i}{\partial A_i} > 0. \tag{43}$$

Eq. (41) indicates that controlling for prices p_i and p_X, markup power index ρ_i, the input mix $\frac{x_i}{l_i}$ and parameter α, the predetermined firm short-run productivity A_i is an *ex post* exogenous determinant of ω_i. Similarly, eq. (42) and (43) indicate that with suitable controls for other relevant variables, A_i is also an *ex post* exogenous determinant of ν_{Ki} and δ_i. Overall, the dispersion in the distribution of A_i is a common cause of the dispersion in the distributions of ω_i, ν_{Ki} (and ν_{Li}) and δ_i. Also, for empirical analysis, ω_i, ν_{Ki} and δ_i can all be used as suitable proxies for the unobservable A_i. However, none of them is perfectly accurate because (i) ν_{Ki} and δ_i have the domain $[0, 1]$, and thus are uninformative about absolute scale of the physical productivity: they are only suitable as a measure of relative productivity or competitiveness vis-à-vis rival firms; (ii) ω_i is scaled by the effect of input mix $\frac{x_i}{l_i}$. In regression analysis, (i) is not a problem because the constant term and/or the industry and year dummies can capture the scale of physical productivity. To mitigate the potential bias caused by the input mix $\frac{x_i}{l_i}$, ω_i should be used with χ_{Li} as a control variable. Recall that in Theorem 3 we have introduced the observable variable Λ_i as a proxy measure of A_i. Identity (17) shows Λ_i is a positive linear function of A_i, with the coefficient $\frac{p_i}{(p_X)^{\alpha}}$ dependent on the unobservable prices p_i and p_X. It can therefore be used to empirically validate the claims that A_i is a common determinant of ω_i, ν_{Ki} (and ν_{Li}) and δ_i (see Section 4.4).

Theorem 8 below addresses the central question of the paper about the driving force of rise of market power and fall of labour income share. It states that the dispersion in the productivity distribution, measured by CV_A, is the common root cause of (i) the increase of industry-level weighted average of gross-profit share of value added, above the simple (unweighted) mean, and (ii) the suppression of the industry-level weighted average of labour share of value added below the unweighted mean. Before stating the theorem, we introduce the notation ς_i to denote the value added share of firm i in an industry, and μ_y and μ_y^{ς} to indicate respectively the unweighted and ς-weighted means of the distribution of y, for $y \in \{\nu_K, \nu_L, \varsigma\}$. For an industry with n firms, note the following mathematical facts: $\mu_\varsigma = \frac{1}{n}$, and

$$\begin{aligned} \mu_y^{\varsigma} &\equiv \sum_{i=1}^{n} \varsigma_i y_i = \mu_y + n \times cov\left[y, \varsigma\right], \\ \mu_y^{\varsigma} &= \mu_y \left(1 + corr\left[y, \varsigma\right] CV_y CV_\varsigma\right), \end{aligned} \tag{44}$$

where $cov\left[y, \varsigma\right]$ and $corr\left[y, \varsigma\right]$ are respectively the covariance and correlation coefficient between y and ς, CV_y and CV_ς are respectively the coefficient of variation for y and ς.

Theorem 8 *Let* $\mu_{\nu_K}^{\varsigma} \equiv \sum_{i=1}^{n} \varsigma_i \nu_{Ki}$ *and* $\mu_{\nu_L}^{\varsigma} \equiv \sum_{i=1}^{n} \varsigma_i \nu_{Li}$. *Suppose* $\frac{d\nu_{Ki}}{dA_i} > 0$, $\frac{d\varsigma_i}{dA_i} > 0$, $\frac{dCV_{\nu_K}}{dCV_A} > 0$, $\frac{dCV_{\nu_L}}{dCV_A} > 0$ *and* $\frac{dCV_\varsigma}{dCV_A} > 0$. *Then*

$$corr\left[\varsigma, \nu_L\right] = -corr\left[\varsigma, \nu_K\right] < 0, \tag{45}$$

$$\frac{\mu_{\nu_K}^{\varsigma} - \mu_{\nu_K}}{\mu_{\nu_K}} = corr\left[\varsigma, \nu_K\right] CV_{\nu_K} CV_\varsigma, \ \ with \ \frac{d\left(\frac{\mu_{\nu_K}^{\varsigma} - \mu_{\nu_K}}{\mu_{\nu_K}}\right)}{dCV_A} > 0. \tag{46}$$

$$\frac{\mu_{\nu_L}^{\varsigma} - \mu_{\nu_L}}{\mu_{\nu_L}} = corr\left[\varsigma, \nu_L\right] CV_{\nu_L} CV_\varsigma, \ \ with \ \frac{d\left(\left|\frac{\mu_{\nu_L}^{\varsigma} - \mu_{\nu_L}}{\mu_{\nu_L}}\right|\right)}{dCV_A} > 0, \tag{47}$$

i.e., a rise of the dispersion in firms' productivity CV_A *causes* $\frac{\mu_{\nu_K}^{\varsigma} - \mu_{\nu_K}}{\mu_{\nu_K}}$, *a measure of the increase of the weighted average of gross-profit share of value added above the unweighted mean, to increase, and causes* $\left|\frac{\mu_{\nu_L}^{\varsigma} - \mu_{\nu_L}}{\mu_{\nu_L}}\right|$, *a measure of the suppression of the weighted average of labour share of value added below the unweighted mean, to increase.*[43]

Intuitively, more productive firms are more competitive, and have more market power, higher value added shares, lower labour share of value added and higher gross profit share of value added. This implies that firms' value added shares ς and overall market power index ν_K (respectively labour shares of value added ν_L) are positively (respectively negatively) correlated (hence inequalities (45)). Because the dominant frontier firms have higher value added shares, which are the weights used for industry-level weighted average of market power index

[43] Eq. (47) is essentially a repetition or a straightforward implication of eq. (46) because of the fact $\nu_L + \nu_K \equiv 1$. However, it is still worth stating separately for its economics meaning.

ν_K and labour share of value added ν_L, they drive the value-added-share-weighted means of ν_K and ν_L, and thus raise $\mu^{\varsigma}_{\nu_K}$ above μ_{ν_K}, and suppress $\mu^{\varsigma}_{\nu_L}$ below μ_{ν_L}. These effects are stronger if the dominant frontier firms' productivity and their rivals' are further apart, i.e., CV_A rises. The theoretical message of Theorem 8 is that conditional on μ_A, μ_{ν_K} and μ_{ς}, a rise of the dispersion in firms' short-run productivity is the common root cause of a rise of market power concentration, measured by $\mu^{\varsigma}_{\nu_L}$, and a fall of aggregate labour share of value added, measured by $\mu^{\varsigma}_{\nu_L}$.

4 Empirical Analysis

This section starts with a description of the data used to estimate the extended JOOM model, and test its theoretical predictions. In Section 4.2, we first estimate the industry-level technology parameter α and firm-level markup and markdown power indices, and we then discuss the classification of firms into three rent sharing (RS) types, corresponding to the oligopsony model (OL), the wage floor model (WF), and efficient bargaining model (EB). We also test the CRS hypothesis, which is important for the estimation of production function parameters and market power indices. In Section 4.3 we present the results of the wage regressions and discuss how they bear out the theoretical predictions about the effects of collective bargaining. Section 4.4 presents empirical evidence on the hypothesis that the dispersion of firms' short-run productivity is the common root cause of dispersions in firms' overall market power and value added share of labour. Furthermore, we empirically validate the theoretical predictions stated in Theorem 8, and quantify how increased dispersion in the distribution of firms' short-run productivity causes both higher aggregate gross profit margin and lower aggregate value added share of labour.

4.1 Data and Variables

Our data are retrieved from FAME, a dataset published by Bureau van Dijk with comprehensive financial data of companies with 5 or more employees registered in the UK and Ireland. We focus on 4-digit SIC industries[44] in the UK manufacturing sector for a 17-year period, from 2003 to 2019. FAME is particularly suitable for our analysis because, by covering thousands of public and private companies, it provides exhaustive information not only for most of the large companies, but also for a vast number of smaller entities, which are more likely to include fringe firms with (almost) no market power.[45] The key variables retrieved from FAME dataset are listed in Table 3.

Table 4 summarises the descriptive statistics of the key variables of interest and their coefficients of variation (CV) at the industry level. The numbers show that there is substantial firm heterogeneity and large inequality in

[44] We also check robustness of our findings with 5-digit SIC-code industries and find results are mostly consistent.

[45] We note that the coverage in FAME is better than other well-known financial dataset, such as Compustat, as it includes private companies which are not required to file account.

Table 3: Data and Variables

Theoretical variable	Variable in data
Revenue R	Turnover
Variable cost VC	Cost of goods sold
Variable labour cost wl	Pay roll
Flexible labour input l	Employment
Wage w	$\frac{\text{Pay roll}}{\text{Employment}}$
Industry	4-digit SIC code
Cost of intermediate input $p_X x = VC - wl$	Cost of goods sold - Pay roll
Gross profit $\pi = R - VC$	Turnover - Cost of goods sold
Gross profit margin $\delta = \frac{\pi}{R}$	$\frac{\text{Gross profit}}{\text{Turnover}}$
Value added $\pi + wl$	Gross profit + Pay roll
Value added per worker $\omega = \frac{\pi+wl}{l}$	$\frac{\text{Gross profit + Pay roll}}{\text{Employment}}$
Labour share of value added $\nu_L = \frac{wl}{\pi+wl}$	$\frac{\text{Pay roll}}{\text{Gross profit + Pay roll}}$
Gross profit share of value added $\nu_K = \frac{\pi}{\pi+wl}$	$\frac{\text{Gross profit}}{\text{Gross profit + Pay roll}}$

Notes: On the left, we list the most relevant theoretical variables. On the right, we show how these variables are measured using data in FAME.

Table 4: Summary Statistics (1)

	Obs	Mean	Std dev		Obs	Mean	Std dev
ω	60367	68.72	88.98	ν_K	60367	.5860	.1466
δ	60367	.2842	.1370	s	60367	.0578	.1406
ν_L	60367	.4140	.1466	ς	60367	.0583	.1484
CV_ω	3156	.5196	.3153	CV_{ν_K}	3156	.2272	.1317
CV_δ	3156	.4467	.1867	CV_s	3156	1.307	.8043
CV_{ν_L}	3156	.3181	.1380	CV_ς	3156	1.249	.8148

Notes: See Table 3 for definitions of ω, δ, ν_L and ν_K. s and ς are firms' market shares in terms of, respectively, revenue and value added in the corresponding SIC4 industry. CV are the coefficient of variation of the variables in a SIC4 industry.

terms of CVs of δ, ω, ν_L and ν_K for 4-digit SIC-code industries in the UK manufacturing sector. Furthermore, the within-industry dispersion in the distributions of firms' market shares, in terms of revenue share s and value added share ς, is strikingly large.

4.2 Estimation Results

4.2.1 Production Function, Market Power, and Rent Sharing Types

The theoretical underpinning for the identification of the short-run production function parameters rests on the notion of competitive fringe firm, discussed in Section 2.4. The empirical estimation of parameter α and χ_L are given by eq. (18) and (19). Concretely, for each year t and industry k, a firm i is classified as a "competitive fringe firm" if its gross profit is in the bottom 5% of the distribution. Accordingly, we estimate α_{kt} by:

$$\tilde{\alpha}_{kt} = median\left\{1 - \psi_{Likt} : \delta_{\min kt} \leq \delta_{ikt} \leq \delta_{\min kt} + 0.05\right\}, \tag{48}$$

where $\delta_{\min kt}$ is the minimum of δ_{ikt} across all i-firms in industry k at time t. Once $\tilde{\alpha}_{kt}$ is obtained, the estimator $\tilde{\chi}_{Likt}$ is calculated according to:

$$\tilde{\chi}_{Likt} = \frac{1 - \tilde{\alpha}_{kt}}{\tilde{\alpha}_{kt}} \frac{p_{Xkt} x_{ikt}}{w_{ikt} l_{ikt}} - 1, \tag{49}$$

where $p_{Xkt} x_{ijt}$ and $w_{ikt} l_{ikt}$ are available from our dataset. The estimator $\tilde{\rho}_{ikt}$ is then computed as

$$\tilde{\rho}_{ikt} = 1 - (1 + \tilde{\chi}_{Likt}) \frac{\phi_{Likt}}{1 - \tilde{\alpha}_{kt}}, \tag{50}$$

where ϕ_{Likt} is the revenue share of labour for firm i in industry k in period t. For ease of notation, in the remainder of the paper, we use $(\alpha_{kt}, \chi_{Likt}, \rho_{ikt})$ unless specifically stated otherwise. For the empirical analysis, they should be interpreted as $(\tilde{\alpha}_{kt}, \tilde{\chi}_{Likt}, \tilde{\rho}_{ikt})$.

After obtaining $\tilde{\alpha}_{kt}$, the proxy measure for the unobservable variable A can also be computed according to:

$$\tilde{\Lambda}_{ikt} \equiv \frac{(w_{ikt})^{1-\tilde{\alpha}_{kt}}}{\left(\frac{p_{Xkt} x_{ikt}}{w_{ikt} l_{ikt}}\right)^{\tilde{\alpha}_{kt}} \phi_{Likt}}. \tag{51}$$

Table 5 shows that the mean value of output elasticity of intermediate input α is 0.81, which is within the range of values reported in the literature. Because the magnitude of Λ is proportional to A, the coefficient of variation of Λ is informative about the dispersion of A. Table 5 also shows that the distribution of Λ is highly dispersed, indicating that the distribution of A must also be highly dispersed.

The estimated distribution of χ_{Likt} and δ_{ikt} allows us to define the RS types. For given industry k in year t,

Table 5: Summary Statistics (2)

	Obs	Mean	Std dev
α	3517	.8098	.1254
Λ	60367	5.984	32.66
CV_Λ	3156	.4106	.5015

we divide the sample of firms into three subsets using the following partition of the $(\delta_{ikt}, \chi_{Likt})$ plane:

$$\text{RS type I} \equiv \{(\delta_{ikt}, \chi_{Likt}) : \ln(1+\chi_{Likt}) \geq 0.5\ln(1+\delta_{ikt}) > 0\}, \tag{52}$$

$$\text{RS type II} \equiv \{(\delta_{ikt,Likt}) : |\ln(1+\chi_{Likt})| < 0.5\ln(1+\delta_{ikt})\}, \tag{53}$$

$$\text{RS type III} \equiv \{(\delta_{ikt,Likt}) : \ln(1+\chi_{Likt}) \leq -0.5\ln(1+\delta_{ikt}) < 0\}. \tag{54}$$

As the point $(\delta_{ikt}, \chi_{Likt}) = (0,0)$, which theoretically represents the competitive fringe firms, is on the common boundary of the three subsets, the proposed partition has the desirable property of having the fringe firms as the limit points for the three RS types. At the same time, this partition clearly separates RS types I and III (by having RS type II in between) except for the limit point $\delta_{ikt} = 0$. The use of function $\ln(1+\chi_{Li})$ ensures that we have a symmetry around $\chi_{Li} = 0$, since the range of $\ln(1+\chi_{Li})$ is $(-\infty, \infty)$, whereas the parameter value choice of 0.5 allows to have a reasonable sample size of RS type II firms. Furthermore, the function $\ln(1+\delta_{ikt})$ allows for a more clear separation between RS types I and III for higher values of δ_{ikt}.

Table 6: RS Types Distribution

	RS type			
	I	II	III	Total
Obs.	11863	6533	41971	60367
%	19.7	10.8	69.5	100

Table 6 shows the number of firms by RS types over the sample period. RS types I, II and III contain 20%, 11% and 70% of UK manufacturing firms, respectively. Table 13 of Appendix C.1, which reports the changes of RS type distribution between 2005 and 2015, unveils that there is a sizable degree of persistency of RS types. Figures 3 and 4 show that the boundaries between the RS types, respectively, on the $(\ln(1+\delta_{ikt}), \ln(1+\chi_{Likt}))$ plane and on the $(\ln(1+\nu_{Kikt}), \ln(1+\chi_{Likt}))$ plane (δ and ν_K being the two measures of overall market power we advocate). The fact that the correlations of χ_L respectively with δ_{ikt} and ν_{Kikt} differ is not surprising since eq. (38) and (40) show the relationship between δ and ν_K is not linear, and it is affected by the technology

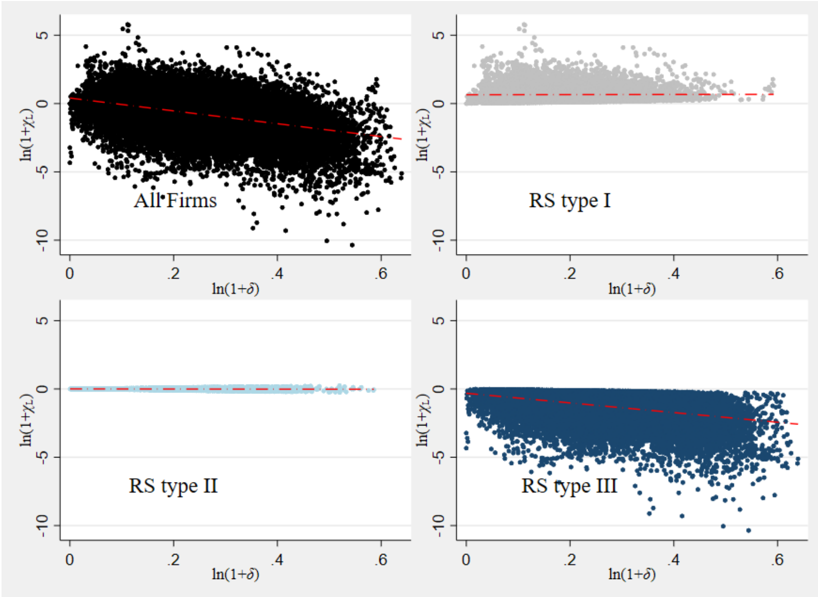

Figure 3: Scatter plots of $(\ln(1+\delta_{ikt}), \ln(1+\chi_{Likt}))$ and the subsets of partition. The full set (of all firms) is partitioned into three mutually exclusive subsets, labelled RS Types I, II and III.

parameter α as well as the wage markdown power index χ_L.

The estimated value of χ_L has two interpretations: a direct one and an inferred one. Its direct interpretation is the extent to which a firm is inclined to choose buying in the make-or-buy decision relative to the competitive fringe firm. For $\chi_L = 0$, it is the same as the competitive fringe firm; for $\chi_L > 0$, it is more inclined to buy; for $\chi_L < 0$, it is more inclined to make. The indirect interpretation of χ_L refers to the wage markdown power index. Our theory associates $\chi_L < 0$ and the preference for in-house production with bilateral monopoly and Nash bargaining solution. This is complementary to the institutional theories of the firm *à la* Williamson (1979) and Grossman and Hart 1986). One reason for the firms to have chosen in-house production can be relationship-specific investments, which make such firms vulnerable to being "held up" by the relationship-specific intermediate inputs suppliers. The organisational solution to this problem has been to integrate with those inputs suppliers, hence produce more in-house and out-source less. The incomplete contract theory of the firm (Grossman and Hart 1986) furthermore suggests that vertical integration does not eliminate the "hold-up" problem: it just replaces an internal one for the external one. Interestingly, the internal bargaining problem is less bad for the firms' owners because they have a stronger bargaining position based on asset ownership. In the context of our model, the internal "hold-up" problem involves workers collectively bargaining with the asset owners of the firm over sharing of quasi rent, therefore supporting the interpretation of RS type II and III as collective bargaining mechanisms.

Table 7 shows that consistent with the hypothesis that collective bargaining enhances workers' bargaining power, the mean of ν_L increases with the RS type. This comparison is, however, without control of (proxy)

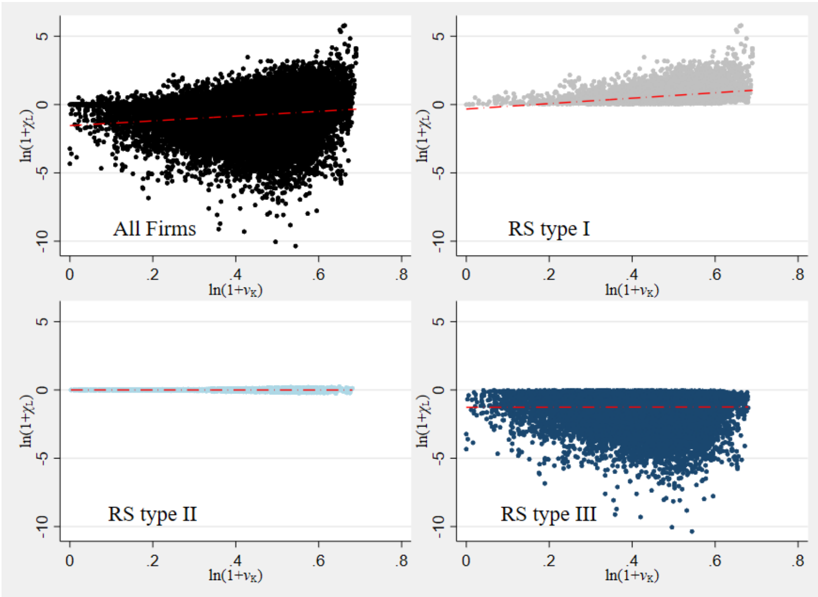

Figure 4: Scatter plots of $(\ln(1+\nu_{Kikt}), \ln(1+\chi_{Likt}))$ and subsets of partition. The full set (of all firms) is partitioned into three mutually exclusive subsets, labelled RS Types I, II and III.

Table 7: Summary Statistics (3)

	RS Type I			RS Type II			RS Type III		
	Obs	Mean	Std dev	Obs	Mean	Std dev	Obs	Mean	Std dev
ω	11863	92.01	156.5	6533	69.25	77.55	41971	55.92	38.38
δ	11863	.2147	.1078	6533	.2328	.1274	41971	.3118	.1366
ν_L	11863	.3534	.1443	6533	.4074	.1759	41971	.4290	.1376
ν_K	11863	.6466	.1443	6533	.5926	.1759	41971	.5710	.1376
Λ	11863	6.810	9.268	6533	5.408	4.284	41971	5.815	38.82

measures of productivity, say, ω or Λ. We investigate this topic in depth with control of the effect of productivity on workers' bargaining power in Section 4.3.

4.2.2 Test of CRS Hypothesis

The CRS hypothesis $\theta_X + \theta_L = 1$ affects the accuracy of using δ as an index of overall market power. More importantly, it is essential for our estimation of the short-run production function parameters θ_X and θ_L and markup power index ρ. It is then important to validate the hypothesis empirically.

For this, we note that under CRS, eq. (8) implies

$$\delta_{ikt} \approx \rho_{ikt} \text{ for RS type II with } \chi_{Likt} \approx 0. \tag{55}$$

This approximate equation will play an important role in our empirical validation of the CRS hypothesis. For this purpose, it is important that our estimation of χ_{Li} and classification of RS types are robust to the CRS hypothesis itself. This is indeed the case since our identification of the approximate competitive fringe firms is (reasonably) insensitive to the CRS hypothesis, and thus the estimation of χ_{Li} and our classification of the RS types are robust. This provides a sound theoretical basis for using the empirically identified RS type II (with $\chi_{Li} \approx 0$) to test the CRS hypothesis. Eq. (8) implies that for RS type II firms, $\delta_{ikt} \approx [1 - (\theta_{Lkt} + \theta_{Xkt})] + (\theta_{Lkt} + \theta_{Xkt})\,\rho_{ikt}$. Accordingly, we can use the graph in the (ρ, δ) plane to visually inspect the elasticity of scale $(\theta_{Lkt} + \theta_{Xkt})$: under CRS, its intercept should be zero, and its slope should be 1. Figure 5 shows the scatter plot of $(\delta_{ikt}, \rho_{ikt})$ in the (δ, ρ) plane for RS type II, in comparison with the benchmark line: $\delta_{ikt} = \rho_{ikt}$. The 45° line fits the data remarkably well, thus providing strong support for the CRS hypothesis.

Next we estimate the scale elasticity $(\theta_{Lkt} + \theta_{Xkt})$ under the assumption that $(\theta_{Lkt} + \theta_{Xkt})$ is constant across industry k and time t, although neither θ_{Lkt} nor θ_{Xkt} is so. Eq. (8) implies the following equation:

$$\delta_{ikt} = [1 - (\theta_{Lkt} + \theta_{Xkt})] + (\theta_{Lkt} + \theta_{Xkt})\,\rho_{ikt} + \theta_{Lkt}\frac{(1-\rho_{ikt})\,\chi_{Likt}}{(1+\chi_{Likt})} + \varepsilon_{ikt}. \tag{56}$$

When taking eq. (56) to the data, θ_{Lkt}, the coefficient of regressor $\frac{(1-\rho_{ikt})\chi_{Likt}}{(1+\chi_{Likt})}$, is treated as constant over time and across industries. Let $\hat{\theta}_L$denote the estimated coefficient, then the discrepancy $\left(\theta_{Lkt} - \hat{\theta}_L\right)\frac{(1-\rho_{ikt})\chi_{Likt}}{(1+\chi_{Likt})}$ enters the error term. Our data shows that, for the full sample with all firms, the two regressors ρ_{ikt} and $\frac{(1-\rho_{ikt})\chi_{Likt}}{(1+\chi_{Likt})}$ are negatively correlated with correlation coefficient of -0.2649. This biases the estimate of $(\theta_{Lkt} + \theta_{Xkt})$ using the full sample. Fortunately, for RS type II, the discrepancy $\left(\theta_{Lkt} - \hat{\theta}_L\right)\frac{(1-\rho_{ikt})\chi_{Likt}}{(1+\chi_{Likt})}$ drops out because $\chi_{Likt} \approx 0$, allowing for consistent estimate of $(\theta_{Lkt} + \theta_{Xkt})$. The economics implication of this restriction to RS type II is that to estimate the elasticity of scale consistently, it is important to isolate the production function feature (i.e., a

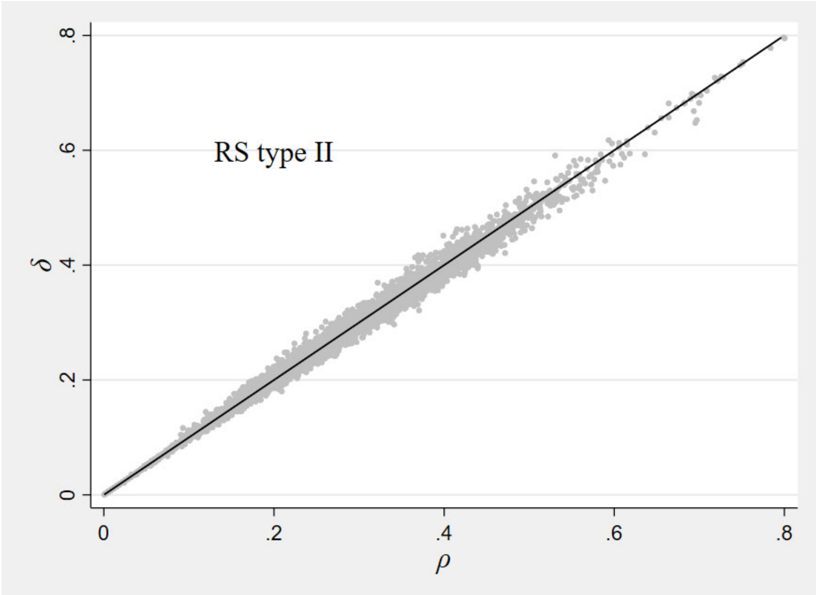

Figure 5: Constant Returns to Scale (CRS) for RS type II. The benchmark for CRS is the 45° line where $\delta_{ikt} = \rho_{ikt}$.

technology parameter) from the difference in labour market rent-sharing types (i.e., institutions). The regression results reported in Table 8 support our approach: the estimated coefficients on ρ_{ikt} clearly differs between the RS type II sample and the pooled data as expected. We therefore only use the former for structural estimation of the scale elasticity, which results in value 0.9988. Using a 5% significance level, we fail to reject the null hypothesis that the coefficient on ρ_{ikt} is equal to one and we also fail to reject the null hypothesis that the coefficients of all the year dummy variables are all equal to zero. Overall, these results provide strong support for the CRS hypothesis.

4.3 Wage Regressions and Rent-Sharing Mechanisms

In the previous section we have shown the importance of taking the RS type into consideration when testing the CRS hypothesis – restricting the analysis to RS type II in order to isolate features of technology/production function from the effects of wage markdown power. Now we show that controlling for rent-sharing types is also important for structural estimation of wage regressions, since the theory predicts that labour market institutions affect rent sharing and wage determination.

Consider the following two regression equations:

Table 8: Regressions of δ_{ikt} on ρ_{ikt}

regressor	coefficient	RS type II (1)	All firms (2)
ρ_{ikt}	$(\theta_L + \theta_X)$	.9988***	.4651***
		(.0006)	(.0208)
$\frac{(1-\rho_{ikt})\chi_{Likt}}{(1+\chi_{Likt})}$	θ_L	.2424***	.0040***
		(.0086)	(.0015)
Ind. FE		Yes	Yes
Year FE		Yes	Yes
R^2 adj		0.999	0.693
Obs		6533	60367

Notes: The table shows the estimated coefficients of eq. (56) for RS type II and all firms. The coefficient $(\theta_L + \theta_X)$ is the elasticity of scale of the short-run production function. Standard errors are clustered at industry level. *** indicates statistical significance at 1% level.

$$w_i = \xi_0 + \xi_1\omega_i + \xi_2\omega_i \ln(1-\delta_i) + \xi_3\omega_i \ln(1+\chi_{Li}) + \xi_4 \ln(1-\delta_i) + \xi_5 \ln(1+\chi_{Li}) + \varepsilon_i, \quad (57)$$

$$\ln w_i = \xi_6 + \xi_7 \ln \omega_i + \varepsilon_i. \quad (58)$$

Eq. (57) is used for structural estimation of model parameters α and β, to be backed out from the coefficient $\xi_1 > 0$, with variables $\omega_i \ln(1-\delta_i)$, $\omega_i \ln(1+\chi_{Li})$, $\ln(1-\delta_i)$ and $\ln(1+\chi_{Li})$ as relevant controls. Based on theoretical predictions summarised in Table 2. the following two hypotheses can be tested:

(H1) The coefficient ξ_1 is the same for RS types I and II.

(H2) The value of ξ_1 for RS type III should exceed that for RS types I and II.

Eq. (58) is a reduced-form regression, useful to test the following two hypothesis:

(H3) $\xi_7 \in (0,1)$ for all RS types.

(H4) The value of ξ_7 for RS type III exceeds that for RS types I and II.

Table 9 reports the wage regression results based on eq. (57). As explained in the introduction, our analysis is based on a static model, which features short-run production function. In our theoretical model each firm's short-run productivity A_i is predetermined, and should be treated as exogenous for analysing the determination short-run market outcome. Following the theoretical underpinnings, for regression equation (57), the explanatory variable ω_i, which is a proxy of A_i,[46] is also treated as exogenous, which justifies the use of OLS regression. For robustness check, we also include fixed effect to control for unobserved heterogeneity due to labour and managerial

[46] We empirically validate the claim that ω_i is a proxy measure of A_i in Section 4.4, and report evidence of correlation between ω_i and Λ_i (a partial measure of A_i) in Table 11.

Table 9: Regressions of w on ω

	RS type I		RS type II		RS type III	
	(1) OLS	(2) Firm FE	(3) OLS	(4) Firm FE	(5) OLS	(6) Firm FE
ω	.1290***	.0980***	.1223***	.1161***	.1807***	.2014***
	(.0248)	(.0317)	(.0330)	(.0314)	(.0248)	(.0227)
$\omega \ln(1-\delta)$	.0559***	.0381***	.0690***	.0641***	.1106***	.1009***
	(.0106)	(.0144)	(.0244)	(.0211)	(.0155)	(.0128)
$\omega \ln(1+\chi_L)$	-.0262***	-.0192***	-.0469	-.0071	-.0311***	-.0175***
	(.0056)	(.0073)	(.0652)	(.0232)	(.0076)	(.0053)
$\ln(1-\delta)$	9.710***	10.41**	6.096***	4.982**	6.934***	7.037***
	(2.999)	(4.603)	(1.384)	(2.234)	(.8699)	(1.141)
$\ln(1+\chi_L)$	.5088**	1.051*	1.076	-1.293	-.4975	-.1333
	(.2390)	(.5790)	(5.974)	(2.244)	(.4158)	(.2700)
Ind. FE	Yes	No	Yes	No	Yes	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2 adj	0.519	0.779	0.597	0.852	0.616	0.884
Obs	11863	11863	6533	6533	41971	41971

Notes: The table shows the estimated coefficients of eq. (57). Standard errors are clustered at industry level. ***, ** and * respectively indicates statistical significance at 1%, 5% and 10% level.

quality and other firm-level institutional differences that are (almost) time invariant.[47] The estimated values of ξ_1 are positive and statistically significant at 1% level for all RS types. The estimated coefficients for RS types I and II are very similar: a result consistent with (H1). In light of the theoretical predictions summarised in Table 2, the estimated coefficients for RS type III imply that the value of the production function parameter α is in the range of $[0.80, 0.82]$, which is consistent with the mean value 0.81 reported in Table 4. If we set $\alpha = 0.81$ and consider that the range of values of ξ_1 for RS types I and II are $[0.10, 0.13]$, we infer that the value of parameter β is in the range of $\left[\frac{0.1}{(1-0.1)(1-0.81)}, \frac{0.13}{(1-0.13)(1-0.81)}\right] = [0.58, 0.79]$. This indicates moderate toughness of wage competition, in line with the literature. Importantly, by a large margin these results are consistent with hypothesis (H2), indicating that the efficient bargaining mechanism increases workers' quasi rent share relative to oligopsony and the wage floor mechanism.

Estimated eq. (57) can be rewritten as:

$$w_i = \hat{c} + \left[\hat{\xi}_1 + \hat{\xi}_2 \ln \frac{1}{1-\delta_i} + \hat{\xi}_3 \ln(1+\chi_{Li})\right] \omega_i + \varepsilon_i,$$

where $\hat{c}$ summarises the terms that do not directly depend on ω_i. The net effect of ω_i on w_i is measured by the term in brackets. Table 9 shows that $\hat{\xi}_2 > 0$ at 1% level of statistical significance for all RS types. This implies

[47] Further robustness check using the instrument variable approach is reported in Table 14 of Appendix C.2, which also shows comparable results.

Table 10: Regressions of $\ln w$ on $\ln \omega$

	RS type I		RS type II		RS type III	
	(1) OLS	(2) Firm FE	(3) OLS	(4) Firm FE	(5) OLS	(6) Firm FE
$\ln \omega$	.3832***	.3443***	.3925***	.4680***	.5072***	.4690***
	(.0206)	(.0317)	(.0190)	(.0765)	(.0254)	(.0170)
Ind. FE	Yes	No	Yes	No	Yes	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2 adj	0.522	0.852	0.648	0.857	0.645	0.903
Obs	11863	11863	6533	6533	41971	41971

Notes: The table shows the estimated coefficients of eq. (58). Standard errors are clustered at industry level. *** indicates statistical significance at 1% level.

that firms with higher overall market power, measured by δ_i, tend to share with their employees a smaller fraction of their quasi rents. This can be one of the microeconomic mechanisms that cause firm level wage stagnation. This tendency can be either reenforced or mitigated depending on the firms' rent sharing types, as indicated by the fact that $\hat{\xi}_3 < 0$ for all RS types, with statistical significance of 1% level for RS types I and III. For RS type I, $\chi_{Li} > 0$ implying $\hat{\xi}_3 \ln(1 + \chi_{Li}) < 0$: a reenforcement of wage stagnation.[48] For RS type III, $\chi_{Li} < 0$ implying $\hat{\xi}_3 \ln(1 + \chi_{Li}) > 0$: a mitigation of wage stagnation.[49] Overall, these provide further evidence that collective bargaining (including RS types II and III) enhances workers' bargaining power (relative to RS type I), more so with efficient bargaining (i.e., RS type III).

Table 10 reports OLS and FE regression results for the wage equation (58). The coefficient on $\ln \omega$ is known in the literature as the 'elasticity of rent sharing'. Its estimates for RS types I and II are respectively in the ranges of $[0.34, 0.38]$ and $[0.39, 0.47]$, the value for RS type III is in the range of $[0.47, 0.51]$, all consistent with hypothesis (H3). All OLS (our preferred) regressions are also consistent with (H4), thus indicating that the efficient bargaining mechanism enhances workers' wage bargaining power.

Recalling that 11% and 70% of all UK manufacturing firms in our dataset can be classified as RS types II and III, respectively, the importance of the role played by collective bargaining in wage determination and income distribution cannot be understated. The fact that cross-firm wage differentials only partially track the cross-firm differences in labour productivity (also measured by ω) shows that collective bargaining can mitigate but not eliminate firm-level wage stagnation. Importantly, the fact that hypotheses (H2) and (H4) are confirmed in our data shows that the mitigation is quantitatively significant.

[48] In the OLS results for RS type I, the maximum value of the term in the sample is $\hat{\xi}_1 = 0.129$, and the 1 percentile value is reduced to 0.045.

[49] In the OLS results for RS type III, the maximum value of the term in the sample is 0.404, exceeding $\hat{\xi}_1 = 0.181$, and the 1 percentile value is to 0.064. These indicate that the effects of χ_{Li} can mitigate or even offset the wage stagnation effect of δ_i.

4.4 Root Cause of Market Power Concentration and Wage Stagnation

In this section, we examine the root cause of wage stagnation at firm level and in aggregate. We start by noting that the representative-firm style of analysis is no longer suitable because the wide dispersion between the superstar firms and the competitive fringe firms makes the central location no longer a useful approximation. For example, the superstar firms who have superior productivity and market power and inferior labour share of value added, have more influence on the aggregate performance along the latter two dimensions, but not necessarily on the first. For this reason, the analysis needs to focus on the dispersion in variables' distributions, and to the interrelations between these dispersions. This insight has been captured by Theorem 8 in Section 3.4, and we operationalise it in this section.

Our theoretical argument is that the dispersion of firms' short-run productivity A is a common root cause of dispersions of ω, δ and ν_K (or ν_L). Since A is unobservable, in empirical analysis its effects need to be examined using suitable proxy measure, such as Λ introduced in Theorem 3. We therefore regress respectively $\ln \omega$, δ and ν_K on $\ln \Lambda$. The results are reported in Table 11, which give strong support to our approach.

Table 11: Regression of $\ln \omega$, δ and ν_K on $\ln \Lambda$

	RS type I			RS type II			RS type III		
	$\ln \omega$ (1)	δ (2)	ν_K (3)	$\ln \omega$ (4)	δ (5)	ν_K (6)	$\ln \omega$ (7)	δ (8)	ν_K (9)
$\ln \Lambda$	2.510***	.3441***	.4748***	2.173***	.5141***	.6184***	.6030***	.2301***	.1689***
	(.1052)	(.0207)	(.0275)	(.0820)	(.0114)	(.0262)	(.0485)	(.0096)	(.0151)
α	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
χ_L	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2 adj	0.765	0.666	0.555	0.797	0.868	0.689	0.392	0.695	0.354
Obs	11863	11863	11863	6533	6533	6533	41971	41971	41971

Notes: The variable Λ is a partial measure of the unobservable variable A, which is a common determinant of variables ω, δ and ν_K. These variables also depend on technology parameter α, labour market imperfect competition χ_L, and rent-sharing type. All regressions include industry and year fixed effects. Standard errors are clustered at industry level. *** indicates statistical significance at 1% level.

Table 12: Correlation Coefficients, Coefficients of Variation and Simple Means

	$corr\,[\varsigma, \nu_L]$ (1)	CV_ς (2)	CV_{ν_L} (3)	CV_{ν_K} (4)
Mean	-.0788	1.2490	.3176	.2272
Obs	3156	3156	3156	3156

Note: ς refers to market shares in terms of value added, ν_L is the labour share of value added and ν_K is the capital share of value added

Next we validate the predictions of Theorem 8 about the common root cause of the increase of weighted average of overall market power above the unweighted mean, and of the suppression of weighted average of labour share of value added below the unweighted mean, by quantifying eq. (46) and (47). The descriptive statistics relevant for our quantitative analysis are summarised in Table 12, which includes the sizeable coefficient of variation of ν_K distribution (in line with the large CVs of ω, δ and Λ reported in Tables 4 and 5). Although the firms at the top of the ν_K distribution have small probability weights, the positive correlation between ν_K and value added share ς implies that those firms tend to be also at the top of ς distribution. Since ς is the weight for weighted average of ν_K, the positive correlation implies the inequality in ν_K and ς distributions tend to increase the ς-weighted mean of ν_K above the unweighted mean, thus serving as a cause of increased aggregate-level market power. The quantitative results are calculated in two alternative ways.

First, we use the estimated value of $corr\left[\varsigma, \nu_L\right]$:

$$\begin{aligned}
\frac{\mu_{\nu_K}^{\varsigma} - \mu_{\nu_K}}{\mu_{\nu_K}} &= -corr\left[\varsigma, \nu_L\right] CV_{\nu_K} CV_{\varsigma} = .0788 \times .2272 \times 1.2490 = 2.2\%, \\
\frac{\mu_{\nu_L}^{\varsigma} - \mu_{\nu_L}}{\mu_{\nu_L}} &= corr\left[\varsigma, \nu_L\right] CV_{\nu_L} CV_{\varsigma} = -.0788 \times 0.31808 \times 1.2478 = -3.1\%.
\end{aligned}$$

The simulation shows that the dispersion in the distribution of firms' productivity increases the industry-level weighted average of market power (measured by ν_K) 2.2% above the unweighted mean, and suppresses the industry-level weighted mean of ν_L 3.1% below the unweighted mean.

Second, the estimated value of $corr\left[\varsigma, \nu_L\right] = -.0788$ has the expected negative sign but appears too much weaker than theoretical prediction. Should the industry correspond to suitably defined market, $corr\left[\varsigma, \nu_L\right] = -1$ would be expected. For this reason, we explore how results change when using $corr\left[\varsigma, \nu_L\right] = -1$ as an alternative:

$$\begin{aligned}
\frac{\mu_{\nu_K}^{\varsigma} - \mu_{\nu_K}}{\mu_{\nu_K}} &= -corr\left[\varsigma, \nu_L\right] CV_{\nu_K} CV_{\varsigma} = .2272 \times 1.2490 = 28\%, \\
\frac{\mu_{\nu_L}^{\varsigma} - \mu_{\nu_L}}{\mu_{\nu_L}} &= corr\left[\varsigma, \nu_L\right] CV_{\nu_L} CV_{\varsigma} = 0.31808 \times 1.2478 = -40\%.
\end{aligned}$$

The simulated effects are now larger, showing that the inequality in the distribution of firms' productivity increases the industry-level weighted average of market power (measured by ν_K) 28% above the unweighted mean, and suppresses the industry-level weighted average of labour share of value added 40% below the unweighted mean. This shows that the effects of dispersion in the distribution of firms' productivity on market power and income distribution could be quantitatively significant.

5 Policy Implications

In this section we explore the welfare and policy implications of our analysis. It is well known that markup power has a static inefficiency implication in the form deadweight loss: the part of loss of consumer surplus, relative to perfectly competitive equilibrium, that is not transferred to producer surplus. When competing firms' productivity is dispersed, imperfect competition causes another form of static inefficiency in addition to deadweight loss. To see this, consider a static Cournot oligopoly model in which firms' Cobb-Douglas production functions are $F_i(x_i, l_i) = A_i x_i^{\alpha} l_i^{1-\alpha}$, i.e., they are the same except for the differential productivity A_i. Under perfect competition only the most efficient firm(s) would produce and the market price would equal the lowest marginal cost among all firms. In the Nash equilibrium, a form of productive inefficiency arises because some less efficient firms also produce, since the most efficient firms produce less than socially optimal, and thus reallocate some of their sales or value added to the less productively efficient firms. This line of argument can trace its origin to Banerjee and Duflo (2005), and Hsieh and Klenow (2009), who treat the dispersion in firm productivity distribution as a measure of productive inefficiency. If imperfect competition in labour market is added to the analysis through the canonical joint oligopoly-oligopsony model, then a new form of deadweight loss is introduced. That is the part of loss of worker surplus (a counterpart of consumer surplus) that is not transferred to producer surplus. Furthermore, the productive inefficiency now also includes the part that arises because some of the less efficient firms take over some employment of labour that would only belong to the most efficient firms under perfect competition.

We have previously shown that firms' gross profit margin δ and gross profit share of value added ν_K are both suitable measures of overall market power, and that ω, δ and ν_K are useful proxies of productivity A. Intuitively, the insight of Banerjee and Duflo (2005) and Hsieh and Klenow (2009) carries over to the dispersions in ω, δ and ν_K. Overall, large dispersions in ω, δ and ν_K, which can be the consequence of the rise of superstar firms, are therefore indicative of (i) market power concentration with static inefficiency implication, as well as (ii) suppressed aggregate labour share of value added. Figures 1 and 2 visualise the fact that the inequality in the distributions of ω, δ, ν_K and Λ are not only large, but also persistent over time. Overall, the rise of superstar firms has income inequality implication and does not capture the full efficiency gains technically feasible.

The superstar firms play a complex role in market competition. In their infancy, the "would be" superstar firms are innovators who strive for superior productivity. Successful superstar firms gain in sales and value added shares, and they exert more competitive pressure on their rivals. The anticipated rise in their market power provides incentive for their innovation in the first place. This has been recognised as an important driver of innovation and economic development by economists since Schumpeter (1934, 1942). It also explains the commonly observed positive correlation between (past) innovation and existent market power among heterogeneous firms, driven by

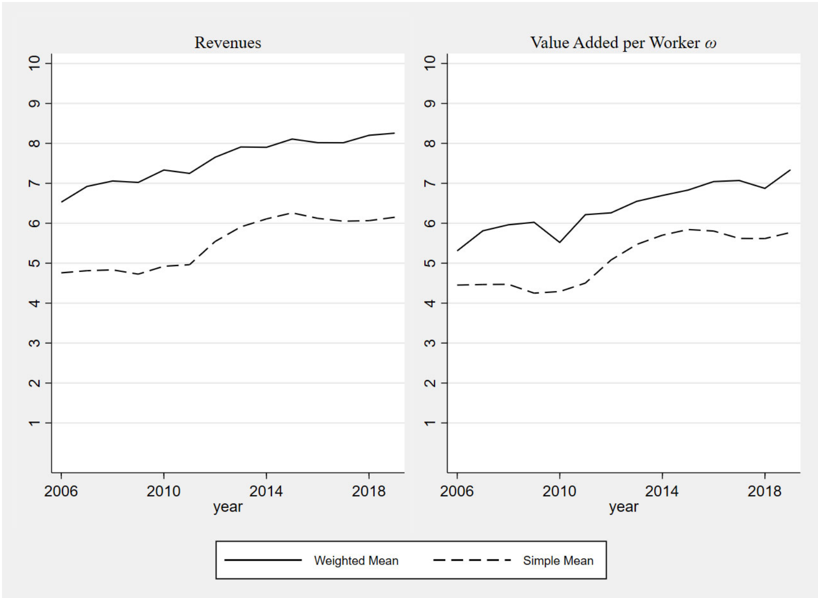

Figure 6: Top 10 Rank Persistency in Revenues and Value Added Per Worker

superstar firms.

If the dominance of a superstar firm is transitory, followed by catching up by rival firms, and hence a churn in the rankings, as envisaged by Schumpeter (1934), then the rise of superstar firms has the potential to benefit both workers and consumers, and enhance efficiency in the long run. But what if dominance is not transitory? Figure 6 shows respectively the rank persistence along the dimensions of revenue and value added per worker. Rank persistence is a measure of entrenchment of industry leading firms' dominant positions. The graphs in Figure 6 show the weighted and unweighted means of the number of firms that are in the top 10 rank (in the relevant metric) in 4-digit SIC-code manufacturing industries in each year, as well as three years ago.[50] Rank persistence over time is evident along both dimensions of revenue and value added per worker. In the presence of both superstar firms' entrenchment of their dominant positions and a slowdown of productivity growth, the dispersion in market power distribution, which also results in market power concentration with dominant firms, appears excessive. This assessment is consistent with Philippon (2019) among others.[51] In summary, we see clear evidence of prolonged, rank-persistent and excessive dispersion in firms' short-run productivity and overall market power. These observations make the so called trade-off between static and dynamic efficiencies feeble. This new insight underscores the importance of addressing market power concentration and entrenchment to promote equitable and efficient economic growth.

[50] Rank persistence in turnover was used by CMA in their The State of UK Competition reports 2020 and 2022.

[51] Philippon (2019) shows evidence that investment and productivity growth do not necessarily increase with rise of industry concentration. For evidence of persistent super-normal profits, see Furman and Orszag (2018), Barkai (2020) and Gutiérrez and Philippon (2017).

6 Conclusion

To investigate the relationship between market power and income distribution, we develop a unifying hybrid industrial-labour economics model with imperfect competition in both product and labour markets, which underpins a post-neoclassical theory of income distribution that captures rent-sharing mechanisms more generally. We show that predetermined differences in firms' short-run productivity are a root cause of dispersions in firms' competitiveness, market power and income distribution between labour and capital.

Based on our theoretical model, we provide a novel way of estimating production function parameters and market powers, which applies the factor cost share approach only to the competitive fringe firms. Using data of UK manufacturing firms, we find evidence of three types of rent-sharing mechanisms, ranging from oligopsony, wage floor and efficient bargaining, respectively accounting for around 20%, 11% and 70% of the firms in our data set.[52] We show that collective bargaining enhances workers' bargaining power and results in higher shares of quasi rents accruing to workers. This helps alleviate, but does not eliminate, the wage stagnation problem at the firm level. We also find that the dispersion in firms' short-run productivity distribution is a common root cause of heightened market power concentration and suppressed aggregate labour share of value added at the industry level. Our welfare and efficiency analyses show that these dispersions, if left to persist and entrench, have inefficiency as well as income inequity implications.

One important advantage of our methodology is that it can be implemented using "standard" accounting data, sidestepping estimation problems due to unobserved prices and measurement errors of fixed capital. Accordingly, its application can be extended to multiple countries and to other sectors, including services, for which available evidence is scant despite being the most important part of the economy in developed nations.

Our analysis provides various take-away messages for antitrust economists and enforcement agencies alike. First, we should pay more attention to labour market imperfect competition and rent-sharing institutions; otherwise, the measurement of overall market power is likely to miss one of its key components, the wage markdown power. Furthermore, from a methodological perspective, ignoring labour market factors tends to cause biases in the estimation of both production function and market power; specifically, a mistaken attribution of effects of labour market imperfect competition to technological changes. Second, we should pay attention to income distribution between labour and corporate profit, because firms' gross profit share of value added measures both income distribution and firms' overall market power. The deep connection between market power and income distribution is embodied by this single variable. This measure has the added advantage of being suitable for aggregation at industry level or for the whole economy. This advantage supersedes the most prominent alternative measures, such as Lerner index, gross profit margin, and revenue-share-based concentration measures.[53]

[52] We note again, the percentages reported here do not add up to 100% because of the accumulation of rounding up errors.
[53] For this reason, the value-added-share based concentration measures are superior.

Third, we should pay attention to prolonged, rank-persistent and excessive dispersion in firms' productivity and market power distributions because these are signs of both inequity of income distribution and inefficiency, not a trade-off between the two. Lastly, we should pay attention to deals and activities that entrench firms' dominance or increase barriers to knowledge diffusion, which are the likely deep root cause of prolonged, rank-persistent and excessive dispersion in firms' productivity and market power distributions.

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Appendix

A Proofs

A.1 Proof of Lemma 1

The first-order conditions for the maximisation problem (1) are:

$$\frac{\partial \mathfrak{L}_i}{\partial q_i} = P_i(\mathbf{q}) + \frac{\partial P_i(\mathbf{q})}{\partial q_i} q_i - \lambda_i = 0, \tag{59}$$

$$\frac{\partial \mathfrak{L}_i}{\partial x_i} = -p_X + \lambda_i \frac{\partial F_i(x_i, L_i(\mathbf{w}))}{\partial x_i} = 0, \tag{60}$$

$$\frac{\partial \mathfrak{L}_i}{\partial w_i} = -L_i(\mathbf{w}) - w_i \frac{\partial L_i(\mathbf{w})}{\partial w_i} + \lambda_i \frac{\partial F_i(x_i, L_i(\mathbf{w}))}{\partial L_i} \frac{\partial L_i(\mathbf{w})}{\partial w_i} = 0, \tag{61}$$

$$\frac{\partial \mathfrak{L}_i}{\partial \lambda_i} = q_i - F_i(x_i, L_i(\mathbf{w})) = 0. \tag{62}$$

Let $\mathfrak{L}_i^*$, R_i^* and C_i^* respectively denote maximised profit, and its (optimal) revenue and cost components. The following equation:

$$\frac{\partial \mathfrak{L}_i^*}{\partial q_i} = \frac{\partial R_i^*}{\partial q_i} - \frac{\partial C_i^*}{\partial q_i} = 0,$$

and eq. (59) imply (2). Based on these results, we can define or interpret λ_i in eq. (60) and (61) as either marginal revenue or marginal cost. We can then use λ_i in the definition of marginal revenue product of labour, as $MRPL_i = \lambda_i \frac{\partial F_i(x_i, L_i(\mathbf{w}))}{\partial x_i}$.

A.2 Proof of Theorem 2

Eq. (60) and (3) imply (6). Eq. (61), (3) and (4) imply

$$\frac{\lambda_i}{p_i} = 1 - \rho_i = \frac{\left(1 + \frac{1}{\epsilon_{Li}}\right) \phi_{Li}}{\theta_{Li}}, \tag{63}$$

where $\epsilon_{Li} \equiv \frac{1}{\frac{\partial L_i(\mathbf{w})}{\partial w_i} \frac{w_i}{L_i(\mathbf{w})}}$, and

$$\chi_{Li} = \frac{1}{\epsilon_{Li}}. \tag{64}$$

Eq. (63) and (64) imply (7). Eq. (7) and (6) imply,

$$\begin{aligned} \phi_{Li} &= \frac{\theta_{Li}(1 - \rho_i)}{1 + \chi_{Li}}, \\ \phi_{Xi} &= \theta_{Xi}(1 - \rho_i), \end{aligned} \tag{65}$$

and

$$1 - (\phi_{Li} + \phi_{Xi}) = \rho_i + \frac{\theta_{Li}(1 - \rho_i)\chi_{Li}}{(1 + \chi_{Li})} + (1 - \theta_{Li} - \theta_{Xi})(1 - \rho_i). \tag{66}$$

Identities in (5) and eq. (66) imply

$$\delta_i \equiv 1 - \phi_{Li} - \phi_{Xi}, \tag{67}$$

and (8). Constant returns to scale imply

$$\theta_{Li} + \theta_{Xi} = 1, \tag{68}$$

and the rest of the proof is trivial.

A.3 Proof of Theorem 3

Eq. (60), (61) and (64) imply

$$\frac{\theta_{Li}}{\theta_{Xi}} = \frac{w_i\left(1+\chi_{Li}\right)l_i}{p_X x_i}. \tag{69}$$

For the Cob-Douglas production function $F_i\left(x_i, l_i\right) = A_i x_i^{\alpha} l_i^{1-\alpha}$: $\theta_{Xi} = \alpha$ and $\theta_{Li} = 1-\alpha$, eq. (69) implies

$$\psi_{Li} = \frac{1-\alpha}{1+\alpha\chi_{Li}}, \tag{70}$$

and (13). Eq. (14) and (15) are immediate implications of (70). (16) is implied by (6).

A.4 Proof of Proposition 4

Eq. (28) and (29) imply $\frac{\partial R_i}{\partial l_i} \equiv MRPL_i = b$. $\omega_i \equiv \frac{R_i - p_X x_i}{l_i}$ allows eq. (28) to be rewritten as (32). $\chi_{Li} \equiv \frac{MRPL_i - w_i}{w_i} = \frac{b-w_i}{w_i}$ and (32) imply (33). For the Cobb-Douglas production function $F_i\left(x_i, l_i\right) = A_i x_i^{\alpha} l_i^{1-\alpha}$, $\frac{\partial R_i}{\partial l_i} \equiv MRPL_i = \frac{\partial R_i}{\partial q_i}\left(1-\alpha\right)A_i\left(\frac{x_i}{l_i}\right)^{\alpha} = b$, $\frac{\partial R_i}{\partial l_i} = \frac{\partial R_i}{\partial q_i}\alpha A_i\left(\frac{x_i}{l_i}\right)^{\alpha-1} = p_X$. These two equations imply (34).

A.5 Proof of Theorem 5

Eq. (30) and $\rho_i \equiv 1 - \frac{MC_i}{P_i}$ imply (6), for both (WF) and (EB) models. Eq. $\frac{\partial R_i}{\partial l_i} = \frac{\partial R_i}{\partial q_i}\frac{\partial q_i}{\partial l_i} = p_i\left(1-\rho_i\right)\frac{\partial q_i}{\partial l_i} = \frac{p_i q_i}{l_i}\left(1-\rho_i\right)\theta_{Li} = \left(1+\chi_{Li}\right)w_i$ imply

$$\frac{1+\chi_{Li}}{1-\rho_i} = \frac{\theta_{Li}}{\phi_{Li}}. \tag{71}$$

Eq. (6), (71) and (67) imply (7) for the EB model. Finally, for the (WF) model, $\chi_{Li} = 0$ holds, implying that (71) is trivially satisfied. The rest of proof is trivial.

A.6 Proof of Theorem 6

Trivial.

A.7 Proof of Proposition 7

Eq. (41) is implied by the Cobb-Douglas production function and eq. (6). Eq. (42) is implied by the Cobb-Douglas production function, eq. (6) and the definition of ψ_{Li}. Eq. (43) is implied by the Cobb-Douglas production function and the definition of ψ_{Li}.

A.8 Proof of Theorem 8

Eq. (45) is implied by the hypothesis: $\frac{\partial \nu_{Li}}{\partial A_i} < 0$, $\frac{\partial \varsigma_i}{\partial A_i} > 0$. Eq. (47) and (46) are then straightforward implications of eq. (44), the hypothesis: $\frac{\partial CV_{\nu_L}}{\partial CV_A} > 0$ and $\frac{\partial CV_{\varsigma}}{\partial CV_A} > 0$ and the identity $\nu_L + \nu_K \equiv 1$.

B Extensions

B.1 JOOM with Price Competition and Wage Posting

In this section we study a variant of the JOOM presented in Section 2, by replacing quantity competition in the product market with price competition. Let the firm-specific demand be $D_i(\mathbf{p})$, and the short-run profit maximisation problem be:

$$\max_{p_i,x_i,w_i,D_i(\mathbf{p})\leq F_i(x_i,L_i(\mathbf{w}))} \pi_i(\mathbf{p},\mathbf{w},x_i) = p_i D_i(\mathbf{p}) - w_i L_i(\mathbf{w}) - p_X x_i. \tag{72}$$

The Lagrangian multiplier method is given by:

$$\max_{p_i,x_i,w_i,\lambda_i} \mathfrak{L}_i = p_i D_i(\mathbf{p}) - w_i L_i(\mathbf{w}) - p_X x_i - \lambda_i (D_i(\mathbf{p}) - F_i(x_i, L_i(\mathbf{w}))). \tag{73}$$

The first order conditions are:

$$\frac{\partial \mathfrak{L}_i}{\partial p_i} = D_i(\mathbf{p}) + p_i \frac{\partial D_i(\mathbf{p})}{\partial p_i} - \lambda_i \frac{\partial D_i(\mathbf{p})}{\partial p_i} = 0, \tag{74}$$

$\frac{\partial \mathfrak{L}_i}{\partial x_i} = 0$ and $\frac{\partial \mathfrak{L}_i}{\partial w_i} = 0$, which are identical to (60) and (61). The optimal Lagrangian multiplier λ_i remains to be interpreted as both the marginal cost and marginal revenue, and therefore $\frac{\lambda_i}{p_i} = 1 - \rho_i$ holds, where ρ_i continues to denote the Lerner index. Let

$$\frac{\partial \mathfrak{L}_i}{\partial \lambda_i} = D_i(\mathbf{p}) - F_i(x_i, L_i(\mathbf{w})) = 0. \tag{75}$$

The marginal revenue is given by

$$\lambda_i = p_i + \frac{D_i(\mathbf{p})}{\frac{\partial D_i(\mathbf{p})}{\partial p_i}} = \left(1 - \frac{1}{\epsilon_i}\right) p_i, \tag{76}$$

where $\epsilon_i \equiv -\frac{\partial D_i(\mathbf{p})}{\partial p_i} \frac{p_i}{D_i(\mathbf{p})}$ is the residual demand elasticity of firm i.

Eq. (6), (63) and (64) remain valid for this variant of JOOM. Consequently, eq. (6) - (8) can be extended hereto.

B.2 JOOM with Quantity and Employment Competition

Let the product market demand system be described by $P_i(\mathbf{q})$ for all i, and the labour market supply by wage function $W(L)$, where $L = \sum_{j=1}^{n} l_j$ is the total aggregate labour input and l_j is labour input of firm j. For this variant, the short-run profit maximisation is given by:

$$\max_{q_i,x_i,l_i,q_i\leq F_i(x_i,l_i)} \pi_i(\mathbf{q},\mathbf{l},x_i) = P_i(\mathbf{q}) q_i - W(L) l_i - p_X x_i, \tag{77}$$

with the Lagrange multiplier method:

$$\max_{q_i,x_i,l_i,\lambda_i} \mathfrak{L}_i = P_i(\mathbf{q}) q_i - W(L) l_i - p_X x_i - \lambda_i (q_i - f_i(x_i, l_i)). \tag{78}$$

The first order conditions that need slightly new treatment are:

$$\frac{\partial \mathfrak{L}_i}{\partial x_i} = -p_X + \lambda_i \frac{\partial F_i(x_i, l_i)}{\partial x_i} = 0, \tag{79}$$

$$\frac{\partial \mathfrak{L}_i}{\partial l_i} = -W(L) - W'(L) l_i + \lambda_i \frac{\partial F_i(x_i, l_i)}{\partial l_i} = 0, \tag{80}$$

$$\frac{\partial \mathfrak{L}_i}{\partial \lambda_i} = q_i - F_i(x_i, l_i) = 0. \tag{81}$$

The optimal Lagrangian multiplier λ_i remains to be interpreted as both the marginal cost and marginal revenue, and therefore $\frac{\lambda_i}{p_i} = 1 - \rho_i$ holds, where ρ_i continues to denote the Lerner index. Define the residual labour supply elasticity for this variant by $\epsilon_{Li} \equiv \frac{1}{\frac{\partial W}{\partial l_i}\frac{l_i}{W}}$ and note that $\epsilon_{Li} = \frac{\epsilon_L}{s_{Li}}$, where $\epsilon_L \equiv \frac{1}{\frac{\partial W}{\partial L}\frac{L}{W}}$ is the market level labour supply elasticity and $s_{Li} \equiv \frac{l_i}{L}$ is the firm's labour market share. With these minor adjustments in place, eq. (6), (63) and (64) remain valid for this variant of JOOM. Consequently, eq. (6) - (8) can be extended to the current variant of JOOM.

B.3 JOOM with Price and Employment Competition

Let the product market demand system be described by $D_i(\mathbf{p})$ for all i, and the labour market supply by wage function $W(L)$, where $L = \sum_{j=1}^{n} l_j$ is the total aggregate labour input and l_j is labour input of firm j. The modified short-run profit maximisation problems are given by:

$$\max_{p_i, x_i, l_i, D_i(\mathbf{p}) \leq F_i(x_i, l_i)} \pi_i(\mathbf{p}, \mathbf{l}, x_i) = p_i D_i(\mathbf{p}) - W(L) l_i - p_X x_i. \tag{82}$$

$$\max_{p_i, x_i, l_i, \lambda_i} \mathfrak{L}_i = p_i D_i(\mathbf{p}) - W(L) l_i - p_X x_i - \lambda_i (D_i(\mathbf{p}) - F_i(x_i, l_i)). \tag{83}$$

The first order conditions are the same as equations (74), (79) and (80) and

$$\frac{\partial \mathfrak{L}_i}{\partial \lambda_i} = D_i(\mathbf{p}) - F_i(x_i, l_i) = 0. \tag{84}$$

For this setting, we need to redefine: $\epsilon_i \equiv -\frac{\partial D_i(\mathbf{p})}{\partial p_i}\frac{p_i}{D_i(\mathbf{p})}$ and $\epsilon_{Li} \equiv \frac{1}{\frac{\partial W}{\partial l_i}\frac{l_i}{W}}$ with $\epsilon_{Li} = \frac{\epsilon_L}{s_{Li}}$ and $\epsilon_L \equiv \frac{1}{\frac{\partial W}{\partial L}\frac{L}{W}}$. Then eq. (6), (63) and (64) remain valid for this variant of JOOM. Consequently, eq. (6) - (8) can be extended to the current variant of JOOM.

C Supplementary Results

C.1 Stability and Trend of RS Types Distribution

Table 13 reports the Markov transition matrices of firms in the sample between 2005 and 2010 (top panel) and between 2005 and 2015 (bottom panel). For instance, the probability of transition from RS type I to RS type II after 5 (respectively 10) years is 14.5% (respectively 12.4%). The fact that the percentages on the diagonal are large suggests that there is persistency in the RS type classification, in particular for RS types I and III.

Table 13: RS Types Transition Matrix

	RS type 2010			
RS type 2005	I	II	III	Total
I	4,435 (54.09)	1,190 (14.51)	2,575 (31.40)	8,200 (100.00)
II	1,147 (23.65)	1,377 (28.39)	2,326 (47.96)	4,850 (100.00)
III	2,027 (8.66)	1,779 (7.60)	19,600 (83.74)	23,406 (100.00)
Total	7,609 (20.87)	4,346 (11.92)	24,501 (67.21)	36,456 (100.00)
	RS type 2015			
RS type 2005	I	II	III	Total
I	3,848 (47.55)	1,002 (12.38)	3,242 (40.06)	8,092 (100.00)
II	1,179 (24.77)	1,056 (22.18)	2,525 (53.05)	4,760 (100.00)
III	2,056 (8.93)	1,632 (7.09)	19,329 (83.98)	23,017 (100.00)
Total	7,083 (19.75)	3,690 (10.29)	25,096 (69.97)	35,869 (100.00)

C.2 IV Wage Regressions

Our theoretical analysis underpins the argument that firms' short-run productivity A is predetermined and its proxy measurement ω should be treated as exogenous in wage regressions. For robustness check, we may entertain an alternative analysis that argues for a reverse causality: higher wages w causing higher value added per worker ω. Specifically, since w measures the average wage rate among varying skill levels, higher w may indicate that a firm employs a higher proportion of high-skilled workers, which may cause higher ω, and thus an endogeneity problem. If firms' differences in employing high- or low-skilled workers are constant over time, then the fixed effect regression can duly control for this unobserved heterogeneity. Hereafter, we check the robustness of our results using two different instrumental variables: lag values of ω and fixed capital per worker. The use of lags of ω can soften any concern that change in labour quality in t (and, in turn, in average wage) may drive changes in productivity in the same period. We use fixed capital per worker as an alternative IV since in our theoretical framework fixed capital is a determinant of short-run productivity. We note that there is no contradiction with our claim in the introduction that fixed capital is difficult to measure (accurately) because it contains both tangible and intangible components, since the variable we use here is the fixed assets as reported in firms' balance sheet. Whereas this variable may not provide us a precise measure of fixed capital, it is still informative for a check of robustness. Tables 14 reports the results of the two IV regressions for RS types I and III, together with OLS regression results for ease of comparison. We do not report the estimates for RS type II because we obtain very low value of the first-stage F statistics, most likely due to the fact of small sample size of RS type II. The main features of the OLS (our preferred specification) results are by and large confirmed in the IV regressions, specifically the support for hypothesis (H2).

Table 14: Regressions of w on ω (2)

	RS type I			RS type III		
	(1) OLS	(2) IV	(3) IV	(4) OLS	(5) IV	(6) IV
ω	.1290***	.1414***	.1655***	.1807***	.1847***	.3466***
	(.0248)	(.0202)	(.0624)	(.0248)	(.0234)	(.0315)
$\omega \ln(1-\delta)$	.0559***	.0552***	.0605**	.1106***	.1263***	.2045***
	(.0106)	(.0077)	(.0272)	(.0155)	(.0152)	(.0196)
$\omega \ln(1+\chi_L)$	-.0262***	-.0310***	-.0685***	-.0311***	-.0479***	-.0101
	(.0056)	(.0048)	(.0236)	(.0076)	(.0131)	(.0074)
$\ln(1-\delta)$	9.710***	15.17***	.9944	6.934***	8.257***	7.340***
	(2.999)	(3.801)	(13.22)	(.8699)	(.9917)	(1.417)
$\ln(1+\chi_L)$	.5088**	1.309***	8.898*	-.4975	.3607	-3.320***
	(.2390)	(.4155)	(5.150)	(.4158)	(.7371)	(.5006)
Ind. FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2 adj	0.519			0.616		
F-test (1st Stage)		43.04	1.951		9.209	17.40
Obs	11863	7075	10940	41971	33514	39013

Notes: The table shows the estimated coefficients of eq. (57). Columns (2), (3), (5) and (6) are IV regressions. The IVs used for (2) and (5) are lag value of ω, and its respective interaction terms with $\ln(1-\delta)$ and $\ln(1+\chi_L)$. The IVs used for (3) and (6) are logarithm of fixed capital per worker, and the respective interaction terms of fixed capital per worker with $\ln(1-\delta)$ and $\ln(1+\chi_L)$. Kleibergen-Paap Wald F-stat is reported for the first stage. Standard errors are clustered at industry level. ***, ** and * respectively indicates statistical significance at 1%, 5% and 10% level.