Equilibrium Effects of the Minimum Wage: The Role of Product Market Power*

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Abstract

We study the role of product market power in the equilibrium effects of the minimum wage. Higher minimum wages are known to induce workers' reallocation from small to larger firms. If firms set prices strategically, they optimally respond to larger market shares by raising their markups. We call this novel mechanism *concentration channel* of the minimum wage. We show that product market power can overturn the commonly-held view that higher minimum wages boost the aggregate labor share. On the one hand, the minimum wage pushes the labor share up by compressing firms' monopsony power on the labor market. On the other hand, the concentration channel depresses the labor share by fuelling firms' monopoly power on the product market. Consistently with our theory, we document on Italian balance-sheet data that the firm-level labor share response to higher sectoral minimum wages is decreasing in product market concentration. To quantify the aggregate labor share response, we construct a novel structural model embedding frictional labor markets and oligopolistically-competitive product markets. We estimate the model on Italian social security data replicating key labor market statistics for different worker types and the detailed structure of sectoral product markets. We find that the labor share is hump-shaped in the level of minimum wage with a peak around the median wage. Our results stress the importance of factoring in product market power for a correct evaluation of minimum wage reforms.

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Keywords: Wage Distribution, Minimum Wage, Worker and Firm Heterogeneity, Equilibrium Search Model, Monopsony, Spillover Effects, Reallocation, Oligopolistic Competition, Endogenous Markups.

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1 Introduction

Minimum wages (MW) are one of the most prominent labor market policies, being implemented in the majority of advanced and developing economies. Against the backdrop of historically high levels of income inequality in many countries, their use has been advocated as a measure to support the income of the poor and to reduce earnings differentials. More recently, it has been suggested that MWs may also help at balancing the secular decline in workers' bargaining power (Stansbury and Summers, 2020). An extensive empirical literature, pioneered by Card and Krueger (1995), focuses on the evaluation of MW reforms on targeted groups.[1] A large number of reduced-form studies suggest that the effects of MW reforms depend on the degree of competitiveness of both the labor and the product market (Azar et al., 2019; Okudaira et al., 2019; Link, 2019; Cengiz et al., 2019; Harasztosi and Lindner, 2019). On the one hand, monopsony power is a natural candidate to explain the muted – or even positive – employment effects of MW reforms (Manning (2016)). On the other hand, the extent of monopoly power has obvious implications on the price pass-through and on the overall adjustment of the economy following a MW rise. However, to the best of our knowledge, the role of product market power in shaping the economy's response to a MW reform has not been studied yet.

This paper fills this gap by characterizing theoretically and assessing quantitatively the role of product market power in the equilibrium effects of MW reforms. We show that modelling the response of product market power is key to correctly evaluate both the aggregate and distributional impact of the MW. Our analysis provides novel insights on how the effects of MW are importantly shaped by the extent of competition in both the input and output markets.

First, we show that adding strategic price setting to a simple monopsony model makes the response of the labor share to the MW qualitatively ambiguous. On the one hand, higher MWs increase the labor share by compressing firms' monopsony power on the labor market. This effect – widely known in the existing literature – arises because the MW forces some firms to increase their pay and flattens out the labor supply curve they face, thus removing an obstacle to grow larger in size. On the other hand, though, the MW also induces low productive firms to either shrink in size or to exit the market (Draca et al. (2011); Chava et al. (2019); Mayneris et al. (2018); Aaronson et al. (2018)). As a result, workers reallocate towards larger firms, which increase their market shares (Dustmann et al. (2022)). If the demand elasticity is increasing in the number of competitors, as in standard models of oligopolistic competition, then firms optimally respond to higher own market shares by raising their markups. Therefore, the reallocation process triggered by

[1] See Wascher and Neumark (2006) and Belman and Wolfson (2019) for meta-studies on the employment effects of the minimum wage, and Neumark (2017) for a recent survey of the empirical literature.

the MW rise ends up fuelling product market concentration, which boosts the aggregate markup. We call this novel mechanism *concentration channel* of the MW. By increasing firms' monopoly power, the concentration channel reduces the aggregate labor share of the economy. Overall, depending on whether the increase in monopoly power dominates the reduction in monopsony power, the aggregate labor share can even *shrink* in response to higher MWs.

We test the key predictions of our theory on firms' balance sheet data from Italy. Absent a nation-wide minimum wage, we leverage the variation induced by industry-specific wage floors bargained at the national level. First, we document large positive effects from increases in industry-specific MWs on the firm-level labor share with a semi-elasticity of 0.5. Then, upon interacting the MW level with the Herfindahl-Hirschman Index (HHI) of value added in the sector where the firm operates, we show that the labor share response is more muted the higher product market concentration is. In particular, we uncover a monotonically decreasing relationship between the level of concentration and the effect on the labor share, that turns negative around HHI values of 0.3. Consistently with our theory, such decreasing pattern is mainly explained by the response of profits, which is strictly negative for low concentrated sectors whereas it turns positive for highly concentrated ones. Finally, we document that the labor share response is decreasing in firm's productivity, particularly so in highly concentrated sectors. This supports the mechanism behind our concentration channel such that high productive firms are the ones most likely to increase their profits and reduce their labor share in response to MW rises.

To gauge the quantitative response of the aggregate labor share to MW rises, we construct a novel structural model with heterogeneous workers and firms competing in frictional labor markets and oligopolistically-competitive product markets. Our model merges together the wage posting model of Engbom and Moser (2021) – a collection of Burdett and Mortensen (1998) economies with endogenous job creation – and the oligopolistic-competition model of Atkeson and Burstein (2008). The economy is populated by a mass of workers who differ in their ability level and engage in random search in frictional labor markets. On the production side, heterogeneous firms compete by posting wage piece rates and costly vacancies in the labor market – segmented by worker ability type – and by playing a Cournot-Nash game in sectoral product markets. A distinctive feature of our model is that firms face both an upward sloping labor supply and a downward sloping product demand curve. The former follows from the presence of search frictions and the wage posting protocol, whereas the latter is a consequence of consumers' preferences, characterized by imperfect substitutability across goods, and firms' granularity in their sectoral markets. Hence, our model features an endogenously determined joint distribution of markups and markdowns across firms, and provides a structural decomposition of the sources of market power, thus allowing us to study the impact of the MW on firms' labor and product market power separately. Importantly, despite being very rich, the model remains tractable and amenable to estimation.

We estimate the model by replicating a number of key labor and product market statistics for Italy. In particular, we follow closely Engbom and Moser (2021)'s strategy of segmenting the labor market by worker ability type. We pin down worker ability types by replicating in our model the empirical AKM wage variance decomposition, which we estimate on matched employer-employee data covering the period 1990-2018. Our framework allows for a flexible account of worker transitions in the labor market, that we can match exactly for the different types. This is very important, as these transitions directly relate to the degree of labor market power of firms, thus giving discipline to the identification of markdowns. Next, as Bontemps et al. (2000), we non-parametrically estimate the distributions of marginal revenue productivity across firms by inverting the observed wage distributions – stratified by industry (1-digit level) – for each worker type. Importantly, along with the solution to the product markets equilibrium, this allows us to back out industry-specific *physical* productivity distributions. The non-parametric nature of the estimation also has the advantage of guaranteeing an essentially perfect fit to the wage distribution. For what concerns the product market, we map the sectoral markets in our model to detailed 4-digit sectors, for which we can measure the number of competing firms in the data. In our calibration, we exactly reproduce the distribution of the number of firms in each sector by different industries. Consistently, we draw firms' productivity from the corresponding industry-specific distribution. In sum, the model is able to replicate both key labor market empirical patterns by worker type and the distribution of firms across detailed sectors of the economy, taking into account industry-specific differences in productivity.

We study the equilibrium effects of introducing a mandatory MW in our model economy. We run a sequence of experiments, that span from targeting the 5^{th} to the 55^{th} percentile of the baseline wage distribution. We track the evolution of the labor share and market power indexes across MW reforms. We uncover a hump-shaped response of the labor share to the MW level with a peak around the median wage. This non-monotonic pattern is explained by the concurrent reduction in firms' monopsony power and increase in monopoly power. For small and medium MW reforms, the positive response of the labor share is driven by the reduction in monopsony power, showing up as an increase in the aggregate markdown. For large MW reforms, instead, the increase in monopoly power, showing up as an increase in the aggregate markup, becomes the dominating force that pushes the labor share down. We therefore demonstrate that the concentration channel is a key driver of the labor share response to higher MWs. Turning to the aggregate impact of the MW, we find far-reaching effects on the equilibrium wage distribution, which progressively moves rightward as the MW rises. This is mainly due to substantial pay rises in the bottom half of the wage distribution and the progressive selection into higher-paying firms. Higher MWs are further shown to discourage vacancy posting of firms, causing a modest rise in the unemployment rate. Despite the fall in employment, aggregate output and welfare are increasing in the MW level. This is due to sizable productivity gains from worker reallocation towards more productive firms. Indeed, higher MWs push low productive firms to either shrink or exit the market, which reduces congestion externalities in the labor market and allows more productive firms to grow in size more cheaply. Furthermore, the reallocation process compresses the variance of market power across firms, which is an index of misallocation of the labor input, thus further increasing aggregate productivity. In terms of distributional impact, low and medium MW levels bring about substantial welfare gains for low- and middle-ability workers, who enjoy wage increases and suffer from only moderate rises in unemployment. On the contrary, high MWs mainly benefit high-ability types, who are almost completely shielded by the surge in unemployment and are the main claimants of firm profits.

Finally, to gauge the quantitative role of product market power, we repeat the same policy experiments in two alternative economies that are observationally equivalent to our baseline, except for the working of output markets: in the first one, which we term MP economy, we model product markets as monopolistically competitive, implying constant and identical markups across firms; in the second one, which we term *markupless* economy, product markets are perfectly competitive, hence all markups are shut down.

A comparison of the counterfactual experiments among these alternative economies clearly reveals that allowing for product market power is absolutely key for quantifying the impact of MW reforms. Indeed, even though the response of most aggregate variables is qualitatively similar across the *markupless* and the baseline economy, magnitudes are completely different: following a relatively large MW reform (92% Kaitz index), the estimated surge in unemployment is 50% larger than in the baseline and the growth of value added is more than twice as large, implying that productivity gains are largely overstated when neglecting product market power. Differences in the extent of reallocation among the two economies are intuitive, as product market power induces decreasing returns to scale in revenues, eroding the appetite for growing of larger firms. At the same time, we also stress that large differences become apparent only at relatively high MW levels, consistently with the success of models such as Engbom and Moser (2021) to match the reduced-form evidence of MW reforms that would fall among the smallest considered in our experiments. Moreover, we show that the dynamics of factor shares following the

MW reforms are completely different among these alternative economies. Indeed, both the MP and the *markupless* economy miss the positive response of the aggregate markup, that is brought about by the concentration channel. This has relevant implications for the labor share, that grows substantially more in the MP economy than in our baseline with endogenous markups, and is no longer hump-shaped. Instead, in the *markupless* economy the labor share stays approximately constant for the small reforms and decreases markedly in the larger ones. This is entirely driven by a composition effect due to the stronger workers' reallocation towards large, low-markdown firms. Last, we find that product market power also matters for the distributional impact of the reforms. In particular, in the *markupless* economy wage gains are larger throughout the distribution but especially at the bottom, and welfare gains from large reforms are more concentrated at the top, due to the more pronounced dynamics of the profit share. Summing up, factoring in product market power turns out to be crucial for the quantitative assessment of MW reforms. First, the quantitative response of aggregate variables would be importantly biased if one were to neglect product market power. Second, allowing for *endogenous* market power importantly changes the dynamics of the factor shares. These differences not only matter for the overall adjustment of the economy, but also have a primary role in shaping the distributional impact of MW reforms.

This paper makes two important contributions to the literature. First, to the best of our knowledge, we are the first to formalize the concentration channel as a relevant general-equilibrium effect of the MW. Even within the context of the notoriously low concentrated Italian economy, we show that the concentration channel is a key determinant of the distributional impact of large MW reforms. Second, we construct a novel structural model featuring both endogenous markups and markdowns. Our framework is the first in the existing literature that puts together a wage-posting model of the labor market and an oligopolistic-competition model of the product market, which are workhorse models of wage- and price-setting decisions, respectively.

Related Literature. This paper is related to four main strands of literature. First, it contributes to the new literature on structural modelling of the equilibrium effects of the MW. Hurst et al. (2022) and Drechsel-Grau (2021) propose search models to study the distributional impact of the MW across heterogeneous households, while Ahlfeldt et al. (2022) focuses on the spatial dimension. The closest papers to ours in this literature are Engbom and Moser (2021) (henceforth, EM) and Berger et al. (2022) (henceforth, BHM). EM constructs a quantitative wage-posting model of the labor market with firm- and worker-heterogeneity composed by a collection of Burdett and Mortensen (1998) economies with endogenous job creation to study the effect of the MW on earnings inequality. Our model nests EM's as a limit case by letting product market power vanish.

We show that neglecting product market power can lead to severely distorted estimates of the aggregate and distributional impact of medium and large MW reforms. BHM study the welfare effects of the minimum wage by enriching the general-equilibrium model with oligopolistically-competitive local labor markets of Berger et al. (2021) with worker heterogeneity in wealth and productivity. Our paper is complementary to BHM as far as the sources of firm profits are concerned. While BHM microfound labor market power as the result of idiosyncratic preferences for workplaces and assumes technological decreasing returns, we model labor market power as rooted in search frictions and allow for decreasing returns in revenue productivity. Unlike BHM's, our framework accommodates both (frictional) unemployment and residual wage dispersion as equilibrium outcomes. The former allows us to quantify the impact of the MW on *involuntary* unemployment, the latter to structurally identify the extent of labor market power from the empirical wage distribution and observed workers' flows. Even more importantly, we show that neglecting the endogenous markup response can bias estimates of the distributional impact of the MW.

Second, this paper is related to the empirical literature on firms' response to the MW. Link (2019) and Harasztosi and Lindner (2019) report consistent evidence on sizable price responses of affected firms to higher MWs. Both papers, as well as Cengiz et al. (2019), emphasize the negative relationship between the degree of product market competition and the firm-level employment response to MW reforms. Azar et al. (2019) and Okudaira et al. (2019) reach similar conclusions about labor market competition. Dustmann et al. (2022) documents substantial reallocation of workers from lower- to higher-paying firms following the introduction of a nationwide minimum wage in Germany. Dube et al. (2016) and Ahlfeldt et al. (2018) find muted employment effects of MWs, however accompanied by a reduction in labor market flows and wage spatial convergence. Using the methodology pioneered by Lee (1999), Autor et al. (2016) documents limited spillovers from small MW rises in the US, while Engbom and Moser (2021) and Haanwinckel (2020) report sizable spillover effects of repeated increases in the nationwide MW in Brazil. Derenoncourt et al. (2021) and Staiger et al. (2010) document strategic wage-setting by estimating positive cross-employer wage elasticity.

Third, this paper contributes to the long-standing tradition of wage-posting models of the labor market, whose foundations are laid down by Burdett and Mortensen (1998), van den Berg and Ridder (1998), Bontemps et al. (1999), Bontemps et al. (2000) and Postel-Vinay and Robin (2002). Since the seminal contribution by Manning (2003), this class of models has been widely used as theoretical underpinning for estimating firms' labor market power (Bachmann and Frings, 2016; Webber, 2015; Manning, 2021; Langella and Manning, 2021). Recent theoretical innovations in this literature have been advanced by Flinn and Mullins (2021), Bilal and Lhuillier (2021), and the aforementioned EM[2].

Finally, this paper speaks to the literature on oligopolistic competition in sectoral product markets. Motivated by the empirical evidence that large firms tend to charge higher markups (De Loecker et al., 2020; Autor et al., 2020; Kehrig and Vincent, 2021), this class of models derives a positive relationship between firm markups and own market shares by assuming that a finite number of firms competes á la Cournot in sectoral product markets (Atkeson and Burstein (2008), Burstein et al. (2021), Grassi et al. (2017), De Loecker et al. (2021), Edmond et al. (2015), Edmond et al. (2018), Ferrari and Queiros (2021)). The closest papers in this literature to ours are Deb et al. (2020) and MacKenzie (2020). Both papers propose models featuring oligopolistic competition on sectoral product markets and oligopsonistic competition on local labor markets to study the contribution of the secular trend in market power to wage inequality across firms and gains from international trade, respectively. Our model differs from theirs since labor market power stems from search frictions rather than for idiosyncratic preferences for employers, which allows us to structurally estimate firm-level markdowns from observed workers' flows. As a result, we are able to separately identify markdowns and markups without taking a stand on the relative boundaries of product and labor markets. Tortarolo and Zarate (2020) and Yeh et al. (2022) propose complementary strategies to ours to disentangle markups and markdowns empirically.

2 Stylized Model

In this section we show how endogenous product market power can importantly change the dynamics of the labor share following a MW reform. To do so, we develop two versions of a stylized monopsony model that differ only for the presence of endogenous product market power. In the first economy, firms face upward-sloping labor supply curves, but product markets are perfectly competitive. In the second economy, we introduce endogenous product market power. We analytically study the effects of introducing a MW on the labor share in the two model economies and compare their predictions.

[2]By augmenting the wage-posting model of EM with product market power, our model also relates to the line of research on dynamic wage-posting models initiated by Coles and Mortensen (2016) and Moscarini and Postel-Vinay (2013). Bilal et al. (2019) and Elsby and Gottfries (2021) propose dynamic models featuring technological decreasing returns and on-the-job search to study firms and workers' dynamics simultaneously, while Gouin-Bonenfant (2020) uses an extension of Coles and Mortensen (2016)'s model to quantify the relation between productivity dispersion and aggregate labor share.

2.1 Perfectly competitive product market

Baseline equilibrium. The economy is populated by a continuum of firms that operate a linear technology and differ only in productivity z, drawn from some distribution $\Gamma(.)$, with $z \in [\underline{z}, \bar{z}]$. Firms solve the problem

$$\max_{\ell} \; \bar{p}z\ell - w(\ell)\ell \tag{1}$$

$$\text{s.t.} \; w(\ell) = \ell^{\frac{1}{\eta}}, \tag{2}$$

where Equation 2 represents the inverse labor supply curve, with η being the elasticity of labor supply. Taking the FOC and solving for the optimal level of wage, it is straightforward to obtain

$$w^*(z) = \underbrace{\frac{\eta}{1+\eta}}_{\psi} \bar{p}z, \tag{3}$$

where we have denoted with ψ the equilibrium wage markdown. Therefore, we can easily compute the firm-specific labor share $LS(z)$ as

$$LS^*(z) = \frac{w^*(z)\ell^*(z)}{\bar{p}z\ell^*(z)} = \frac{w^*(z)}{\bar{p}z} = \psi. \tag{4}$$

Hence, in this economy all firms have identical labor shares, in equilibrium. As a consequence, the aggregate labor share will also be equal to the equilibrium markdown:

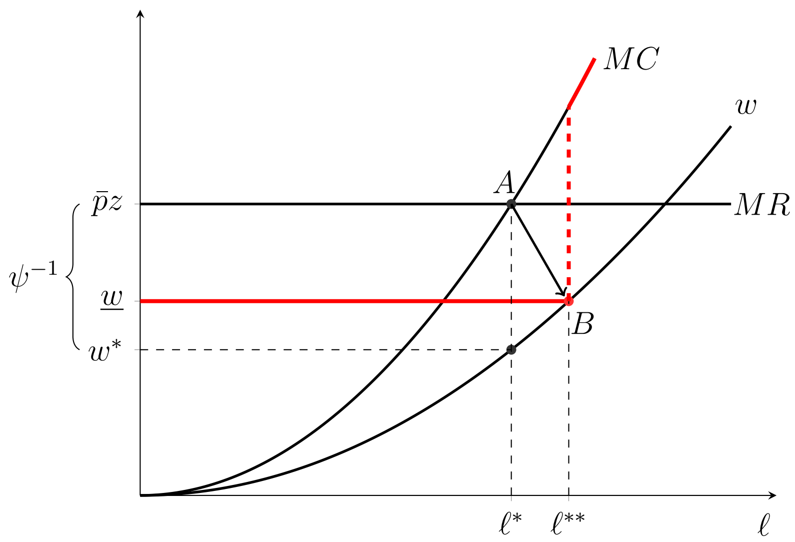
$$\bar{LS}^* = \int_{\underline{z}}^{\bar{z}} LS^*(z) \, \frac{w^*(z)\ell^*(z)}{WL} \, d\Gamma(z) = \psi, \tag{5}$$

where WL is the total wage bill of the economy.

Introduction of a MW. We now introduce a minimum wage $\underline{w}$ in this economy. We assume that the reform is binding for at least some firms ($\underline{w} > w^*(\underline{z})$). The introduction of a MW causes the exit of those firms whose marginal revenue product lies below the mandated minimum wage ($z < \underline{w}/\bar{p}$). Among continuing firms, some will be affected by the minimum wage in their wage setting (see Figure 1), whereas the most productive firms – that were already setting wages above the MW – will not be affected. We denote with $\tilde{z}(\underline{w})$ the lowest firm productivity level such that the MW is not binding.

The introduction of the MW alters the shape of the marginal cost (MC) curve, in fact removing the incentives for firms to remain small in order to save up on wages. Formally, the MC curve becomes a flat line until the point in which $\underline{w}$ crosses the old curve, and

Figure 1: Effects of the introduction of the MW on affected firms



it coincides with the old one thereafter. This implies that all affected firms pay exactly the minimum wage at the new equilibrium (i.e., the reform is binding for them). As a consequence, given that their marginal revenue product is constant, their markdown increases (i.e. they exert *less* market power), and their labor share also increases. Instead, non-affected firms will keep paying the same equilibrium wage as before, with the same labor share as the previous equilibrium. Therefore, the aggregate labor share unambiguously goes up.

Proposition. The introduction of a binding MW causes the aggregate labor share to increase: $\bar{LS}^{**}_{MW} > \bar{LS}^{*}$.

Proof. In the new equilibrium, at least one firm will set a higher labor share, whereas the rest of them will keep exactly the same labor shares as the old equilibrium. Therefore, the aggregate level (a weighted average of the firm-specific labor shares) must go up. ■

2.2 Imperfectly competitive product market

Baseline equilibrium. The economy is populated by a finite number of firms[3] N that operate a linear technology and differ only in productivity z, drawn from some distribution $\Gamma(.)$, with $z \in [\underline{z}, \bar{z}]$. Firms solve the problem

[3]This assumption resembles that of oligopostic competition. We need the number of firms to be finite, in order to make the demand elasticity depend on it.

$$\max_{\ell} \; p(\ell)z\ell - w(\ell)\ell - \kappa \tag{6}$$

$$\text{s.t.} \; p(\ell) = \left(\frac{z\ell}{Y}\right)^{-\frac{1}{\epsilon(N)}}, \tag{7}$$

$$w(\ell) = \ell^{\frac{1}{\eta}}, \tag{8}$$

where Equation 7 represents the inverse product demand curve,[4] with $\epsilon(N)$ being the elasticity of demand, and Equation 8 represents the labor supply equation. We let the elasticity of demand be an increasing function of the number of competing firms ($\epsilon_N > 0$), allowing for a reduced-form notion of oligopolistic competition.[5] Moreover, note that we have introduced an overhead cost κ, that is needed in order to induce firm exit upon a cost push shock. Taking the FOC and solving for the optimal level of wage, it is straightforward to obtain

$$w^*(z) = \underbrace{\frac{\epsilon(N) - 1}{\epsilon(N)}}_{\mu(N)^{-1}} \underbrace{\frac{\eta}{1+\eta}}_{\psi} p^*(z)z, \tag{9}$$

where we have denoted with $\mu(N)$ the equilibrium price markup and with ψ the equilibrium wage markdown. Therefore, we can easily compute the firm-specific labor share $LS(z)$ as

$$LS^*(z) = \frac{w^*(z)\ell^*(z)}{p^*(z)z\ell^*(z)} = \frac{w^*(z)}{p^*(z)z} = \frac{\psi}{\mu(N)}. \tag{10}$$

Differently from before, labor shares in this economy reflect the presence of a *double wedge*, representing respectively the profits made in the labor and in the product market. Given that all firms face the same elasticities, they all have identical labor shares in equilibrium. As a consequence, the aggregate labor share will also be equal to the double wedge formula:

$$\bar{LS}^* = \int_{\underline{z}}^{\bar{z}} LS^*(z) \, \frac{\ell^*(z)w^*(z)}{LW} \, d\Gamma(z) = \frac{\psi}{\mu(N)}, \tag{11}$$

where LW is the total wage bill of the economy.

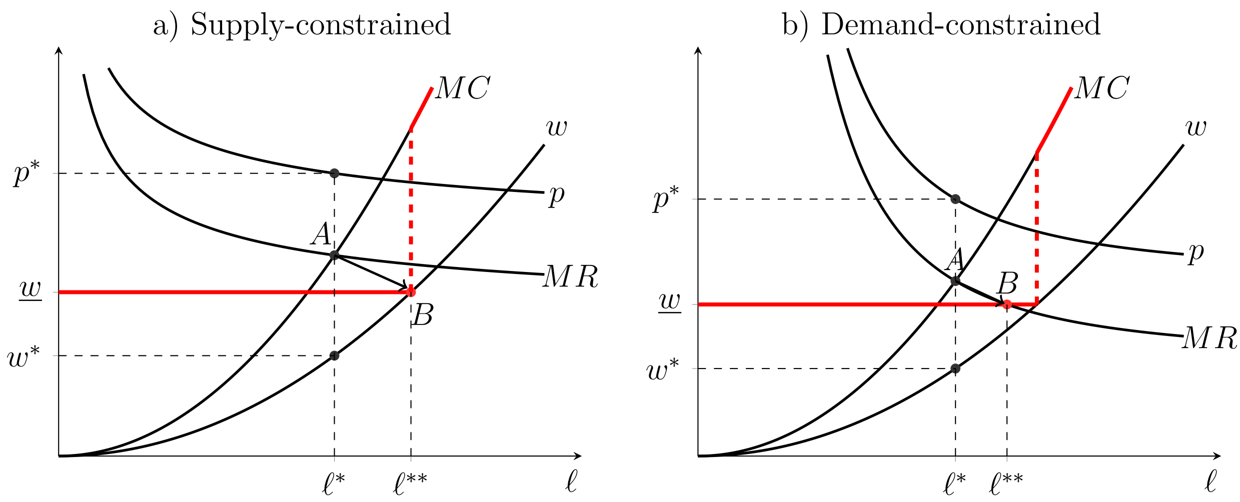
Introduction of a MW. We now introduce a minimum wage $\underline{w}$ in this economy. We assume that the reform is large enough to cause the exit of at least some firms, those

[4]Demand curves of this kind can be micro-founded as stemming from consumers with CES preferences over different varieties.

[5]In oligopolistic competition models, the elasticity is typically decreasing in the firm's market share, that in turn is affected by the number of competitors.

for which operating profits do not exceed the overhead cost ($\Pi^{**}_{MW}(z) < 0$). We denote with $\hat{z}(\underline{w})$ the marginal firm with respect to the exit decision. Among continuing firms, some will be affected by the minimum wage in their wage setting (see Figure 2), whereas the most productive firms – that were already setting wages above the MW – will not be *directly* affected. We denote with $\tilde{z}(\underline{w})$ as the lowest productivity firm among the latter group. We can distinguish two groups of affected firms depending on whether the new MC curve cuts first the labor supply (supply-constrained firms) or the marginal revenue curve (demand-constrained firms). Relatively less productive firms, i.e. those close to the cutoff $\hat{z}(\underline{w})$, will be demand-constrained.

Figure 2: Effects of the introduction of the MW on affected firms



The contraction of the number of firms, triggered by the exit of the least productive ones, causes a flattening of the demand elasticity ($\epsilon(N') < \epsilon(N)$). As a consequence, all firms charge higher markups in equilibrium ($\mu(N') > \mu(N)$). Depending on whether the MW is binding or not at the firm-level, labor shares may react differently. In particular, those firms that are not constrained by the MW end up having *more* market power than before, thanks to the flattening of the product demand. Therefore, their labor share falls with respect to the old equilibrium. Instead, constrained firms lose at least part of their labor market power, showing up as an increase in the equilibrium markdown.[6] At the same time, they also benefit from the less elastic product demand, charging higher markups. These two forces push the labor share in opposite directions. Eventually, the overall dynamics of the aggregate labor share is generally ambiguous, depending on the relative strength between the increase in markups and markdowns, as well as the share of

[6]It is easy to show that supply-constrained firms will charge a strictly higher markdown than before, whereas demand-constrained firms will charge a markdown of 1 (i.e. they are stripped of any labor market power altogether).

directly affected firms. In the next Proposition we provide a sufficient condition in order to have the aggregate labor share *fall* in response to a MW reform.

Proposition. The introduction of a sufficiently large MW (i.e. such that $\mu(N') > \mu(N)/\psi$) causes the aggregate labor share to decrease: $\bar{LS}^{**}_{MW} < \bar{LS}^{*}$.
Proof. The condition requires the reform to be large enough so that it triggers enough exit to make the increase in markup $\left(\frac{\mu(N')}{\mu(N)}\right)$ larger than the inverse markdown. Under this condition, demand-constrained firms will have an equilibrium labor share that is smaller than the one in the old equilibrium. As explained before, supply-constrained ($z \in [\hat{z}(\underline{w}), \tilde{z}(\underline{w})]$) and not directly affected firms ($z \in (\hat{z}(\underline{w}), \bar{z}]$) have an even lower labor share than demand-constrained ones. Therefore, in the new equilibrium all firms will set a lower labor share, and the aggregate level (a weighted average of the firm-specific labor shares) must also go down. ■

Figure 3: Effects of the introduction of the MW on the firm-specific labor shares

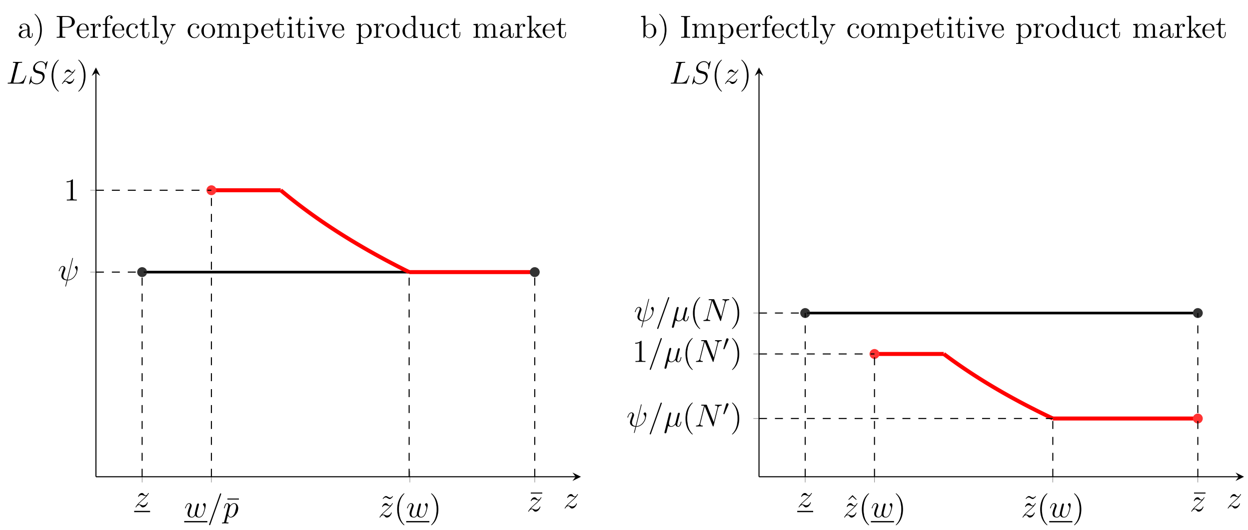


Figure 3 summarizes graphically the effects of the introduction of the MW on the labor shares across the firm productivity distribution, comparing the scenarios with and without endogenous product market power. One can see that the impact of the MW on the labor share is very different across the two economies. In particular, the reform depicted in the Figure - that satisfies the condition provided in the Proposition - delivers results with the opposite sign.

Summing up, in this Section we have shown that in a simple monopsony model with perfectly competitive product markets, the aggregate labor share unambiguously goes up in response to a MW rise. The same holds in any model with product market power where markups are exogenous, as well. Instead, when markups are endogenous, i.e., when the demand elasticity decreases with the MW reform (e.g. because of firm exit), then the labor share response is qualitatively ambiguous. If the negative effect on the demand elasticity is large enough, then the aggregate labor share may be *reduced* by the MW rise.

3 Empirical Analysis

In this section we test the key prediction of the stylized model, namely that – due to the *concentration channel* – the labor share response to the MW depends on the degree of competitiveness of the product market. To do so, we leverage balance sheet data from Italy, that allows us to measure the labor share at the firm level, jointly with data on detailed industry-specific wage floors published by Istat, the Italian national statistical agency. Due to the absence of a mandated national minimum wage in Italy, we resort to information on minimum pay levels agreed by collective bargaining agreements, that represent statutory pay floors which apply to all private-sector employees. These contractual wages are agreed at the national level, hence they provide an exogenous source of variation of labor costs to firms, just like the introduction of a minimum wage. Differently from the latter, however, these agreements set an entire array of minimum pay levels that vary by job title. As a consequence, the direct effects on an increase in contractual pay are not necessarily fully concentrated in the bottom part of the wage distribution. However, as long as the effects of rises are heterogeneous across firms – e.g. because some firms have smaller profit margins or a stronger bite of contractual pay due to smaller *wage cushions*[7] – the concentration channel is still expected to operate in the same way.

3.1 Institutional background

The collective bargaining system in Italy consists of a large number of contracts negotiated between trade unions and employers' associations. Beyond regulating other aspects of labor contracts,[8] these agreements set wage floors that are sector and skill-specific, and typically have a duration of 3 years (2 years prior to 2009). Importantly, these contracts have a virtually universal coverage – i.e. their validity extends *erga omnes* –

[7]This is defined as the log ratio between the actual wages and the minimum pay envisaged by the law (Cardoso and Portugal, 2005).

[8]For instance, the maximum number of hours of work, the number of days off and the rules for promotions and training are set within these agreements.

and are generally used by labor courts and labor inspectors as a reference for a "fair wage". As a consequence, non-compliance to contractual wages in Italy is extremely rare (Adamopoulou and Villanueva, 2022). Moreover, bargaining at the firm level is also very unusual, with the exception of a few large firms. Therefore, agreed wages represent a very important component of worker pay in the Italian economy.[9] For a more detailed description of the institutional framework see D'Amuri and Nizzi (2018).

3.2 The Data

CERVED data. We leverage administrative data on balance sheets for the universe of incorporated Italian firms covering the period 2005-2020. This dataset allows us to compute the labor share – defined as the ratio between total labor costs and value added – at the firm level, as well as to observe all typical balance sheet variables (e.g. value added, investment, profits). For each firm-year we match information on the number of employees and on the total wage bill coming from INPS (the Italian Social Security institute), so that we can derive a measure of average wage. Finally, the industry classification is used to match the relevant level of contractual wage for each year.

Contractual wages data. As explained in Section 3.1, the Italian collective bargaining system is highly centralized. Collective agreements are signed at the nation-wide industry level, with no room for further adjustments at the local level. Contracts envisage wage floors for different worker categories. In this paper, we use data on average contractual wages at the detailed industry level (3-digit) that are made publicly available by Istat for the period 2005-2020 at the monthly frequency, computed as a weighted average of the levels set by the detailed collective contracts within each industry. Wage floors vary over time both because of renewals and the effect of pay rises agreed in the past. In principle, different firms within the same 3-digit industry may apply different labor contracts. Given that we do not have data on contractual pay at the contract level, our strategy involves using the average industry-level contractual wage.[10] In practice, this implies that shocks to labor costs at the firm level are potentially measured with error, possibly leading to a downward bias of our estimates.

[9]Indeed, D'Amuri and Nizzi (2018) document that in the period 2005-2016 contractual wages defined at national level accounted for about 88% of overall total gross earnings. Moreover, a number of studies demonstrates the important role of collective bargaining for downward wage rigidity (Devicienti et al., 2007) and wage inequality (Erikson and Ichino, 1994; Manacorda, 2004; Devicienti et al., 2019; Leonardi et al., 2019) in Italy.

[10]The 3-digit level is the most disaggregated level provided by Istat. Instead, Devicienti and Fanfani (2021) match contract-level information on wage floors to the same firm-level data. Their results are very much consistent with ours.

Finally, we attach to each firm the level of concentration of the detailed sector (4-digit) to which it belongs, as measured by the Herfindahl-Hirschman index (HHI) of value added in 2019.[11] We make the implicit assumption that the concentration of a sector does not vary over time. Using CERVED data, we verify that both the level, and especially the ranking of the different sectors along the concentration dimension, does not change substantially over time.[12] This is reassuring that our fixed measure of concentration does not create any substantial misclassification.

Overall, our estimating sample includes about 6,2 million yearly observations covering each year between 326,000 and 476,000 firms, corresponding to more than 20% of private-sector firms (Devicienti and Fanfani, 2021). The total number of employees working at firms included in our sample is between 7.5 and 9.9 million, representing between 63 and 77% of total private-sector employees. Hence, our data captures the bulk of the Italian private-sector economy.

3.3 The Effect of Minimum Wages on the Labor Share

We study the effect of a rise in minimum wages, set by collective contracts, on the labor share at the firm level. We estimate the following regression model:

$$y_{it} = \beta \log MW_{j(i),t} + \gamma_{k(i)} \times \phi_t + \alpha_i + \epsilon_{i,t}, \tag{12}$$

where y_{it} is the labor share of firm i at time t, defined as the ratio between total labor costs and value added, $\log MW_{j(i),t}$ is the natural logarithm of the contractual wage floor of the 3-digit industry j in which firm i operates, $\gamma_{k(i)} \times \phi_t$ are time-industry (2-digit) fixed effects capturing business cycle and other time-varying shocks at the industry level, α_i are firm fixed effects and ϵ_{it} is an idiosyncratic error term. Our coefficient of interest β captures the response of the labor share to contractual wage growth. To study the heterogeneity of the effect by the level of concentration of the product market, we augment the model in Equation 12 by adding an interaction term between $\log MW_{j(i),t}$ and the sector-specific HHI (4-digit), controlling also for the level of HHI.

Table 1 shows the regression results of the models with and without the interaction term, controlling for either sector (4-digit) or firm fixed effects. Columns 1 and 2 show that raises in minimum wages have a large positive effect on the labor share; on average, a 1-percent increase in the wage floor causes the labor share to increase by 0.5-0.6

[11] We can measure concentration only in 2019, thanks to a confidential dataset representative of the universe of Italian firms with at least 1 employee, provided by Istat.

[12] In particular, the correlation over time of the sector-level HHI - measured with CERVED data, therefore being representative of the relatively larger firms - ranges between 0.7 and 0.96, whereas the correlation in the relative ranking is between 0.8 and 0.98.

percentage points. Importantly, the coefficient is remarkably robust to the inclusion of firm FE, implying that most of the effect does not operate through firms' selection following the shock. Columns 3 and 4 show that the coefficient of the interaction term, that measures the differential effect by the level of concentration, is very large and negative. Combining the coefficient estimates, the regression implies that the effect is positive for low-concentration sectors but it tends to become negative as concentration increases. To better capture the heterogeneous effects by HHI, we repeat the estimation of the model in Column 4 binning the observations by the level of concentration and using a non-linear interaction term. The estimated coefficients yield a monotonically negative relationship between the level of concentration and the effect on the labor share, that turns negative around values of the HHI of 0.3 (see Figure D.1 in Appendix D).

Table 1: The Effect of Minimum Wages on the Labor Share

	(1) Labor share	(2) Labor share	(3) Labor share	(4) Labor share
Log wage floor	0.623***	0.526***	0.470***	0.511***
	(0.015)	(0.008)	(0.016)	(0.008)
Log wage floor × HHI (4-digit)			-0.913***	-1.287***
			(0.011)	(0.008)
Time × Industry (2-digit) FE	Yes	Yes	Yes	Yes
Sector (4-digit) FE	Yes	No	Yes	No
Firm FE	No	Yes	No	Yes
N	6,116,066	6,116,066	6,116,066	6,116,066
R^2	0.247	0.733	0.248	0.734

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

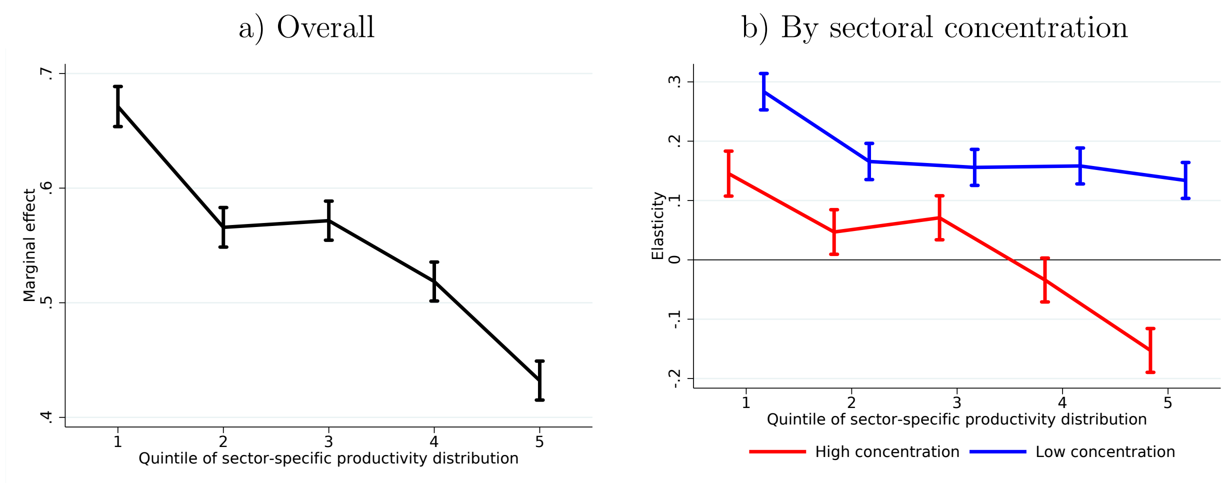
Source: CERVED (2005-2020), INPS and Istat data. *Note*: Linear regressions of labor share, defined as the ratio between total labor costs and value added. Regression models in columns 3 and 4 also control for the sector-specific level of HHI.

Several different adjustment mechanisms at the firm level may bring about changes in the measured labor share. The data at our disposal allow us to dig deeper into the nature of these adjustments. Therefore, in Table 9 we repeat the same regression of Column 4 of Table 1, our preferred specification, for different dependent variables: log average wage, log size, log value added and log profits. Our estimates show that the average effect on wages does not depend on the level of concentration. Instead, firm size and value added respond differently depending on the HHI. In particular, firms in more concentrated sectors grow by less (or even shrink) following the wage increase. The dynamics of the value added qualitatively follows the one of firm size, but it is much less pronounced. As a result, profits in high-concentration sectors *increase* with the wage floor, in stark contrast with what happens in low-concentration sectors. Taken together, these findings show that the differential reaction of the labor share is strictly associated with opposite dynamics of the profit shares at the firm level.[13] Furthermore, as predicted by our simple theory, the more concentrated the sector – arguably, the less fierce the competition – the more negative (positive) the response of the labor (profit) share.

3.4 Heterogeneous Effects by Productivity

We further investigate whether the productivity level of firms matters for the effect of increases in the wage floor. To do that, we assign firms to the most frequent quintile of the detailed sector (4-digit)-year distributions of log value added per worker. We then estimate the same model of Equation 12, augmented by an interaction term between $\log MW_{j(i),t}$ and indicators for the corresponding quintile of the firm. Finally, in order to study whether the heterogeneity of the effect varies also by the concentration level of the sector, we repeat the same regressions splitting the sample between industries above or below the (weighted) average level of HHI.[14]

Figure 4: Heterogeneous Effects by Firm Productivity



Source: CERVED (2005-2020), INPS and Istat data. *Note*: linear regressions of labor share (see Table 1 in the main text), defined as the ratio between total labor costs and value added. The graph of panel (a) plots the estimated coefficients of interaction term between the quintile of the sector-specific productivity distributions and the natural logarithm of wage floor. The graph of panel (b) plots the same coefficients for separate regressions that include only sectors above (or below) the weighted average of HHI.

Figure 4 (panel a) reveals that the effect on the labor share is decreasing with firm's

[13]This is not a simple by-product of the response of the labor share. For instance, labor-capital substitution would not necessarily imply that profits move in the opposite direction.

[14]Results are virtually identical if we split according to the unweighted average.

productivity, consistently with our simple theory. Differences in the estimated coefficients are quite large: the effect for the bottom quintile is more than 60% larger than the one for the top quintile. Interestingly, the split by sector concentration uncovers two additional facts. First, the response in high-concentration sectors is always smaller, along the whole productivity distribution. Second, the difference by the level of concentration widens especially at the top of the productivity distribution, when the effect becomes negative for the most productive firms in concentrated sectors. These results are remarkably consistent with the prediction of our simple model (Figure 3), that implies a negative gradient of the effect on the labor share both by firm productivity and by product market concentration.

As previously, we again break down the results on the labor share into its components (Figure D.2). We uncover a positive gradient by firm productivity in the response of both firm size and value added. However, the change in value added is larger than the one of firm size for low-productivity firms, causing a drop in their profits. Instead, more productive firms experience a less than proportional variation in value added relative to the change in firm size. As a consequence, profits tend to *rise* in the upper part of the productivity distribution. If we compare these patterns by the level of concentration, we find that the wage response is relatively similar, whereas large differences arise in the reaction of firm size and value added. In particular, it is especially in high-concentration sectors that the value added response is detached from the response of firm size, determining the largest increase in profits. Note that high productivity firms in highly concentrated sectors experience a large rise in profits in the face of a reduction in value added. This implies that their profit share is unambiguously increasing.

Overall, the set of empirical results reported in this Section demonstrates that: i) the response of the labor share is less positive (more negative) the more concentrated the sector in which the firm operates; ii) the response is also less positive (more negative) the higher the productivity level of the firm; and iii) negative labor share responses are associated to positive responses of the profit share. All of these pieces of evidence are perfectly in line with the predictions of our theory.

4 Quantitative Model

In this section we construct a novel structural model to quantify the role of product market power in the equilibrium effects of the MW. Our aim is to develop a framework that allows us separately identify firm-level markups and markdowns and to assess their response to MW reforms. To do so, we put together two state-of-the-art models of wage- and price-setting decisions, namely Engbom and Moser (2021) and Atkeson and Burstein

(2008). In our model, heterogeneous firms compete by posting wages and vacancies in the labor market – segmented by worker ability type – and by setting prices in sectoral product markets. Firms are atomistic in the labor market and granular in the product market. The presence of search frictions implies that firms exert dynamic monopsony power on the labor market by playing a wage-posting game; granularity in the product market entails that firms operate in an oligopolistic environment by setting their prices strategically. The model delivers both endogenous markups and markdowns, which react to changes in the competitive environment induced by policy reforms such as the MW.

4.1 Economic Environment

Consider a continuous-time economy populated by a measure L of workers and a measure M of firms. Both workers and firms are infinitely-lived and discount future streams of consumption at the rate r. The economy is assumed to be in steady-state. In what follows, labor markets are indexed by j, whereas product markets are indexed by k.

Consumers. Consumers are hand-to-mouth individuals with linear preferences over a consumption good. Therefore, they simply consume all their income in any period.

Workers. In the labor market, workers differ in their permanent ability level a, which is drawn from a distribution $\Omega(a)$. We think of the ability parameter as reflecting both observable and unobservable invariant heterogeneity across workers. Workers compete in frictional labor markets that are segmented by ability level (i.e. j denotes both the labor market *and* the worker type), by searching for jobs and accepting or rejecting job offers. At any point in time, a worker can be either employed or unemployed, and may transit across these two labor market states according to Poisson rates that vary across worker types. In particular, δ_j denotes the rate at which a worker of type j separates from employment, while $\lambda(\theta_j)$ denotes the rate at which an unemployed worker of type j finds a job offer, which depends on labor market tightness θ_j as specified below. Workers also differ in their intensity of search on-the-job, with s_j denoting their relative search efficiency with respect to an unemployed worker. These differences are meant to capture differentials in the access to professional networks, as well as more general differences in the propensity to lose employment and/or to switch employers, for instance because of family constraints inducing certain choices or preventing geographical relocation. This added flexibility allows us to replicate more precisely labor market transitions across worker types. As it will be clear, this is key to discipline the amount of labor market power in our model economy. Finally, we also assume that the value of leisure b_j may differ across worker types, which allows the model to deliver heterogeneous reservation wages.

Final good producers. Final good producers operate under perfect competition and assemble a homogeneous consumption good from intermediate good varieties through a double-nested CES technology. The parameter ρ denotes the elasticity of substitution across different sectoral goods, while σ controls the elasticity of substitution across varieties of the same sectoral good. Following the existing literature, we assume that $\rho > 1$ and $\sigma > \rho$, meaning that goods are more substitutable within than across sectors.

Firms. Firms differ in their level of permanent physical productivity z and in their competitive environment. More precisely, we assume that each firm hires workers from a single labor market j and sells its output in a single product market k. As a consequence, the equilibrium choices of producers with the same level of physical productivity will differ depending on the degree of competition faced on both markets. Productivity types are drawn from a distribution $\Gamma_{j,k}(z)$, which is allowed to differ across labor and product markets. All firms operate a linear technology: the output of a firm with productivity z hiring from market j is

$$y(\ell_j|z) = z\, a_j\, \ell_j,$$

where ℓ_j denotes the amount of type-j labor hired by the firm. Firms maximize per-period profits by posting vacancies v and wage piece rates w, and by choosing their employment size ℓ. It is important to note that vacancies are an essential input for production, as they are needed to find workers and to maintain the equilibrium size.

Labor market frictions. Labor markets are segmented by worker type. Both unemployed and employed workers search at random for job offers. A job offer corresponds to the possibility of working at a piece rate w until the match gets destroyed. Earnings are equal to the product between the piece rate and the ability level a_j. Piece rates are drawn from a continuous wage offer distribution $F_j(w)$, an equilibrium object that is determined by firms' optimization. Without loss of generality, we let the support of $F_j(w)$ be $[\underline{w}_j, \bar{w}_j]$. The search effort of unemployed workers is normalized to 1, while the one of employed workers is equal to s_j. Therefore, the total search effort of market j is equal to $S_j = u_j + e_j\, s_j = u_j + (1 - u_j)\, s_j$, where u_j and e_j denote respectively the mass of unemployed and employed type-j workers. The total number of matches occurring at any point in time is regulated by an aggregate CRS matching function

$$M(S_j, V_j) = \chi\, S_j^{\xi}\, V_j^{1-\xi},$$

where V_j is the total stock of vacancies posted by firms operating in market j, χ represents the matching efficiency level and ξ the elasticity of matches to aggregate search effort. We define the labor market tightness $\theta_j = \frac{V_j}{S_j}$, the job-finding rate $\lambda(\theta_j) = \frac{M(S_j,V_j)}{S_j}$ and the firms' meeting rate $q(\theta_j) = \frac{M(S_j,V_j)}{V_j} = \lambda(\theta_j)/\theta_j$. Labor market frictions, along with wage-setting power of firms, imply upward sloping labor supply curves faced by employers.

Product market competition. In each product market, a finite number of firms N_k competes á la Cournot. Given that $N_k < \infty$, firms are granular in their product markets, accounting for a well-defined share of sectoral output. It is important to note that, for given elasticity of demand, the market structure N_k and the firm productivity distribution $\Gamma_{j,k}$ shape the competitive environment of each sector. That is, strategic interaction among sectoral firms produces heterogeneous elasticities of residual (or firm-level) demand depending on the number of active firms within each sector and their realized productivity distribution, thereby giving rise to an endogenous markup distribution in the economy.

4.2 Final good producers' problem

Final good producers solve the following profit maximization problem:

$$\max_{\{y_{ik}\}} PY - \int_0^1 \sum_{i=1}^{N_k} p_{ik} y_{ik} \, dk \tag{13}$$

$$\text{s.t.} \quad Y = \left(\int_0^1 Y_k^{\frac{\rho-1}{\rho}} \, dk \right)^{\frac{\rho}{\rho-1}} \tag{14}$$

$$Y_k = \left(\sum_{i=1}^{N_k} y_{ik}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{15}$$

As apparent from the formulation of the CES aggregators, we assume that there is a measure 1 of sectors k, and that in each sector a finite number of firms N_k compete, each of which producing a single variety. Henceforth, we use the consumption good as numeraire and normalize its price to 1, i.e., $P = 1$.

4.3 Workers' problem

Let U_j and $W_j(w)$ be the Hamilton-Jacobi-Bellman (HJB) equations representing respectively the value of a type-j unemployed and employed worker holding a job that pays w.

$$rU_j = b_j + \lambda(\theta_j) \int_{\underline{w}_j}^{\bar{w}_j} \max\left\{W_j(w), U_j\right\} \, dF_j(w). \tag{16}$$

$$rW_j(w) = a_j\, w + \Pi_j + s_j\, \lambda(\theta_j) \int_{\underline{w}_j}^{\bar{w}_j} \max\left\{W_j(w'), W_j(w)\right\} \, dF_j(w') + \delta_j \left(U_j - W_j(w)\right). \tag{17}$$

An unemployed worker of type j receives flow value of leisure b_j and finds a job offer at rate $\lambda(\theta_j)$, that she accepts if it provides a higher value than unemployment. In equilibrium, workers set a reservation wage $\underline{w}_j^{R,U}$, so that all offers equal or higher than it are accepted. The value of the reservation wage is the level of wage such that $W_j(w) = U_j$.

Instead, an employed worker of type j earns (and consumes) labor earnings $a_j w$ and profits Π_j, and finds another job opportunity at rate $s_j\lambda(\theta_j)$, which she accepts if it pays better than the one she currently holds. Finally, her job is destroyed at rate δ_j, in which case she flows into unemployment.

Labor market transitions and the wage distribution. Let $G_j(w)$ be the share of employed type-j workers who earn wage rate equal or lower than w. This share evolves in response to inflows (unemployed workers who accept jobs with $w' \leq w$) and outflows (employed workers who accept jobs with $w' > w$ or lose their job) according to the following Kolmogorov forward equation:

$$\dot{G}_j(w) = \lambda(\theta_j)u_j F_j(w) - \Big(\delta_j + s_j\lambda(\theta_j)(1 - F_j(w))\Big)e_j G_j(w). \tag{18}$$

Similarly, the measures of employed e_j and unemployed u_j workers evolve according to labor market transitions governed by the separation and job-finding rates:

$$\dot{u}_j = \delta_j e_j - \lambda(\theta_j)u_j. \tag{19}$$

$$\dot{e}_j = \lambda(\theta_j)u_j - \delta_j e_j. \tag{20}$$

Under the assumption of constant population ($u_j + e_j = 1$), one can solve for these distributions in steady-state (i.e. setting $\dot{G}_j(w) = \dot{u}_j = \dot{e}_j = 0$):

$$G_j(w) = \frac{\lambda(\theta_j)F_j(w)}{\delta_j + s_j\lambda(\theta_j)(1 - F_j(w))} \frac{u_j}{e_j}. \tag{21}$$

$$u_j = \frac{\delta_j}{\delta_j + \lambda(\theta_j)}. \tag{22}$$

Equation 21 reveals the close connection between G_j, which corresponds to the observed employment wage distribution, and F_j, the wage offer distribution. In general, it can be shown that G_j diverges from F_j, with more and more mass being concentrated in the right part of the support of wages, when $s_j\lambda(\theta_j)$ is high relative to δ_j. As already noted by Burdett and Mortensen (1998), the ratio $\frac{s_j\lambda(\theta_j)}{\delta_j}$ relates to the speed at which workers climb the job ladder in the model and represents a synthetic measure of the extent of labor market frictions in the economy. See Appendix A.1 for further details on the relationship between G_j and F_j.

4.4 Firms' problem

Assuming that the discount rate tends to zero ($r \to 0$), the firms' problem reduces to a static profits maximization problem. As already mentioned, each firm is assigned to a single labor market j and a single product market k. A firm with productivity z solves the following problem:

$$\max_{w \geq \underline{w}/a_j, v, \ell} \; a_j \left(z\, p_k(\ell) - w\right) \ell_j(w,v) - a_j \bar{c}_j \frac{v^{1+\eta}}{1+\eta} - \kappa_j \tag{23}$$

$$\text{s.t. } \; \ell_j(w,v) = \frac{v}{V_j} \frac{\lambda(\theta_j)(u_j + s_j e_j G_j(w))}{\delta_j + s_j\lambda(\theta_j)(1-F_j(w))} \tag{24}$$

$$p_k(\ell) = (a_j z \ell)^{-\frac{1}{\sigma}}\, Y_k(\ell)^{\frac{1}{\sigma}-\frac{1}{\rho}}\, Y^{\frac{1}{\rho}} \tag{25}$$

$$Y_k(\ell) = \left[(a_j z \ell)^{\frac{\sigma-1}{\sigma}} + \sum_{i \neq 1}^{N_k} y_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{26}$$

Firms maximize profits, which are made of total revenues net of labor costs (the wage bill), vacancy posting costs and some market-specific overhead costs κ_j. The maximization problem is subject to two key constraints: the first one, reflecting labor market frictions, is the upward sloping labor supply (Equation 24), that determines the equilibrium firm size of a firm posting a piece rate w and v vacancies; the second one, reflecting the imperfect substitutability of varieties for final good producers, is the downward-sloping goods demand (Equation 25), that constraints the price that can be charged for any production level. See Appendix A.2 and A.3 for details on the derivation of these two constraints.

It is easy to see that setting $p_k(\ell) = \bar{p}$ and $\kappa_j = 0$, i.e. by eliminating all product market power and removing overhead costs, the firms' problem reduces exactly to that of Engbom and Moser (2021). Formally, one can eliminate product market power in the limit as $\sigma, \rho \to \infty$, which makes consumers' demand perfectly elastic. Conversely, removing labor market frictions, the model reduces to Atkeson and Burstein (2008).

4.5 Equilibrium definition

Definition 1 *A steady-state equilibrium of our model economy consists of:*

- *A set of reservation wages* $\{\underline{w}_j^{R,U}, \underline{w}_j^{R,E}\}$ *for both unemployed and employed workers, that solve the workers' problems (16) and (17);*
- *Output demand functions* $y_{ik}(p_{ik}), \forall i, k$ *that solve the final good producers' problem (13)*
- *A set of wage, vacancy posting and employment policies* $\{w_{j,k}(z), v_{j,k}(z), \ell_{j,k}(z)\}$ *that solve the firms' problem (23);*
- *A set of thresholds* $\{\underline{z}_{j,k}\}$ *that determine the marginal firm of each submarket* (j, k)*;*
- *Measures* $\{G_j(w), e_j, u_j, V_j\}$ *and matching rates* $\{\lambda(\theta_j), q(\theta_j)\}$ *that are consistent with firms' optimization, with the laws of motion in steady-state and with the matching technology;*
- *Good market clearing condition ensuring that the aggregate resource constraint holds:*

$$C = Y - \int_0^1 \sum_{i=1}^{N_k} \bar{c}_k \frac{{v_{ik}}^{1+\eta}}{1+\eta} dk - \int_0^1 \kappa_k \; N_k \; dk$$

  where $C = L \int e_a \int_{\underline{w}_a}^{\bar{w}_a} aw \; dG_a(w) \; d\Omega(a) + \int_0^1 \sum_{i=1}^{N_k} \pi_{ik} dk$ *and* Y *is the CES aggregator defined in (14).*

4.6 Equilibrium characterization

Workers' problem. In the labor market, the workers' problem is solved by finding the reservation wage rules. Trivially, employed workers accept all job offers with a piece rate that exceeds the one of their current job ($\underline{w}_j^{R,E}(w) = w$). This reflects the absence of any switching costs and of any other characteristics of jobs (e.g. amenities). We now turn to the determination of the reservation wage for the unemployed workers. By setting $W_j(\underline{w}_j^{R,U}) = U_j$, it is easy to solve for the value of the reservation wage:

$$\underline{w}_j^{R,U} = b_j - \Pi_j + (\lambda(\theta_j) - s_j\lambda(\theta_j)) \int_{\underline{w}_j^{R,U}}^{\bar{w}_j} \frac{\bar{F}_j(w)\, dw}{r + \delta_j + s_j\lambda(\theta_j)\bar{F}_j(w)}, \tag{27}$$

where $\bar{F}_j(w) = (1 - F_j(w))$. Equation 27 determines the optimal behavior of type-j worker (see Appendix A.4 for the derivations). In sum, unemployed workers accept all job offers above $\underline{w}_j^R$, which generally does not coincide with the flow value of leisure b_j, both due to the presence of Π_j and also to the fact that the arrival rates of employed and unemployed workers generally differ ($s_j \neq 1$). When s_j is smaller (larger) than 1, then workers require more (less) than $b_j - \Pi_j$, to be compensated for the loss (gain) in the expected value from future job search.

Final good producers' problem. Final good producers express the following demand functions for each variety i in product market k:

$$y_{ik} = \left(\frac{p_{ik}}{P_k}\right)^{-\sigma} \left(\frac{P_k}{P}\right)^{-\rho} Y \quad \forall i = 1, \ldots, N_k, \ \forall k \tag{28}$$

where we define the ideal price index of sector k as $P_k = \left[\sum_{i=1}^{N_k} p_{ik}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$. Reflecting the double-nested CES preferences, the demand for the good produced by firm i in sector k negatively depends on its price vis-à-vis the overall price level of the sector, and on the price level of the sector vis-à-vis the overall price level of the economy (here normalized to 1). See Appendix A.3 for details on the derivations.

Firms' problem. Replacing the goods demand constraint into the objective function, it is possible to rewrite the firm's problem as a problem with only two control variables (w and v). To ease the exposition, we solve the problem in its general form (i.e. neglecting the functional form of the vacancy posting cost $c_j(v)$, of the labor supply $\ell_j(w, v)$ and of the inverse goods demand $p_k(\ell)$, and we then substitute the exact equations in a second moment. A firm hiring from labor market j and selling its output in product market k solves the following problem:

$$\max_{w,v} \quad a_j \left(z \, p_k(\ell_j(w, v)) - w\right) \ell_j(w, v) - a_j c_j(v) - \kappa_j.$$

The FOCs of this problem are

$$(v): \qquad c_j'(v) = \left((1 + \epsilon_k^{p,\ell}) \, p_k(\ell_j(w, v)) \, z - w\right) \frac{\partial \ell_j(w, v)}{\partial v}, \tag{29}$$

$$(w): \quad \ell_j(w, v) = \left((1 + \epsilon_k^{p,\ell}) \, p_k(\ell_j(w, v)) \, z - w\right) \frac{\partial \ell_j(w, v)}{\partial w}, \tag{30}$$

where $\epsilon_k^{p,\ell}$ denotes the elasticity of inverse demand. Note that this is an equilibrium object which differs across markets and across firms within a market, due to the oligopolistic market structure. In equilibrium, firms optimally choose the level of wages and vacancies that allows them to achieve their optimal size. Importantly, they internalize the fact that growing larger (i.e. selling larger quantities) entails cutting their price. In this sense, product market power works as a force that compresses firm size. Rearranging Equation 30, one can obtain a function for the optimal price:

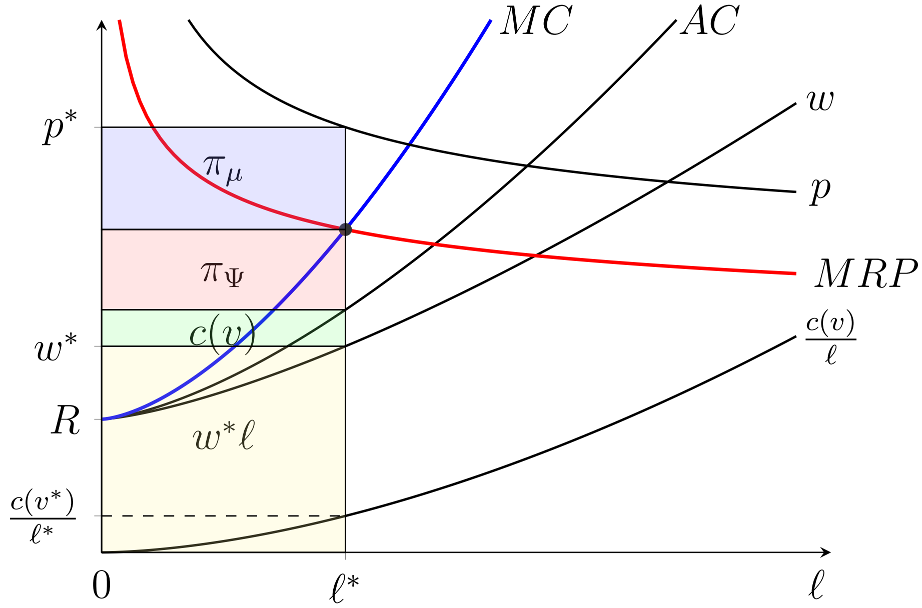
$$\underbrace{(1+\epsilon_k^{p,\ell})\, p_k(\ell_j(w,v))\, z}_{MRP} = \underbrace{\left(1+\frac{1}{\epsilon_j^{\ell,w}}\right) w}_{MC} \tag{31}$$

$$\implies p_k(\ell_j(w,v)) = \underbrace{\left(\frac{1}{1+\epsilon_k^{p,\ell}}\right)}_{Markup\equiv\mu(\ell)} \underbrace{\left(\frac{\epsilon_j^{\ell,w}+1}{\epsilon_j^{\ell,w}}\right)}_{Markdown^{-1}\equiv\psi(\ell)^{-1}} \frac{w}{z}. \tag{32}$$

In equilibrium, firms equate the marginal revenue product (MRP) to the marginal cost (MC) of labor. Marginal revenue product is equal to the marginal product of labor multiplied by a term that reflects the elasticity of inverse demand, that tends to reduce firm's profits following an increase in size. Conversely, the marginal cost of labor is equal to the wage multiplied by the inverse of the wage elasticity of labor supply, reflecting that a size expansion implies an increase in the wage bill that is due both to more workers and higher wages. As a consequence, the optimal price incorporates a double wedge on top of the unitary wage cost (Equation 32), composed of a price markup (μ) and a wage markdown (ψ). These wedges directly reflect the size of the elasticities $\epsilon_j^{p,\ell}$ and $\epsilon_j^{\ell,w}$ in equilibrium. Graphically, the equilibrium size is pinned down by the intersection between the marginal cost (MC) and the marginal revenue (MRP) curves (Figure 5). At the equilibrium, since in our model it is the case that $\epsilon_j^{p,\ell} < 0$ and $\epsilon_j^{\ell,w} < \infty$, the price (wage) will be above (below) the MRP (MC) curve, generating positive operating profits (evaluating actual profits requires subtracting the fixed cost κ_j). Profits from product market power π_μ are equal to the difference between the equilibrium price and the MRP, multiplied by the equilibrium size. Instead, profits from labor market power π_ψ are equal to the difference between the equilibrium wage and the average cost (AC) curve. Notice that an important asymmetry between the two sides of the market is given by vacancy costs, that drive an additional wedge between AC and MC. Therefore, as it is clear from Figure 5, in our model firms also make inframarginal profits, which are needed to cover vacancy costs – an input that does not enter into the production function but is essential to achieve any equilibrium size. See Appendix A.5 for the derivation of the key equations representing the firm's problem.

The Role of Vacancies. As just mentioned, vacancies are essential to production, even though they do not enter directly into the production function. This is because, due to the separation rate δ_j, a constant inflow of labor is needed to maintain any firm size, which in turn requires at least some vacancies being posted in the labor market. In general, it can be shown that there are important complementarities between wages and

Figure 5: Graphical representation of firm's problem



vacancies. Indeed, the elasticity of labor supply to a given of these two inputs crucially depends on the level of the other one. For instance, suppose that a firm is considering investing more in vacancies. The total size increase that is triggered by this choice will be small (large) if the offered wage lies towards the bottom (top) of the wage distribution, reflecting the fact that these additional vacancies will be effective to a different degree at poaching workers from other firms. Conversely, an increase in the piece rate, that determines an improvement in the rank of the firm (i.e. how many other firms it can poach workers from), will deliver a higher return if the stock of vacancies posted is large. Formally,

$$\frac{\partial \ell_j(w,v)}{\partial v} = \hat{f}_j(w,v), \text{ with } \hat{f}_{j,1}(w,v) > 0, \qquad \frac{\partial \ell_j(w,v)}{\partial w} = \hat{g}_j(w,v), \text{ with } \hat{g}_{j,2}(w,v) > 0.$$

In equilibrium, firms choose the optimal mix of wages and vacancies that guarantees them to achieve their optimal size.[15] This implies that it is possible to draw a link between the *structural* wage elasticity of labor supply $\epsilon_j^{\ell,w}$ and the *structural* vacancy elasticity of labor supply $\epsilon_j^{\ell,v}$. To see this, let us take the ratio between the two FOC's:

$$\frac{\epsilon_j^{\ell,w}}{w} = \frac{\epsilon_j^{\ell,v}}{v}\frac{\ell_j(w,v)}{c_j'(v)}. \tag{33}$$

[15]Indeed, the firm's problem may also be rewritten in two steps. In the first step, firms minimize costs (wage and vacancies costs) subject to a size constraint. In the second step, they maximize profits by finding their optimal size.

Hence, all results that apply to the wage elasticity of labor supply can equally be restated with reference to the vacancy elasticity of labor supply. Finally, it is important to realize that the amount of vacancies posted (i.e. the recruiting intensity) shapes the equilibrium relationship between firm size and ranking in the wage offer distribution $F(w)$. Indeed, a high level of vacancies increases the likelihood that own wage offers are sampled by workers. Such a *visibility channel* mediated by vacancies is distinct – albeit complementary – to the standard *wage channel* featuring any model with upward sloping labor supply.[16]

Inspecting Markups and Markdowns. The ability of firms to charge a price above marginal revenue (i.e. a price markup) and a wage below marginal cost (i.e. a wage markdown) depends on the elasticities of the goods demand and of the labor supply that they are facing. As already mentioned, in our model these elasticities are equilibrium outcomes, varying across markets and across firms within a market. To make this explicit, in this section we add an i subscript to elasticities, markups and markdowns. Using the functional forms assumed in Section 2, the inverse demand elasticity that producer i in market k faces is

$$\epsilon_{ki}^{p,\ell} = -\frac{1}{\rho}\hat{s}_{ki} - \frac{1}{\sigma}(1-\hat{s}_{ki}), \tag{34}$$

where $\hat{s}_{ki}$ is the market share of firm i. As it is clear, the elasticity faced by the producer depends on how large the firm is relative to its sector in terms of revenues. In particular, it is equal to a weighted average between $-\frac{1}{\rho}$ and $-\frac{1}{\sigma}$, with the weights being given by the market share. When firms are very small, that is $\hat{s}_{ki} \approx 0$, the elasticity tends to $-\frac{1}{\sigma}$, resembling monopolistic competition within the sector. On the contrary, when firms are very large (i.e. $\hat{s}_{ki} \approx 1$), then the elasticity tends to $-\frac{1}{\rho}$, resembling monopolistic competition across sectors. The fact that the firm's size influences the elasticity reflects the granular nature of product market competition in our model.

Let μ_{ki} be the equilibrium markup of firm i, selling its output in market k. Using Equation 34, we can find a convenient expression for it:

$$\mu_{ki} = \frac{\sigma}{(\sigma-1)\left[1 - \frac{\frac{\sigma}{\rho}-1}{\sigma-1}\hat{s}_{ki}\right]}. \tag{35}$$

Owing to the fact that the demand elasticity depends on the market share, the equilibrium markup is also strictly related to the market share. In particular, it is increasing in the market share under $\sigma > \rho$. The two limit cases are $\mu_{ki} = \frac{\sigma}{\sigma-1}$ for $\hat{s}_{ki} = 0$ and $\mu_{ki} = \frac{\rho}{\rho-1}$ for $\hat{s}_{ki} = 1$.

We now turn to the determination of markdowns. Using the functional forms assumed

[16]Both channels are already present in the model of Engbom and Moser (2021).

in Section 2, the labor supply elasticity that firm i hiring from market j faces is

$$\epsilon_{ji}^{\ell,w} = \frac{w_i \ell_i}{\bar{c}_j v_i^{1+\eta}}, \qquad \text{or} \qquad \epsilon_{ji}^{\ell,w} = \frac{2 s_j \lambda(\theta_j) f_j(w_i)}{\delta_j + s_j \lambda(\theta_j)(1 - F_j(w_i))} w_i. \tag{36}$$

Differently from the goods demand elasticity, it is not possible to derive a closed-form solution for the elasticity of the labor supply. Nonetheless, we can inspect Equation 36 to derive useful insights. From the first formulation, it is apparent how vacancies play a key role in determining the elasticity of labor supply. Indeed, as vacancy costs shrink to zero, $\epsilon_{ji}^{\ell,w}$ tends to infinity. This is because vacancies reflect the presence of search frictions, that are the structural determinant of labor market power in our model. From the second formulation, we can instead study the role of the wage offer distribution and of labor market transitions. Let us first consider job-to-job transition rates. It is easy to see that the labor supply elasticity becomes infinite when $\frac{s_j \lambda(\theta_j)}{\delta_j}$ tends to infinity. This reflects the fact that increasing competition among employers reduces their labor market power. Second, the shape of the wage offer distribution is also a key determinant of labor market power. Indeed, for a given rank (i.e. holding $F_j(w_i)$ constant), an increase in $f_j(w_i)$, that represents *local* competition – in the sense of the percentiles of the wage distribution – , also increases the elasticity. Conversely, a higher rank of the firm in the wage offer distribution implies a lower elasticity, due to the relatively smaller concern of poaching (in the limit, the risk of losing workers because of poaching completely vanishes for the highest paying firm).

Let ψ_{ji} be the equilibrium markdown of firm i hiring labor from market j. Using Equation 36, we can derive an expression for it:

$$\psi_{ji} = \frac{w_i \ell_i}{\bar{c}_j v_i^{1+\eta} + w_i \ell_i}, \qquad \text{or} \qquad \psi_{ji} = \frac{1}{1 + \frac{1}{2 f_j(w_i) w_i} \left[(1 - F_j(w_i)) + \frac{\delta_j}{s_j \lambda(\theta_j)} \right]}. \tag{37}$$

Equation 37 reveals that the markdown is increasing - i.e. labor market power is decreasing - in the ratio between the wage bill and vacancy posting costs, reflecting once again the key role of search frictions. At the same time, the formulation to the right of the Equation also shows that markdowns are, ceteris paribus, increasing in the degree of local competition in the wage offer distribution and in the speed at which workers climb the job ladder; on the contrary, they are decreasing in the rank of the firm. However, caution should be taken when interpreting some of these thought experiments, given that they are not grounded on closed-form solutions (e.g. changes in job-to-job transitions also affect the wage offer distribution).

Summing up, in our model economy equilibrium markups and markdowns vary endogenously across markets and across firms. To fix ideas before the quantitative analysis, it is useful to identify the structural determinants of heterogeneity in market power across markets. As for product markets, the number of firms N_k and the distributions of productivity of competing firms are key determinants of the equilibrium revenue shares, which in turn determine markups. Loosely speaking, the less fierce the competition (i.e. low levels of N_k and a more unequal distribution of z) the higher the markups. Turning to labor markets, lower markdowns (i.e. more rents captured by the firm) are brought about by a slower job ladder (low $\frac{s_j\lambda(\theta_j)}{\delta_j}$) and a more unequal distribution of marginal revenue productivity $\tilde{z}$, which intuitively translates into a more dispersed wage offer distribution, that implies lower levels of local competition. Importantly, the distribution of marginal revenue productivity of each labor market crucially depends on the distribution of physical productivity and on the competitive environment of all the sectoral product markets in which firms operating in the labor market sell their goods, which highlights the tight interconnection between product and labor markets in our framework.

Closing the Model. In order to close the model, we need to specify the relationship between the wage offer distribution F_j, an equilibrium object, and the firms' policy functions. First of all, it is convenient to define the function $\tilde{z} = (1 + \epsilon_k^{p,\ell})\, p_k(\ell_j(w, v))\, z$, that is the structural MRP of a firm with physical productivity z that hires from labor market j and sells in product market k. This allows us to rank firms' wage policy functions, as in Engbom and Moser (2021). Indeed, by simply replacing the definition of $\tilde{z}$ in the FOC, it is easy to see that $w_j(\tilde{z})$ is a strictly increasing function. This allows us to express the F_j in terms of the vacancy posting policy functions:

$$F_j(w_j(\tilde{z})) = \frac{M}{V_j} \int_{\underline{z}_j}^{\tilde{z}} v(z')\, d\tilde{\Gamma}_j(z'), \tag{38}$$

where $\tilde{\Gamma}_j(z')$ is the distribution of active firms in market j and $\underline{\tilde{z}}_j$ is the lowest MRP level among them. Appendix A.6 shows that it is possible to reduce the labor market equilibrium to two differential equations, as in Engbom and Moser (2021). The main difference is that our system of equations is function of $\tilde{z}$, that is an equilibrium object. In other words, the labor market block of our model is independent of the product market block for a *given* distribution of $\tilde{z}$. This feature turns out to be very practical for the solution of our model. Appendix B.6 describes the numerical algorithm that we use to solve our model, ensuring the equilibrium in both the labor and the product market.

5 Quantitative Analysis

We estimate the model by replicating a steady-state equilibrium for the Italian economy, targeting empirical moments from the period 2016–2018. Our objective is to use the parametrized version of the model to assess the equilibrium effects of imposing a mandated minimum wage in the Italian economy.

5.1 Model Estimation

Strategy Overview. We discretize worker types using a finite number of grid points, which correspond to separate labor markets in our model economy. Following the strategy of Engbom and Moser (2021), we conceptually link types j to fixed unobserved heterogeneity, as captured by AKM estimation (Abowd et al., 1999). To estimate the firms' productivity distributions, we follow a two-step procedure. First, we use the labor market structure of the model to nonparametrically estimate the marginal revenue productivity (MRP) distributions by inverting the observed wage distributions, similarly to Bontemps et al. (2000). We adopt this estimation strategy to guarantee the best possible fit to the wage distribution, which is key for the question at hand. We then use the product market structure of the model to infer the underlying physical productivity distributions. Indeed, the MRP distribution conveys information on the joint distribution of physical productivity and markups. Our two-step estimation strategy allows us to decompose the two margins.

Turning to the determination of the other structural parameters, we externally calibrate those of the matching function and the discount factor. Next, we identify the worker ability parameters by estimating the AKM equation with simulated data generated by the model and matching the worker-firm wage variance decomposition observed in our social security data. A number of other parameters determining labor market heterogeneity are directly inferred from the data, by matching with our model the observed transitions for different worker types. Moreover, the share of profits accruing to each worker type are set in order to replicate the distribution of non-labor proceeds across income brackets. Finally, the remaining parameters, namely the elasticity of the vacancy posting cost function, the flow values of leisure, the fixed operating costs, and most notably the elasticities of demand, are estimated jointly using the Simulated Method of Moments (SMM), along with the assignment function of firms to product markets.

Externally set parameters. We externally set the matching function parameters and the parameters governing consumers' preferences. The TFP of the matching function χ is normalized to 1, since it cannot be separately identified from the intercepts $\underline{c}_j$ without data on vacancies. We also set the elasticity of matches with respect to search effort ξ to 0.5, a standard value in the literature (Petrongolo and Pissarides, 2001). Turning to workers' preferences, we set the intertemporal discounting parameter r to 0.004 and assume a monthly frequency, implying an annual interest rate of 4%.

Directly inferred parameters. A number of structural parameters of our model have direct implications on statistics that are easily observed in the data. Hence, their value can be directly pinned down by their empirical counterparts. The measure of active firms M governs the average firm size, that in Italy is 4.2 workers, according to Eurostat data. As for labor market transition rates, we first set $J = 10$ worker types, mapping them to the ten deciles of AKM worker fixed effects. See Appendix B.1 and B.2 for details on the matched employer-employee data used and on the estimation of the AKM equation. Importantly, we treat the empirical and the model-generated data exactly in the same way. Next, we discipline the share of aggregate profits accruing to each worker type by targeting the empirical share of non-labor earnings across the income distribution according to the Survey on Household Income and Wealth (SHIW).[17] This allows us to study the impact of minimum wage reforms on the personal income distribution. Then, we pick the parameters $\{\delta_j\}_{j=1}^{10}$ and $\{s_j\}_{j=1}^{10}$ to replicate the separation and the job-to-job transition rates separately by worker type (see Appendix B.3 for details on labor market transition rates across worker types). As already noted, these are crucial parameters, as they govern labor market power in our model. Hence, we adopt a non-parametric approach to estimate them in order to maximize the accuracy of our estimates.

Firms' marginal revenue productivity estimation. Following the strategy of Bontemps et al. (2000), we estimate the firms' MRP distribution by inverting the observed wage distribution, that corresponds to the G_j distribution of our model. We stratify the data by worker types, which correspond to separate labor markets in our model, and by industry. Figure D.3 shows the empirical distributions of hourly wages for Italy by decile of worker AKM fixed effect.[18] We note that there is substantial variation both in the mean and in the variance of the distribution, with higher types being characterized by both larger and more dispersed earnings. The invertion of the wage distribution essentially boils down to backing out the firms' MRP distribution which rationalizes the observed wage distribution according to our model. Specifically, Equation A.11 in the

[17]In the data, we define non-labor income (profits in the model) as the sum of dividend payments and all other types of compensation (both fixed and variable) that are associated to business ownership.

[18]In the data, we observe the yearly earnings, the number of days worked and whether the job was full-time or part-time. Therefore, we construct a measure of hourly wages by imputing 8 hours of work per day to full-time and 4 hours per day to part-time workers.

Appendix delivers a structural relationship between the density of firms at each MRP level $\gamma(\tilde{z})$ and their labor market policies:

$$\gamma_j(\tilde{z}) = h_j'(\tilde{z}) \frac{V_j/M}{v_j(\tilde{z})}. \tag{39}$$

In words, the measure of firms with equilibrium MRP $\tilde{z}$ is directly related to the local slope of the wage offer distribution $h'(\tilde{z})$ and is inversely related to the amount of vacancies v posted by each of those firms relative to the market average V/M. Plugging in equilibrium values, one can show that the necessary and sufficient condition for a non-negative density is:

$$g_j'(w_j(\tilde{z})) \leq \frac{3s_j(1-u_j)g_j^2(w_j(\tilde{z}))}{u_j + s_j(1-u_j)\, G_j(w(\tilde{z}))}.$$

In fact, this is the same condition derived by Bontemps et al. (2000). The only difference between their framework and ours, regarding the labor market, is the presence of vacancies. It turns out that this does not change the condition needed to ensure a non-negative density. Before applying Equation 39, we need to verify that the above condition is verified for all points of the wage distribution. When the condition is not met, we use a simple algorithm to approximate the observed distribution with an *admissible* one, that is one that our model is able to generate. In practice, this requires to target wage distributions that are only slightly different from the ones in the data (see Appendix B.4 for details and for the derivation of the equations shown above).

As already mentioned, we stratify the wage distributions by decile of AKM worker fixed effect (j types) and by industry (see Figure D.4). This allows us to back out firms' MRP distributions that vary by industry. Importantly, we do *not* map broad industries to product markets in the model, which instead requires a more narrow definition.

Product market structure. In the model, product markets are populated by a finite number of producers N_k that compete oligopolistically. Conceptually, this should be mapped to relatively narrowly defined products. Following the main literature (Grassi et al., 2017), we adopt the 4-digit Ateco aggregation level to determine the number of firms. This implies that the median (mean) number of firms within a sector is 1,388 (8,149), with large heterogeneity in the economy (see Table 2 for summary statistics of the distribution of the number of firms across 4-digit sectors). We also find that this distribution strongly varies across industries (see Figures 6 and D.8), an element that will drive differences in the equilibrium average markups.

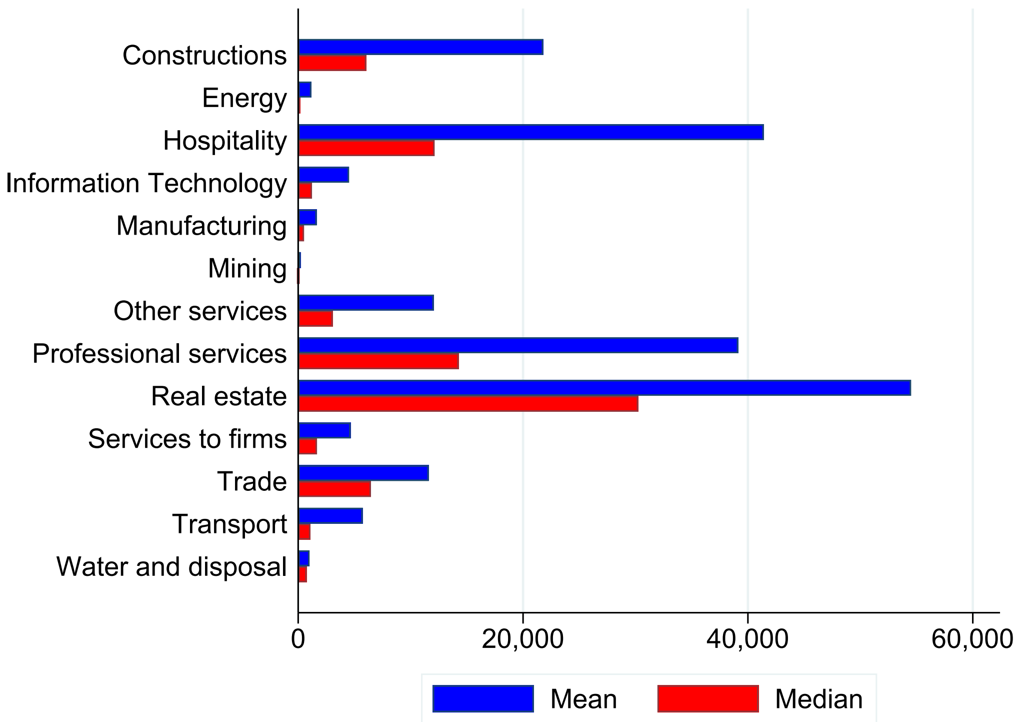
To include these features into our estimated model, for each industry we simulate

Table 2: Summary statistics of the distribution of number of firms within sectors (4-digit)

Statistics	Value
Mean	8,149
Median	1,388
Min	3
Max	160,909
P10	77
P90	19,162
SD	20,939

Source: Structural Business Statistics (Istat), 2019. *Note*: Sectors are defined according to the 4-digit Ateco classification.

Figure 6: Summary statistics of the distribution of number of firms within sectors (4-digit), by industry (1-digit)



Source: Structural Business Statistics (Istat), 2019. *Note*: Sectors are defined according to the 4-digit Ateco classification.

a large number of markets, each of which is populated by a number of firms that is randomly drawn from the corresponding distribution[19]. Given the number of competing

[19]More specifically, we make a draw from the joint distribution of number of firms *and* employment share of each sector that we observe in the data. The correlation structure between number of firms and employment share is then exploited to discipline the variance of productivity within each sector, i.e., address nonrandom deviations from uniform sampling.

firms, their productivity is in turn drawn from the industry-specific productivity distribution, as estimated in the previous step. Hence, our strategy allows us to replicate the extent to which product market size N_k varies across industries along with differences in the productivity distribution.

Internally estimated parameters. Finally, the remaining parameters are internally estimated via SMM. Let ζ be the vector of parameters still to be determined: $\zeta = \Big\{\{\bar{c}_j\}_j\ \eta, \{b_j\}_j, \{\kappa_j\}_j, \{a_j\}_j, \sigma, \rho, \Theta\Big\}$. We choose parameter values that minimize the sum of weighted squared percentage deviations between a set of moments estimated in actual and simulated data:

$$\zeta^* = \arg\min_{m \in \mathcal{M}} \left(\frac{m^M(\zeta) - m^D}{m^D} \right)^2,$$

where m^D is a vector of empirical moments and $m^M(\zeta)$ is the corresponding vector of model-generated moments. First of all, we estimate the parameters $\{\bar{c}_j\}$ to replicate an homogeneous job-finding rate that allows the model to replicate the Italian unemployment rate in 2018 (Istat data).[20] To pin down the elasticity of the vacancy posting cost function η, as Engbom and Moser (2021) we choose to target the share of employment accounted for by firms with a size of 50+, which is 37.21% in Italy for the year 2019 (source: Eurostat). Further, we target the lowest wages recorded in the data by worker type to identify the flow value of leisure $\{b_j\}$. Moreover, we set the overhead costs κ_j to the 99% of the operating profits generated in equilibrium by the less productive firm in our model economy, separately for each labor market. The intuition is that these fixed costs have to be large enough to prevent entry of additional firms in equilibrium.[21] Hence, we set them so that net profits are close to zero for the marginally active firm.[22]

For what concerns worker ability levels, we assign values to $\{a_j\}_{j=1}^{10}$ by replicating the AKM estimation with simulated job histories generated by the model. In particular, we posit a linear relationship between worker ability and her rank across types, normalize the lowest ability to 1 and identify the ability gradient by targeting the empirical worker-firm wage variance decomposition. Intuitively, the steeper the gradient the larger the share of overall wage variance that is attributable to worker fixed effects. See Appendix B.2 for

[20]We prefer this strategy to targeting directly the NE rate observed in our matched employer-employee data by worker type, because non-employment spells are notoriously hard to construct with administrative data on workers' careers, owing to the absence of any information on workers' search behavior or their willingness to accept a job.

[21]In fact, the smallest operating profits provide an upper bound to the overhead costs.

[22]We choose not to set the net profits of marginally active firms exactly to zero to avoid potential exits driven by tiny approximation errors in our counterfactual exercises. In Appendix B.8 we report the opposite case, i.e. where firms do not incur any fixed operating cost, to isolate the role of the extensive margin adjustment in the equilibrium effects of the minimum wage. We find that even without fixed costs – that is silencing the exit channel – all the results would still hold, both qualitatively and quantitatively.

additional details.

Then, we use the product market structure of our model to disentangle the components of MRP into physical productivity, price, and markup. Since firms' sale shares in their sector affect markups according to Equation 35, firms' allocation to product markets is itself a determinant of such decomposition. As a result, we need to jointly estimate the parameters governing the elasticities of demand $\{\sigma, \rho\}$ and the shape of the sampling function governing firm assignment to product markets via SMM.[23] Due to the substantial disagreement in the literature on the validity of markup estimates using revenue data (see Bond et al. (2021), Hashemi et al. (2021) and De Ridder et al. (2022) for details on the ongoing debate), we refrain from targeting an estimate of aggregate markup to identify the elasticities of demand. Moreover, standard measures of markups, such as the one first proposed by De Loecker and Warzynski (2012), would be inconsistent with our framework embedding labor market power and search frictions (for details on this see Hashemi et al., 2021). Since the elasticities of demand are the main drivers of the aggregate markup, to pin down σ and ρ we target the ratio between profit and labor share in Italy, estimated to be 0.539 between 2006 and 2018 (Ciapanna et al., 2022). In order to separately identify the two, we choose the average value added-weighted CR4 index (share of total sales accounted for by the top 4 firms in each product market) as an additional moment that is informative on ρ. Indeed, the larger the cross-sector elasticity of demand, the larger the quantities produced by the largest producers in each market, contributing to higher concentration. We target an average CR4 index of 0.25, as estimated for the year 2019 (source: Istat). Finally, we define a sampling function governing the mean and variance of firm-level employment within each product market. We assume a deterministic relationship between the location parameter of the sampling function, controlling the average employment level, and the ratio between the employment share of the sector and the relative number of firms, which is an index of employment concentration. We let the scale parameter Θ, governing the variance of employment within each sector, be identified jointly with the elasticities of demand by targeting the weighted standard deviation of log value added within sectors, amounting to 1.49 in 2019 (source: Istat). See Appendix B.5 for a detailed explanation of how firms' assignment to product markets is disciplined.

Parameter estimates and model fit. Table 3 shows the model parameter estimates. Panel a reports all parameters that are externally set, that we already commented on in the previous section. Let us turn to the parameters that are directly inferred from the

[23]Notice that if firms, i.e., MRP/employment draws, were assigned to sectoral product markets arbitrarily, random sampling variation in firm assignment to product markets would impede a unique identification of the elasticities of demand.

observed empirical patterns (panel b). First of all, the ratio between number of firms and worker population M is set to 0.238, in order to replicate an average firm size of 4.2.[24] Second, the distribution of estimated shares of profits accruing to the different worker types is heavily skewed towards high-productive types (see panel a of Figure D.5). For instance, the most productive type receives almost 70% of all profits. This large amount of concentration is required to match the empirical distribution of profits across income deciles, that is also highly tilted towards the richest deciles. As for the labor market transition parameters, they follow very closely the dynamics in the data. More precisely, we uncover a negative steep profile of δ_j across worker types (ranging between 0.035 and 0.015), and a hump-shaped profile of search intensity s_j, that starts at 0.2 for the lowest decile, peaks at 0.26 for the middle of the distribution and then declines until 0.12 for the most productive type (see the two top panels of Figure D.6).

Table 3: Model parameter estimates

Parameter	Description	Value	Target/Source	Data	Model
			Panel a. Externally set parameters		
Matching function					
χ	TFP parameter	1.000	Normalization	-	-
ξ	Elast. to search effort	0.500	Petrongolo and Pissarides (2001)	-	-
Household preferences					
r	Discount rate	0.004	Annualized interest rate of 4 percent	-	-
Other parameters					
J	Number of labor markets	10	Deciles of AKM worker fixed effects	-	-
K	Number of product markets	8211	One firm in MRP level w/ lowest density	-	-
			Panel b. Directly inferred structural and auxiliary parameters		
Labor market parameters					
M	Firm-to-worker population ratio	0.238	Average firm size	4.200	4.051
$\{\Pi_j\}$	Share of aggregate profits	Fig. D.5	Distribution of non-labor income	See main text and Fig. D.5	
$\{\delta_j\}$	Separation rates	Fig. D.6	EN rate	See Appendix B.3	
$\{s_j\}$	On-the-job search intensity	Fig. D.6	Job-to-job transition rate	See Appendix B.3	
Productivity distributions and product markets					
$\left\{\tilde{\Gamma}_{j,k}\right\}$	Firm MRP distributions	Fig. D.7	Wage distributions	See Appendix B.4	
$\{N_k\}$	Number of competing firms	Fig. D.8	Distribution of market structures, 4-digit Ateco	See main text	
			Panel c. Internally estimated parameters		
Search costs and labor market parameters					
$\{\bar{c}_j\}$	Vacancy posting cost (scale)	Fig. D.6	Unemployment rate	0.108	0.108
η	Vacancy posting cost (elasticity)	0.530	Share of employment in firms 50+	0.372	0.358
$\{b_j\}$	Flow value of leisure	Fig. D.6	Smallest observed wage	See Appendix B.4	
$\{\kappa_j\}$	Overhead costs	Fig. D.9	Smallest operating profits	See main text	
$\{a_j\}$	Worker ability	-	Relative worker-firm AKM variance	0.886	0.883
Demand elasticity and firms' assignment					
ρ	Elast. of subst. across sectors	1.420	Weighted CR4	0.250	0.235
σ	Elast. of subst. within sectors	10.634	Profit-to-labor share ratio	0.539	0.554
Θ	Sampling function (scale)	-	Standard deviation log value added	1.490	1.437

Source: Model, INPS, Istat, Eurostat and SHIW data. *Note*: Labor market transition estimates and wage distributions are drawn from INPS matched employer-employee data (2016-2018). Statistics on average firm size and the share of employment in large firms are taken from Eurostat data. Finally, statistics on the number of firms in 4-digit Ateco sectors are drawn from the Structural Business Statistics dataset of Istat (2019).

[24]The small difference between empirical and model-implied average firm size stems from the discretization procedure to get an integer number of firms.

We now turn to the firms' productivity distributions, that are of first-order importance for our exercise. The wage invertion, explained in detail in Appendix B.4, delivers MRP distributions characterized by fat tails. Figure D.7 shows their density in log coordinates, revealing that their shape resembles the one of Pareto distributions (whose density is exactly linear in log coordinates). However, the estimated distributions feature some degree of convexity in the central part of the support. Finally, the number of competing firms in each product market is directly drawn from the empirical industry-specific distributions (see Figure D.8), implying by construction a perfect fit.

Turning to the parameters that are internally estimated (panel c), the model yields a vacancy posting cost scale parameter that is U-shaped in worker ability (see panel c of Figure D.6). This profile is needed to generate an unemployment rate of 10.8%, as observed in the data. Instead, flow values of leisure rise substantially in the left part of the ability distribution and then flatten out in the right part (see panel c of Figure D.6).[25] The parameter controlling the curvature of the vacancy posting cost function, η, is estimated to be 0.53, implying a relatively low convexity in the cost function, slightly higher than in Engbom and Moser (2021). The overhead costs κ_j are estimated to be relatively small and to vary somewhat across labor markets (see Figure D.9), ranging between 15% and 43% of the monthly piece-rate wage. The worker ability levels a_j replicate the relative worker-firm AKM variance, delivering a substantial amount of productivity dispersion. Between the least and the most productive type there is a gap of about 190 log points.

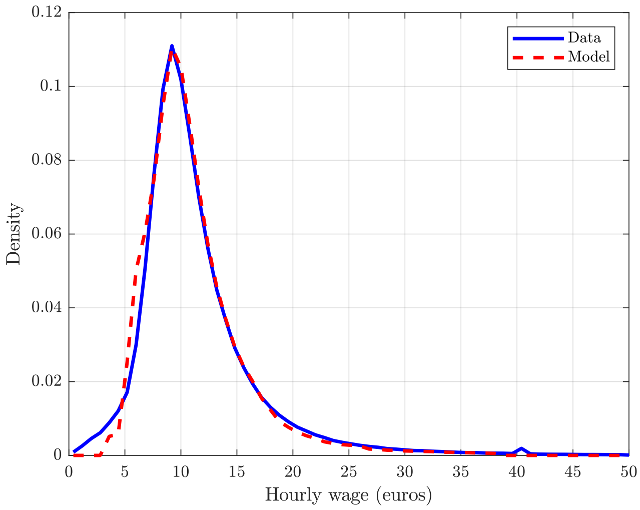
The parameters governing the elasticity of demand are estimated to be $\sigma = 10.63$ and $\rho = 1.42$. A relatively high within-sector elasticity allows the model to replicate the low average degree of product market power of Italian firms, while a low across-sector elasticity makes it consistent with the significant concentration ratio of top 4 firms in sectoral markets. Our estimates are remarkably close to those provided by the existing literature (Edmond et al., 2015; Atkeson and Burstein, 2008; Atkin et al., 2015; Grassi et al., 2017; Edmond et al., 2018; Burstein et al., 2021; De Loecker et al., 2021). This parametrization generates markups that are increasing in firms' sales shares in their sectoral markets, which is supported by a large body of empirical evidence.

Crucially for our analysis, this parametrization allows the model to replicate almost exactly the empirical wage distribution (Figure 7). The virtually perfect fit is due to the flexibility of the model on the shape of the MRP distribution. With some minor caveats, due to non-admissibility of small portions of the distribution (see Appendix B.4 for details), the model does a great job at fitting the observed distribution.

The calibrated model also delivers a right skewed firm size distribution (panel a of

[25]The flow values of leisure consistent with the observed reservation wages and wage distribution are negative. We choose not to trim the wage distribution to the left – and recover positive values – as we would eliminate the most exposed workers to minimum wage rises.

Figure 7: Wage distribution



Source: INPS data (2016-2018) and model.

Figure 8), which is qualitatively consistent with the data. Interestingly, the estimated firms' physical productivity distribution is well approximated by a log-normal distribution, even though it features some left-skewness (panel b of Figure 8). As will be more clear in the following, this distribution is substantially different from the one of MRP. This highlights the importance of factoring in product market power when estimating productivity distributions. Moreover, the estimation reveals that both the distribution of firm size and physical productivity largely differ across industries (see Figures D.10 and D.11).

Table 4: Untargeted statistics

Variable	Data	Model
Vacancy rate	0.013	0.013
Weighted HHI	0.078	0.076
Weighted CR10	0.340	0.328
Weighted CR20	0.420	0.405

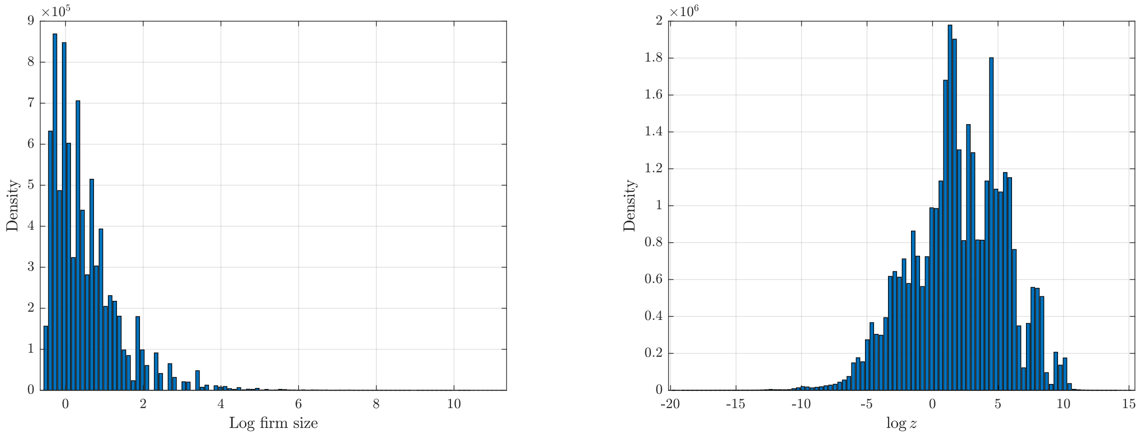
Source: Model and Istat data. *Note*: the table compares some untargeted statistics with those generated by the estimated model.

Importantly, the estimated model also replicates some untargeted statistics (Table 4). In particular, the vacancy rate (the ratio between vacancies and the sum of employment and vacancies) is virtually identical to the empirical one, equalling 1.3%. Moreover, the model almost exactly replicates the average HHI and the CR10 and CR20 at the 4-digit industry level. It is very important that the baseline equilibrium has such a tight fit with the concentration statistics of the product markets, as these are the primary input for

Figure 8: Firm size and productivity distribution

a) Firm size

b) Physical productivity



Source: Model.

markups in the model.

5.2 Labor market policy functions

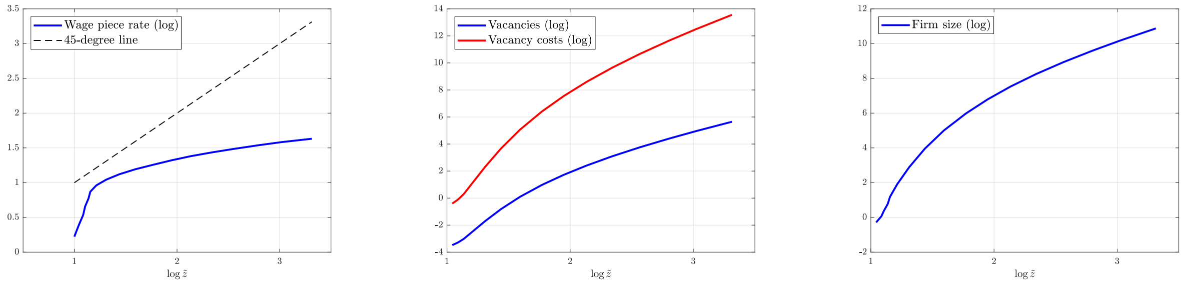
We investigate the properties of the optimal decisions of firms in the labor market (Figure 9). Owing to the Burdett and Mortensen (1998) structure, wage piece rates are monotonically increasing in productivity (recall that MRP $\tilde{z}$ is the relevant notion of firm productivity, as far as the labor market is concerned). Interestingly, the optimal amount of vacancies posted is also increasing in productivity; due to the convexity of the cost function, vacancy costs display a steeper slope in productivity. As a consequence, more productive firms have a larger size in equilibrium, implying a positive association between wages, vacancies and size. Even though the qualitative properties of the policy functions are maintained across labor markets, some differences arise from a quantitative standpoint (see Figures D.12, D.13 and D.14). For instance, the slope of the wage piece rate with respect to MRP varies across labor markets, reflecting differences in the firms' productivity distributions and in the speed at which workers climb the job ladder.

5.3 Equilibrium Effects of the Minimum Wage

We study the equilibrium effects of introducing a mandatory MW in our model economy. We run several experiments, imposing a minimum wage level that gradually grows biting a larger portion of the wage distribution. The smallest value that we consider is 5.8€ per hour, that corresponds to the 5^{th} percentile of the baseline wage distribution. Even

Figure 9: Labor market firms' policy functions

a) Wage piece rate b) Vacancy posting c) Equilibrium size



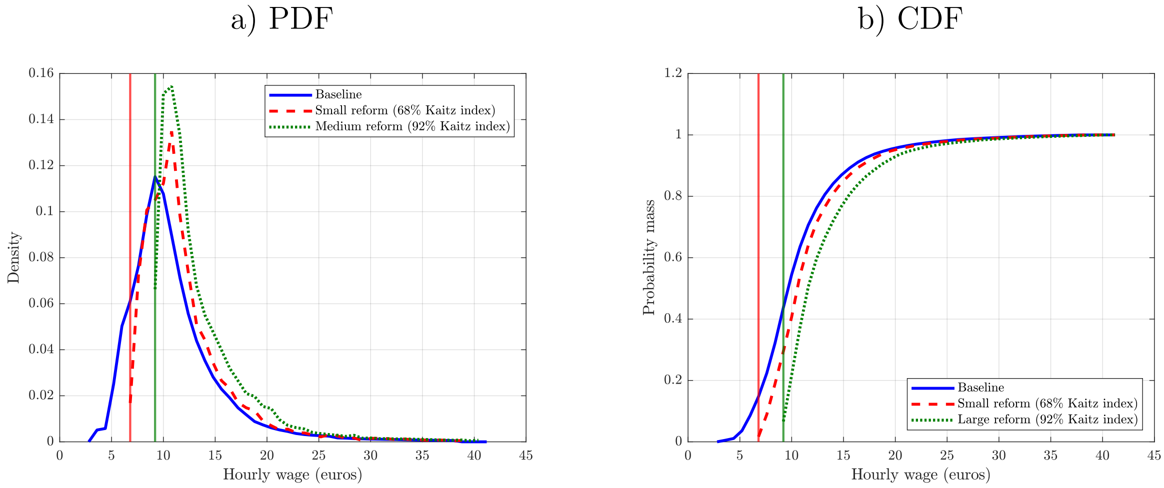
Source: Model. *Source*: the charts show the firms' policy functions in the 5^{th} decile labor market.

though it is a modest increase in absolute value, it still implies a rise of about 62 log points from the lowest observed level of wage in the initial steady-state. The largest policy experiment that we consider is setting the MW to 10.8€ per hour, that is the 55^{th} percentile of the wage distribution, with an increase of about 135 log points. We report the effects of a selection of these simulated reforms below, indexing them by the Kaitz index (the ratio between the mandated minimum wage and the pre-reform median wage), as it is standard in the literature.

A quick glimpse at the wage distribution reveals that the MW rise generates strong spillover effects, in fact moving virtually the whole distribution to the right (Figure 10). These results echo recent findings in Engbom and Moser (2021) and Haanwinckel (2020), who also document far-reaching effects in the wage distribution. The increase in wage is concentrated in the bottom part of the distribution (roughly up to the 30^{th} percentile), but significant effects can be found through the whole distribution (Figure D.15). These large wage effects of the MW are due to two different sources: first, firms react to the reform by raising posted piece rates; second, workers reallocate towards high-paying firms.

We now turn to studying the aggregate effects of the MW reforms on the economy. We start by considering the response of the labor share and of the market power indexes, that are at the core of our model. Figure 11 shows that the aggregate labor share is hump-shaped with respect to the value of the MW, with a peak around the median wage. This is because two offsetting forces push it in opposite directions: on the one hand, due to the increase in pay offered by firms, the aggregate markdown increases, pushing the labor share up. On the other hand, the aggregate markup also goes up – according to the concentration channel – driving the labor share down. Quantitatively, the former effect dominates for relatively low MW values, whereas the opposite happens for high values of MW. Indeed, the response of the markup is convex in the MW level, resulting into

Figure 10: Equilibrium effects of minimum wage reforms on the wage distribution



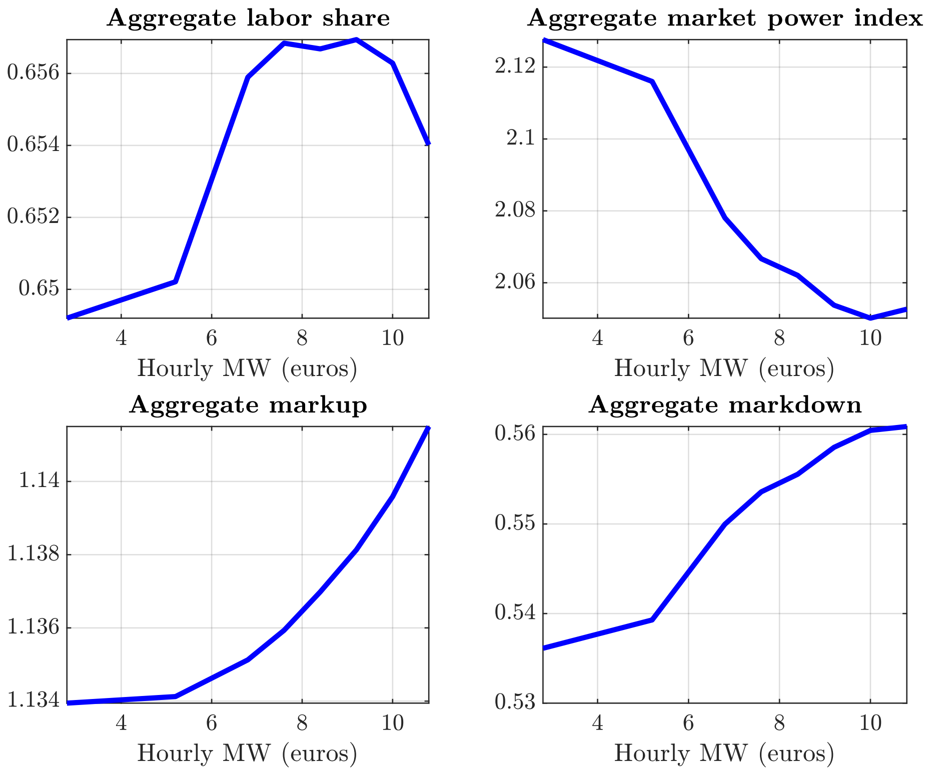
Source: Model. *Note*: the blue line represents the baseline wage distribution, the red dashed line represents the distribution after the small reform (targeting the 10^{th} percentile), the green dotted line represents the distribution after the large reform (targeting the 30^{th} percentile).

a growing importance on the overall dynamics. Owing to the initially stronger reaction of the markdown, the aggregate market power index falls for small and medium MW levels. Then, as the MW gets larger, it first plateaus and eventually reverts back since its dynamics is progressively more driven by the markup change (see Figure D.16). In order to correctly capture the non-monotonic nature of the response of the market power index, it is therefore fundamental to allow for the endogenous response of markups and markdowns.

Table 5 reports the effects on a larger selection of variables of two policy experiments: the first one (which we term *small reform*) imposes a MW equal to the 10^{th} percentile of the original wage distribution (Kaitz index of 68%), whereas the second one (*large reform*) introduces a MW that corresponds to the 40^{th} percentile of the initial distribution (Kaitz index of 92%). The reforms cause an increase in the unemployment rate, due to a drop in the job-finding rate. Despite the fall in employment, aggregate output and welfare significantly increase, both by about 4 (11) percent in the small (large) reform. These large positive effects are entirely due to the productivity gains brought about by reallocation of workers across firms, leading relatively unproductive establishments to either shrink or exit.[26] Indeed, the existence of search frictions entails that the allocation of workers

[26]In Appendix B.8, we provide a robustness check in which we shut down the exit channel by setting the overhead costs equal to zero (Table 8). Importantly, all results go through both qualitatively and quantitatively. The reason is that, instead of exiting, hardly hit firms shrink dramatically, so that their weights almost approaches zero; indeed, one can see that average firm size goes down substantially after the MW reforms, the opposite pattern of what happens in the baseline economy. Hence, the amount of overall labor reallocation taking place is remarkably similar, so that results are practically unaffected.

Figure 11: Effects of minimum wage reforms on labor share and market power indexes



Source: Model. *Note*: the blue lines represent the equilibrium values of each variable in a counterfactual equilibrium with the minimum wage being set to the value shown in the x axis.

across firms is generally sub-optimal: since firms with heterogeneous productivities hire workers on the same labor market, a reduction in vacancy posting from low productive firms alleviates the congestion externalities constraining the optimal size of more productive firms, thus allowing them to grow more cheaply. Consistently, average wages increase by 9 and 22 percent in the two policy scenarios, and wage dispersion reduces dramatically (by 31 and 44 percent). Pushed by these large wage gains, the labor share increases by 0.7 percentage points in the small reform, and slightly more (by 0.8 percentage points) in the large reform. This is due to the fact that the profit share negatively responds to the MW reform. In fact, the decrease of profits generated in the labor market dominates over the concentration channel. In the product markets, firm exit and the reallocation process cause market shares to increase, ultimately pushing markups up. However, this effect is less strong than the increase of the average markdown, which ultimately pushes the profit share down.

Because of the reallocation, employment becomes more concentrated across firms (i.e. average firm size increases). Moreover, the dispersion of market power across firms, captured by the variance of the total market power index (the product between the markup and the inverse markdown), shrinks substantially, signaling an improved allocation. Indeed, heterogeneity in the market power across firms is a key source of misallocation in our model economy.

Table 5: Policy experiments

Variable	Baseline	Small reform (.68 Kaitz index)	Large reform (.92 Kaitz index)
Panel a. Aggregate statistics			
Value added	1.000	1.044	1.110
Aggregate welfare	1.000	1.043	1.107
Unemployment rate	0.107	0.118	0.135
Output per worker	1.000	1.042	1.118
Average wage	11.032	12.032	13.500
Log wage variance	0.132	0.091	0.074
Average firm size	4.051	4.076	4.189
Panel b. Distributional statistics			
Labor share	0.649	0.656	0.657
Profit share	0.351	0.344	0.343
Profit share (product market)	0.163	0.162	0.164
Profit share (labor market)	0.180	0.174	0.171
Panel c. Market power statistics			
Average mpi	2.128	2.078	2.054
Average markup	1.134	1.135	1.138
Average markdown	0.536	0.550	0.559
Misallocation index (mpi std dev)	0.547	0.530	0.507
Panel d. Labor market transitions			
Job-finding rate	0.207	0.185	0.157
Job-to-job flow rate	0.013	0.013	0.012
Job-separation rate	0.025	0.025	0.025

Source: Model. *Note*: the value of the variables Value Added, Aggregate Welfare and Output per worker is normalized to 1 in the baseline equilibrium.

Given the large extent of labor reallocation taking place in our policy experiments, it is interesting to decompose the overall change of the aggregate variables into a component that relates to the change in the firms' policy function (*behavioural effect*), and a component that reflect the change in weights of different types of firms (*compositional effect*). Formally, an aggregate variable X corresponds to a weighted average of the firm-specific variable $x(i)$, where i denotes a specific firm:

$$X = \int x(i)\, \tilde{s}(i) di, \tag{40}$$

where $\tilde{s}(i)$ is the firm-specific weight according to the aggregation reported in Appendix B.7. As a consequence, the change in the variable X can be decomposed as follows:

$$\Delta X \simeq \underbrace{\int \Delta x(i)\, \tilde{s}(i) di}_{\text{Behavioural effect}} + \underbrace{\int x(i)\, \Delta\tilde{s}(i) di}_{\text{Compositional effect}} . \tag{41}$$

Table 6 reports the results of such decomposition for the most important variables. First, we confirm that the wage effects are brought about by both higher posted wages (that explains about 60% of the overall variation) and reallocation towards high-pay firms. Similarly, the increase in posted wages contributes to more than 80% of the reduction in wage dispersion. For most of the other variables – with the notable exception of the markup – the compositional effect works against the behavioural effect. For instance, a large chunk of the increase in the firm-specific markdowns (hence, of their labor shares) is undone by reallocation towards larger, low-markdown firms. Indeed, in our model economy both markups and inverse markdowns (proxies of market power) grow with firm size (Figure D.17). Finally, the markup is pushed up by both an increase in the firms' markup policy, triggered by the larger equilibrium market shares, and by reallocation towards high-pay, high-markup firms. Overall, both components are relevant, with a split of about 33-66%.

We now explore to what extent the firms' reaction varies with their size. Indeed, as it is intuitive, the impact of MW reforms is typically larger for relatively small, low-pay firms, because they are directly constrained by the MW rise. Figure 12 plots the distribution of profits and labor costs along the firm size distribution. Increasing market power indexes command a decreasing wage bill as a share of value added. In fact, we find that the average labor share is hump-shaped in firm size, reflecting the non-monotonic pattern of markdowns (panel a of the Figure). After the large MW reform, an increase in the wage bill share becomes visible for smaller firms. This reflects both the direct effects of the reform, i.e. pay rises that are needed to meet the MW, as well as further increases triggered by an increase in *local* competition. The increase in the wage bill directly erodes profits in the labor market, i.e. the red area π_ψ, pushing up the markdown. Conversely, the effect on profits in the product market, i.e. the blue area π_μ, is more muted.

Finally, we study the distributional impact of the reforms on the different worker types. The effects are heterogeneous mainly because MW rises affect first and foremost

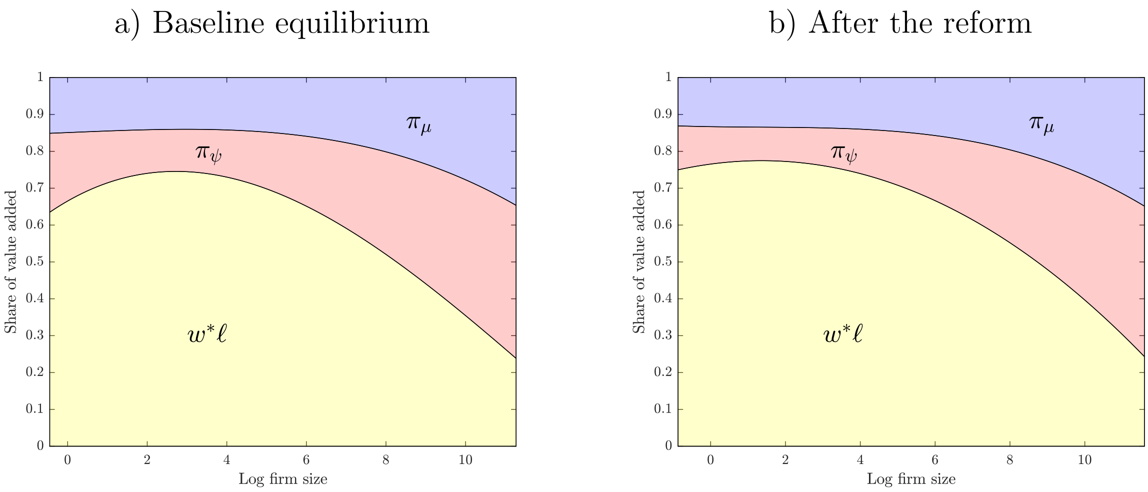
Table 6: Behavior vs. selection: decomposition of main aggregate effects

Variable	Overall change (log points)	Due to policy change (perc.)	Due to reallocation (perc.)
Panel a. Small reform (.68 Kaitz index)			
Average wage	10.610	64.5 %	35.5 %
Average firm size	-10.626	116.2 %	-16.2 %
Average vacancies	-22.387	103.4 %	-3.4 %
Log wage variance	-37.509	82.6 %	17.4 %
Labor share	1.298	221.8 %	-121.8 %
Average markup	0.101	33.3 %	66.7 %
Average markdown	3.077	165.3 %	-65.3 %
Average market power index	-2.976	169.8 %	-69.8 %
Panel b. Large reform (.92 Kaitz index)			
Average wage	22.732	58.4 %	41.6 %
Average firm size	-27.471	124.5 %	-24.5 %
Average vacancies	-57.411	104.1 %	-4.1 %
Log wage variance	-57.481	81.1 %	18.9 %
Labor share	1.607	398.5 %	-298.5 %
Average markup	0.358	32.2 %	67.8 %
Average markdown	5.007	224.3 %	-124.3 %
Average market power index	-4.649	239.0 %	-139.0 %

Source: Model. *Note*: the share of change due to behavioural effects is computed by using the new policy functions but keeping the distribution constant as in the baseline; the share of change due to reallocation is computed by using the new distribution, but keeping the policy functions as in the baseline.

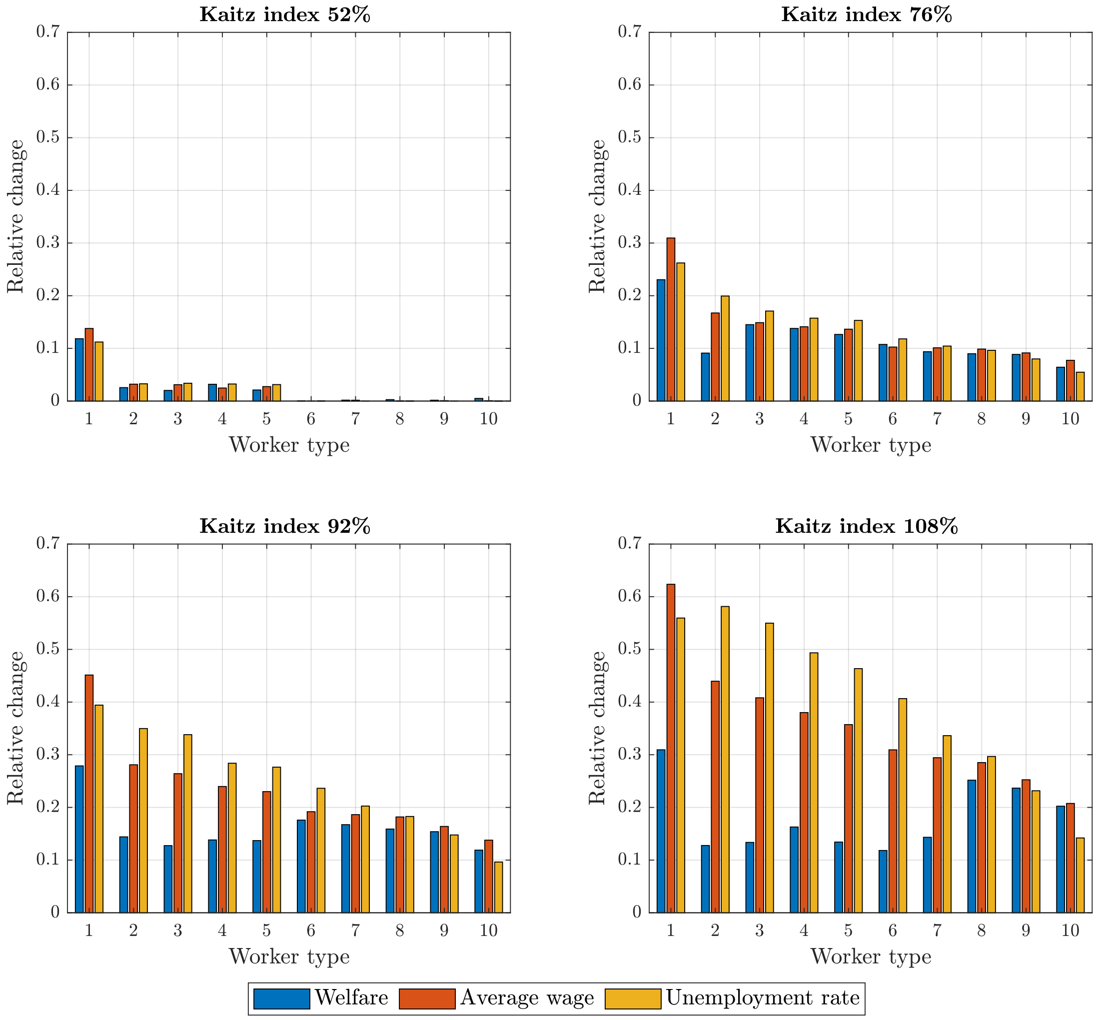
workers in the lowest percentiles of the wage distribution, which tend to be low-type. In particular, these workers experience the largest wage gains as well as the largest increase in unemployment. Moreover, the unequal distribution of profits across worker types adds to the heterogeneity of the effect. Figure 13 shows that wage and disemployment effects are monotonically decreasing in worker type. Given that wage effects initially dominate over employment losses, welfare gains tend to be larger for low and middle types in the case of small reforms, with the high types being almost unaffected. However, relatively high levels of MW generate disemployment effects that are more pronounced than wage gains for middle types, partially eroding their welfare gains. On top of this, the surge in profits generated by large reforms benefits mostly the high types, who are the main claimants of firms' profits. Therefore, the welfare gains of the largest reforms end up being U-shaped in worker type. These results remark the importance of considering the reaction of the profit share, as well as its distribution across worker types, to fully understand the distributional impact of MW reforms.

Figure 12: MW effects on wage bill and profits along the firm size distribution



Source: Model. *Note*: the two charts show the employment-weighted wage bill and profit shares (of value added) by log firm size, before and after the large reform. Profits from the product market (π_μ) are equal to the vertical distance between the price and marginal cost multiplied by firm size; profits from the labor market (π_ψ) are equal to the vertical distance between marginal cost and average cost multiplied by firm size.

Figure 13: Distributional impact of MW reforms



Source: Model. *Note*: the bars represent the change in the corresponding variable under different MW levels, by worker type.

5.4 The Role of Product Market Power

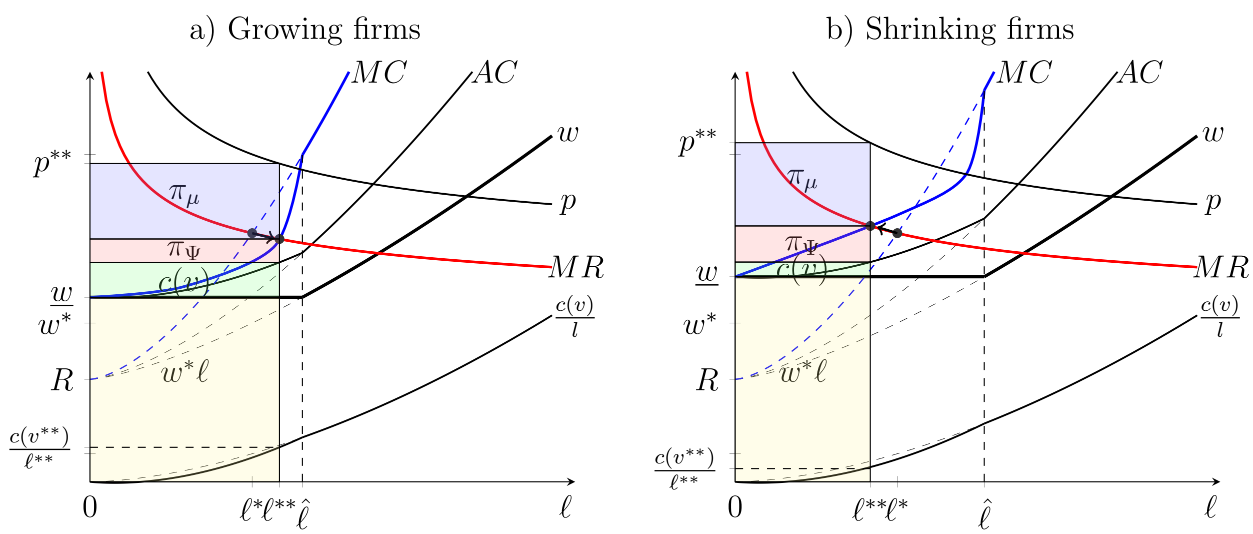
The presence of product market power is important for the equilibrium effects of the MW for several reasons. First, the extent and the distribution of price effects – including changes in equilibrium markups – directly reflect product market power. Second, the presence of a wedge between physical and revenue productivity may imply that (part of) the reallocation taking place towards high-paying firms does not drive aggregate physical TFP up. Third, the sheer amount of reallocation that is triggered by a MW reform may also depend on product market power itself, in that firm exit decisions and changes in their policy functions depend on their competitive environment in the output market. To see this, let us consider the maximization problem of a firm that is facing a MW reform. The introduction of a MW generates a floor below which offered wages cannot go down. If the level of the mandatory minimum wage is below the previous optimal wage, then the policy is not binding for the firm. As the MW rise becomes more substantial, then the MC curve is pushed towards the right relative to the previous equilibrium. This determines an *increase* in the optimal firm size (panel a of Figure 14). This happens because the incentives for the firm to remain smaller so to save on wages, that were previously constraining firm size, now vanish. As the MW rises further, at some point the MC curve will cut the MR curve on the left of the previous equilibrium, determining a *decrease* in the equilibrium firm size (panel b of Figure 14). For each level of minimum wage, the firm will remain active in the market if operating profits (the sum of the π_μ and the π_ψ areas) exceed overhead costs. Product market power affects the firm's response through the shape of the MR curve.[27] In turn, the shape of this curve crucially affects the extent of firm growth (shrinkage) following a MW rise. Importantly, it also affects the amount of profits that the firm will make after the size adjustment. To see this, consider two otherwise identical firms that face two different MR curves: one is an almost horizontal curve, while the other one is close to a vertical line. It can be shown that, for a given cost-push shock, the firm facing an almost vertical demand will shrink by less and that, for a given amount of downsizing, will retain a larger amount of profits. This implies that the extent of firm exit and labor reallocation triggered by a MW reform is importantly mediated by product market power.[28]

Above and beyond these partial-equilibrium considerations, our model economy allows us to uncover the general equilibrium interactions of product and labor market

[27] For instance, perfect competition implies a perfectly horizontal MR curve (and the absence of the π_μ area), while monopolistic competition would imply an isoelastic MR curve.

[28] Indeed, as shown in Figure D.18, firm exit, following the MW reform, is particularly high among low-markup firms. Intuitively, this is due to the fact that these firms enjoy a relatively low amount of profits in the baseline equilibrium. This makes them more susceptible to cost-push shocks such as an increase in the MW.

Figure 14: Partial equilibrium effects of binding MW reform



power in the context of MW reforms. To assess quantitatively the role played by product market power in our policy experiments, we simulate the same MW reforms in two observationally-equivalent economies to our baseline with endogenous markups differing by their product market structure[29]: in the first one, which we term MP economy, we model product markets as monopolistically competitive, implying constant and identical markups across firms; in the second one, which we term *markupless* economy, product markets are perfectly competitive, hence all markups are shut down. To do so, in the first set of alternative experiments we take the limit of our model economy as $\sigma \to \rho$, so that all firms face an identical demand function, and estimate the elasticity parameter again in order to match the same profit-to-labor share as before. In the second set of experiments, we take the limit of our model economy as $\sigma, \rho \to \infty$, implying an infinite demand elasticity and consequently markups that are exactly equal to 1. Importantly, we do *not* change any other parameters of the model economy, as the labor market block was estimated independently of the product market structure. The main conceptual difference between the baseline economy and the alternative ones is that the maps between z and $\tilde{z}$ (MRP) are necessarily different. In both of the alternative economies, this relationship becomes exactly linear. For instance, in the *markupless* economy there is no difference whatsoever between z and $\tilde{z}$. Hence, in this case the $\tilde{\Gamma}$ distributions, backed out from the wage distributions invertion, are interpreted directly as the distributions of physi-

[29]The two alternative economies are calibrated so as to produce the same wage distributions we observe in the data. This way, we can compare the impact of the MW, keeping its incidence in the wage distribution constant. Notice that this is a different exercise than removing product market power or making markups exogenous *in our estimated baseline economy.*

cal productivity. This is akin to the estimation of models such as Engbom and Moser (2021); Bontemps et al. (2000) and all other frameworks that neglect product market power. We follow this strategy because it guarantees to maintain a perfect fit of the wage distribution, that is key for the question at hand. Note that, in fact, we repeat the same experiments in alternative economies whose statistics are equal to the ones generated by the baseline economy.[30] Therefore, a direct comparison between the reaction of these alternative economies vis-à-vis the response of our baseline economy allows us to gauge the importance of product market power in generating equilibrium effects.

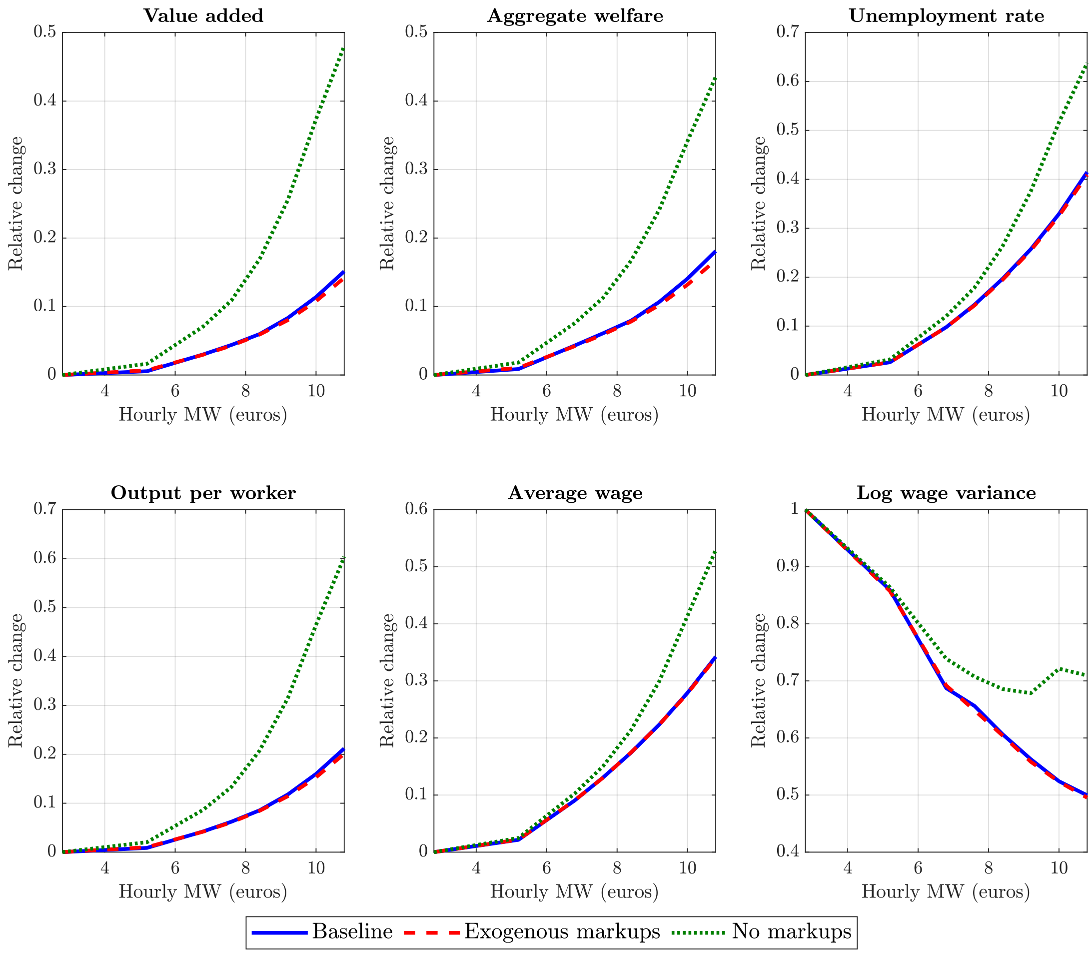
Aggregate variables. Figure 15 compares the effects of the whole array of MW reforms considered on the main aggregate variables across these alternative economies.[31] First, we note that results of the MP economy are remarkably similar to the ones of the baseline economy. This suggests that endogenous market power has little bearing on the quantitative response of the main aggregate variables. Turning to the *markupless* economy, it is immediately apparent that allowing for product market power is absolutely key for the quantification of MW reforms: despite being qualitatively similar, the quantitative response of the main aggregate variables would be importantly biased if one were to neglect product market power. For instance, considering the large reform (92% Kaitz index), through the lens of the *markupless* economy, the rise in unemployment is almost 50% higher. This is because, without the cushion of profits from product market power, many more firms exit the market because they could nor break even any more. At the same time, though, the increase in output is more than two-fold the one in the baseline, implying that the productivity gains from reallocation of the MW reform are largely overstated when not considering product market power. This is apparent from the rise in average firm size (larger by about 67% after the MW reform, against an increase of just 3.4% in the baseline economy; see Table 11). In turn, this also explains the less pronounced reduction in wage dispersion, as firms in the right part of the distribution increase their pay more aggressively than in the baseline. Differences in the magnitude of reallocation gains are intuitive, since the presence of product market power acts as a brake to firm size expansion, in fact determining decreasing returns in revenues. Therefore, removing product market power from the economy makes productive firms willing to grow much more than in the baseline. We conclude that allowing for product market power is essential to capture the overall adjustment of the economy to large MW reforms.

[30] Indeed, the alternative economies are observationally-equivalent to the baseline, except for the profit share of the *markupless* economy. The only structural differences among them lie in the distribution of physical productivity z and in the size of the fixed costs κ_j. However, these differences have little or no bearing on the baseline equilibrium allocation.

[31] Tables 10 and 11 in the Appendix replicate the same counterfactuals table as in the baseline economy.

Indeed, the concentration channel becomes particularly relevant only at high MW levels, whereas the predictions of the baseline and the ones of the *markupless* economy are virtually indistinguishable for small reforms. This explain why models that neglect the role of product market power, such as Engbom and Moser (2021), have still been able to successfully match the empirical evidence on relatively small MW reforms. We claim that such models would miss a very important channel, in the case of large reforms.

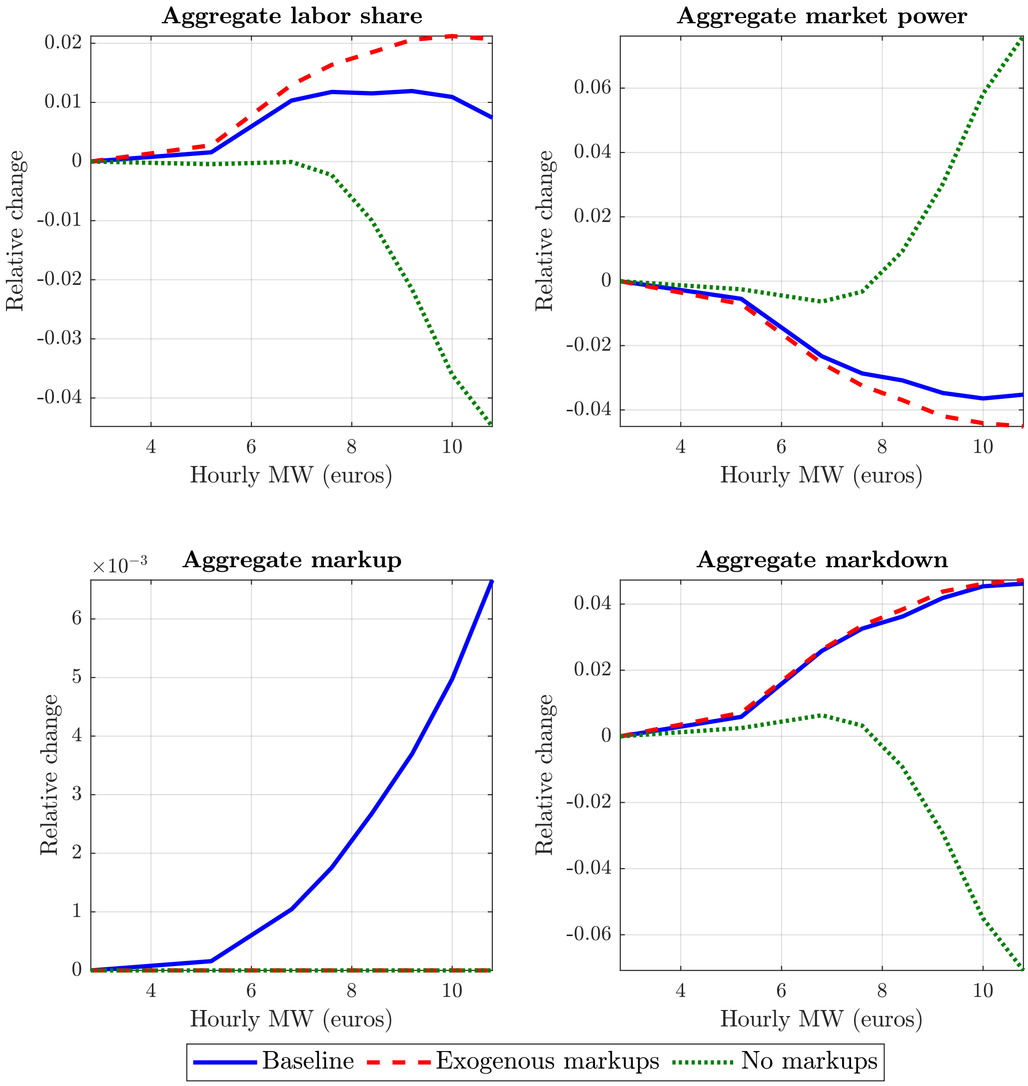
Figure 15: The Role of Product Market Power - Effects of MW reforms on main aggregate variables across economies



Source: Model. *Note*: the lines represent the value in the corresponding variable under different MW levels, across alternative economies.

Having established that product market power is a key component of the quantitative response of the main aggregate variables to MW reforms, we now study the dynamics of factor shares. Remarkably, Figure 16 shows that the dynamics of labor and profit shares are completely different across alternative economies. Indeed, both the MP and the *markupless* economy importantly miss the positive response of the markup, which is

Figure 16: The Role of Product Market Power - Effects of MW reforms on labor share and market power indexes across economies



Source: Model. *Note*: the lines represent the value in the corresponding variable under different MW levels, across alternative economies.

the result of the concentration channel. This has implications on the dynamics of the labor share, that grows faster in the MP economy relative to the baseline. Importantly, the market power index monotonically decreases in all reforms, highlighting the importance of the concentration channel for the hump-shaped response of the labor share to higher MWs. Instead, in the *markupless* economy the labor share stays approximately constant for the small reforms and decreases markedly in the larger ones. This is entirely driven by a composition effect due to the strong reallocation process that moves employment towards low-markdown firms[32]. We conclude that allowing for *endogenous* market power is absolutely key to estimate the dynamics of factor shares of GDP.

Distributional impact of MW reforms. Given that it affects the overall adjustment of the economy, product market power may also be important for the quantification of the distributional impact of MW reforms. For instance, the different dynamics of the profit share will benefit unequally the different worker types. In the baseline economy, welfare gains of MW reforms for low and middle types tend to be hump-shaped. This is because wage gains are initially more important than disemployment effects, but the balance between these two forces tends to revert for high MW levels. Figure D.20 compares the welfare effects of the different worker types across the alternative economies. In particular, it shows that the MP economy delivers welfare gains that are virtually identical to the ones of the baseline. Instead, in the *markupless* economy welfare gains are quite different from the baseline: on the one hand, the hump-shape of the gains at the bottom disappears, because wage gains are now always the dominant force relative to disemployment (see Figure D.21 and D.22); on the other hand, gains from large reforms are more concentrated at the top. We conclude that correctly modeling product market power is crucial also for studying the distributional impact of MW reforms.

6 Concluding remarks

In this paper we study, both theoretically and quantitatively, the role of product market power for the equilibrium effects of the minimum wage. In our policy experiments, conducted with a novel structural model combining frictional labor markets and oligopolistically-competitive product markets, we demonstrate that modelling product market power is crucial for the assessment of MW reforms. In particular, neglecting product market power would lead to overestimate the reallocation gains from the reform and to miss the endogenous response of markups, which has important implications for the dynamics of the labor share.

An interesting research avenue for future work concerns the determination of optimal minimum wages in the presence of product market power. Moreover, possible extensions of our framework are the addition of capital or of an input-output structure, which may add interesting elements of heterogeneity across industries.

[32]Such a composition effect is absent from the stylized model of Section 2 which assumes constant elasticity of labor supply across the firm's productivity distribution.

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A Model Appendix

A.1 Derivation of Steady-State Distributions

Let us start with Equation 21 from the main text:

$$G_j(w) = \frac{\lambda(\theta_j)F_j(w)}{\delta_j + s_j\lambda(\theta_j)(1 - F_j(w))}\frac{u_j}{e_j}.$$

After substituting the steady-state relationship $\frac{u_j}{e_j} = \frac{\delta_j}{\lambda(\theta_j)}$ and defining $\bar{F}_j(w) = 1 - F_j(w)$, we get

$$G_j(w) = \frac{\delta_j F_j(w)}{\delta_j + s_j\lambda(\theta_j)\bar{F}_j(w)} \implies \frac{G_j(w)}{F_j(w)} = \frac{\delta_j}{\delta_j + s_j\lambda(\theta_j)\bar{F}_j(w)}.$$

From the previous expression, it is clear that the G_j dominates in a first-order stochastic dominance sense the F_j distribution. Formally, $G_j(w) \leq F_j(w) \ \forall \, w$. It can also be noted that the parameter s_j regulates the distance between the G_j and the F_j distributions. In particular, as $s_j \to 0$ for a given δ_j, we note that $G_j(w) \to F_j(w)$. Conversely, the distance between the two distributions can be made arbitrarily large by setting large values of s_j. The previous expression can also be rearranged into

$$\begin{aligned}\delta_j + s_j\lambda(\theta_j)G_j(w) &= (\delta_j + s_j\lambda(\theta_j))\frac{G_j(w)}{F_j(w)} \\ &= \frac{\delta_j + s_j\lambda(\theta_j)}{\delta_j + s_j\lambda(\theta_j)\bar{F}_j(w)}\delta_j.\end{aligned}$$

Dividing both sides by δ_j and defining $\tilde{\lambda}_j = \frac{s_j\lambda(\theta_j)}{\delta_j}$, one can obtain

$$1 + \tilde{\lambda}_j G_j(w) = \frac{1 + \tilde{\lambda}_j}{1 + \tilde{\lambda}_j\bar{F}_j(w)}.$$

As already noted, the relationship between the two distributions is completely determined by $\tilde{\lambda}_j$, that regulates the relative speed at which workers climb the job ladder. Intuitively, if employed workers find job offers at a much faster rate than they lose their job (i.e. fall off the ladder), then more mass to higher values in the support of the wage offer distribution. Finally, one can also note that the difference between the two distributions also depends on the available wage offers that beat each level of wage, $\bar{F}_j(w)$. Intuitively, as $\bar{F}_j(w) \to 0$, then $G_j(w) \to F_j(w) = 1$, and conversely $\bar{F}_j(w) \to 1$, then $G_j(w) \to F_j(w) = 0$, i.e. the two distributions need to coincide at the upper and lower point of the wage offer distribution.

A.2 Derivation of Labor Supply Equation

The evolution of the size $\ell_j(w,v)$ of a firm hiring from market j, posting a piece rate w and v vacancies is governed by the following differential equation:

$$\dot{\ell}_j(w,v) = v\, q(\theta_j)\left(\frac{u_j + s_j e_j G_j(w)}{S_j}\right) - \Big(\delta_j + s_j\lambda(\theta_j)(1-F_j(w))\Big)\ell_j(w,v),$$

where the first term represents the inflows, that is the product between the amount of vacancies, the meeting rate and the share of aggregate search effort that accepts the job offer w; instead, the second term represents the outflows, that is workers that either lose employment or find a better job opportunities and decide to leave the firm.

By evaluating the previous equation in steady-state, i.e. setting $\dot{\ell} = 0$, and using the fact that $q_j = \frac{\lambda(\theta_j)}{\theta_j} = \lambda(\theta_j)\frac{S_j}{V_j}$, one can derive

$$\ell_j(w,v) = \frac{v}{V_j}\,\frac{\lambda(\theta_j)(u_j + s_j e_j G_j(w))}{\delta_j + s_j\lambda(\theta_j)(1-F_j(w))},$$

that is the expression shown in the firms' problem in the main text. Using Equation 21 in the main text, one can substitute G_j away and obtain

$$\ell_j(w,v) = \frac{v}{V_j}\,\frac{u_j\,\lambda(\theta_j)(\delta_j + s_j\lambda(\theta_j))}{\big(\delta_j + s_j\lambda(\theta_j)(1-F_j(w))\big)^2}.$$

By using the steady-state expression for u_j and the definition of V_j, it is possible to further simplify the expression into

$$\ell_j(w,v) = v\,\frac{\delta_j\,\lambda(\theta_j)}{\big(\delta_j + s_j\lambda(\theta_j)(1-F_j(w))\big)^2}.$$

A.3 Derivation of Goods Demand Equation

Consider an household seeking to maximize a utility function that is linear in consumption:

$$U = C = \left(\int C_k^{\frac{\rho-1}{\rho}}\,dk\right)^{\frac{\rho}{\rho-1}}, \qquad \text{with} \quad C_k = \left(\sum_{i=1}^{N_k} c_{ik}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}.$$

Let Z_k denote sector-k expenditures and Z be total expenditures:

$$Z_k = \sum_i c_{ik}p_{ik}, \qquad\qquad Z = \sum_k\sum_i c_{ik}p_{ik}.$$

The Lagrangean associated to the household's problem is the following:

$$\mathcal{L} = \left(\int \left[\sum_{i=1}^{N_k} c_{ik}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}\frac{\rho-1}{\rho}} dk \right)^{\frac{\rho}{\rho-1}} - \gamma \left(\sum_k \sum_i c_{ik} p_{ik} - M \right),$$

where the last term represents the budget constraint, with γ being the Lagrange multiplier and M total income. We now take the ratio between the FOC with respect to two different varieties c_{ik} and c_{lk} of the same sector:

$$\frac{c_{ik}}{c_{lk}} = \left(\frac{p_{ik}}{p_{lk}} \right)^{-\sigma} \implies c_{ik} = \frac{p_{ik}^{-\sigma}}{\sum_{l=1}^{N_k} p_{lk}^{1-\sigma}} Z_k \implies c_{ik} = \left(\frac{p_{ik}}{P_k} \right)^{-\sigma} C_k, \tag{A.1}$$

where we have used the definition of Z_k and we have defined the ideal price index of sector k as $P_k = \left[\sum_{i=1}^{N_k} p_{ik}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$. Symilarly, we now take the ratio between the FOC with respect to two different varieties c_{ik} and c_{lm} of two different sectors:

$$\frac{c_{ik}}{c_{lm}} = \left(\frac{p_{ik}}{p_{lm}} \right)^{-\sigma} \left(\frac{C_m}{C_k} \right)^{\frac{\sigma}{\rho}-1}. \tag{A.2}$$

We can use Equation A.1 to substitute away prices and quantities of the single varieties to get

$$\frac{C_k}{C_m} = \left(\frac{P_k}{P_m} \right)^{-\rho} \implies C_k = \frac{P_k^{-\rho}}{\int P_{k'}^{1-\rho} dk'} Z \implies C_k = \left(\frac{P_k}{P} \right)^{-\rho} C, \tag{A.3}$$

where we have used the definition of Z and we have defined the ideal price of the aggregate good as $P = \left[\int P_k^{1-\rho} dk \right]^{\frac{1}{1-\rho}}$.

Putting together Equation A.1 and A.3, one obtains

$$c_{ik} = \left(\frac{p_{ik}}{P_k} \right)^{-\sigma} \left(\frac{P_k}{P} \right)^{-\rho} C \implies p_{ik} = c_{ik}^{-\frac{1}{\sigma}} C_k^{\frac{1}{\sigma}-\frac{1}{\rho}} C^{\frac{1}{\rho}} P,$$

where we have used again Equation A.3. The last expression corresponds to the constraint in the firm's problem, after imposing market clearing ($c_{ik} = y_{ik}$; $C_k = Y_k$; $C = Y$) and normalizing the aggregate price index P to 1.

A.4 Derivation of Reservation Wage

By setting $W_j(\underline{w}_j^{R,U}) = U_j$ and solving for $\underline{w}_j^{R,U}$, one gets

$$\underline{w}_j^{R,U} = b_j - \Pi_j + (\lambda(\theta_j) - s_j \lambda(\theta_j)) \int_{\underline{w}_j^{R,U}}^{\bar{w}_j} (W_j(w') - U_j)) \, dF_j(w').$$

Integrating by parts, one can simplify the integral:

$$\begin{aligned}\int_{\underline{w}_j^{R,U}}^{\bar{w}_j} (W_j(w') - U_j))\, dF_j(w') &= [W_j(w) - U_j]\, F_j(w)|_{\underline{w}_j^{R,U}}^{\bar{w}} - \int_{\underline{w}_j^{R,U}}^{\bar{w}} W_j'(w)\, F_j(w)\, dw \\ &= \int_{\underline{w}_j^{R,U}}^{\bar{w}} W_j'(w)\, dw - \int_{\underline{w}_j^{R,U}}^{\bar{w}} W_j'(w)\, F_j(w)\, dw \\ &= \int_{\underline{w}_j^{R,U}}^{\bar{w}} W_j'(w)\, (1 - F_j(w))\, dw.\end{aligned}$$

Let us now take the derivative of $W_j(w)$:

$$W_j'(w) = \frac{1}{r + \delta_j + s_j \lambda(\theta_j)(1 - F_j(w))}.$$

Combining this with the previous equation delivers the expression shown in the main text.

A.5 Key Equations for Firms' Problem

In this Section, we list all the key equations that compose the firm's problem. These are the equations that are plotted in Figure 5. For simplicity we omit the j and k subscripts. We start with the cost structure: TC represent total costs, MC marginal costs and AC average costs.

$$TC(\ell) = w(\ell)\, l + c(v(\ell)). \tag{A.4}$$

$$\begin{aligned} MC(\ell) &= w(\ell) + w'(\ell)\, l + c'(v(\ell))\, v'(\ell) \\ &= (1 + \epsilon^{w,\ell}) w(\ell) + c'(v(\ell))\, v'(\ell). \end{aligned} \tag{A.5}$$

$$AC(\ell) = w(\ell) + \frac{c(v(\ell))}{l}. \tag{A.6}$$

Equation A.4 simply states that firms face both wage and vacancy costs in our model. Interestingly, the marginal cost schedule (Equation A.5) reflects both the labour supply elasticity – which requires wage rises in order to expand the size – and the presence of vacancy costs. In particular, we also note that convex vacancy posting costs are *not* necessary to generate an increasing MC schedule, as long as either wages are increasing in ℓ or vacancies are convex in ℓ. Finally, the difference between AC and MC, which is a source of operating profits, is made of two different terms: the first one relates to the labor supply elasticity, whereas the second one is represented by inframarginal profits associated to vacancy costs.

On the revenue side, TR represent total revenues, MRP marginal revenues and AR average revenues.

$$
\begin{aligned}
TR(l,z) &= p(\ell)\, l\, z. && \text{(A.7)}\\
MRP(l,z) &= p'(\ell)\, l\, z + p(\ell)\, z \\
&= (1+\epsilon^{p,\ell})p(\ell)\, z. && \text{(A.8)}\\
AR(l,z) &= p(\ell)\, z. && \text{(A.9)}
\end{aligned}
$$

Revenues are simply given by the product between the price and the quantity produced (Equation A.7). The MRP schedule (Equation A.8), similarly to what we have seen with the MC, incorporates the elasticity of inverse demand, owing to the fact that households' preferences imply that the price needs to drop if the producer wants to increase the quantity sold. Finally, differences between AR and MRP, which is other source of operating profits, are uniquely driven by the (negative) price elasticity of product demand.

A.6 Derivation of Equilibrium System of Equations

We replicate the same steps of Engbom and Moser (2021). Starting from the Equation in the main text,

$$
F_j(w_j(\tilde{z})) = \frac{M}{V_j}\int_{\underline{z}_j}^{\tilde{z}} v(z')\, d\tilde{\Gamma}_j(z') \implies f_j(w_j(\tilde{z}))w_j'(\tilde{z}) = \frac{M}{V_j}v_j(\tilde{z})\gamma_j(\tilde{z}). \tag{A.10}
$$

If we define $h_j(\tilde{z}) = F_j(w_j(\tilde{z}))$, this implies that $f_j(w_j(\tilde{z})) = \frac{h_j'(\tilde{z})}{w_j'(\tilde{z})}$. Combining this with Equation A.10 delivers

$$
h_j'(\tilde{z}) = \frac{M}{V_j}v_j(\tilde{z})\gamma_j(\tilde{z}) \implies v_j(\tilde{z}) = \frac{V_j}{M}\frac{h_j'(\tilde{z})}{\gamma_j(\tilde{z})}. \tag{A.11}
$$

Replacing Equation A.10 and A.11 into the FOC's of the firms' problem yields the following system of equations:

$$
(v): \quad h_j'(\tilde{z}) = \frac{M}{V_j}\gamma_j(\tilde{z})\left(\frac{\tilde{z}-w_j(\tilde{z})}{\bar{c}_j}\frac{\delta_j\lambda(\theta_j)}{\theta_j\left[\delta_j + s_j\lambda(\theta_j)\left(1-h_j(\tilde{z})\right)\right]^2}\right)^{\frac{1}{\eta}}. \tag{A.12}
$$

$$
(w): \quad w_j'(\tilde{z}) = (\tilde{z}-w_j(\tilde{z}))\frac{2s\lambda(\theta_j)h_j'(\tilde{z})}{\delta_j + s_j\lambda(\theta_j)\left(1-h_j(\tilde{z})\right)}. \tag{A.13}
$$

This 2-differential equation system in the two functions $w_j(\tilde{z})$ and $h_j(\tilde{z})$ represents the equilibrium in the labor market and can be solved independently from the product market, provided the necessary boundary conditions. In our case, the boundary conditions are given by $\lim_{\tilde{z}\to\underline{\tilde{z}}_j} w_j(\tilde{z}) = \max\left\{\underline{w}_j^{R,U}, \frac{w^{min}}{a_j}\right\}$ and $\lim_{\tilde{z}\to\underline{\tilde{z}}_j} h_j(\tilde{z}) = 0$, where $\underline{\tilde{z}}_j$ is the lowest revenue productivity level among active firms in market j. The first condition states that the lowest productivity firm offers a piece rate that is the lowest possible (either the reservation wage or the minimum wage). Instead, the second condition simply states that the CDF of offered wages is equal to 0 at the lowest possible level of wage. Moreover, a necessary consistency condition is $\lim_{\tilde{z}\to\bar{\tilde{z}}_j} h_j(\tilde{z}) = 1$, where $\bar{\tilde{z}}_j$ is the highest level of revenue productivity among active firms. This guarantees that the total number of vacancies posted by firms corresponds to the aggregate V_j.

So far, the system of equations allows us to solve for the labor market equilibrium for a *given* distribution of $\tilde{z}$. Uncovering the rest of the equilibrium, making it an explicit function of z (physical productivity, the real structural determinant of heterogeneity across firms within markets), requires solving the following additional equations:

$$\tilde{z}_{k,j}(z_i) = (1+\epsilon_{ki}^{p,\ell})\, p_k(\ell_j(\tilde{z}_{k,j}(z_i)))\, z_i. \tag{A.14}$$

$$\epsilon_{ki}^{p,\ell} = -\frac{1}{\sigma}(1-\hat{s}_{ki}) - \frac{1}{\rho}\hat{s}_{ki}. \tag{A.15}$$

$$p_k(\ell_j(\tilde{z}_{k,j}(z_i))) = (a_j\, z_i\, \ell_j(\tilde{z}_{k,j}(z_i)))^{-\frac{1}{\sigma}}\, Y_k(\ell_j(\tilde{z}_{k,j}(z_i)))^{\frac{1}{\sigma}-\frac{1}{\rho}}\, Y^{\frac{1}{\rho}}. \tag{A.16}$$

$$Y_k(\ell_j(\tilde{z}_{k,j}(z_i))) = \left[\sum_{j\neq i}^{N_k} y_{kj}^{\frac{\sigma-1}{\sigma}} + (a_j\, z_i\, \ell_j(\tilde{z}_{k,j}(z_i)))^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}. \tag{A.17}$$

$$Y = \left[\int Y_k^{\frac{\rho-1}{\rho}}\, dk\right]^{\frac{\rho}{\rho-1}}. \tag{A.18}$$

$$\hat{s}_{ki} = \frac{p_{ki}\, y_{ki}}{\sum_{j=1}^{N_k} p_{kj}\, y_{kj}}. \tag{A.19}$$

Crucially, Equation A.14 provides the mapping between revenue productivity $\tilde{z}$ and physical productivity z. Note that this mapping will generally depend on both the labor market j and the product market k. The rest of the Equations guarantee the equilibrium in the product market.

B Estimation Appendix

B.1 Data description and sample selection

We leverage social security data drawn from INPS. Our dataset consists of the complete contribution histories of individuals who worked as employees in private-sector for at least one period in their life between 1990 and 2018. We use a random and representative 6.5% sample of this population. In this dataset, the unit of observation is an event that generated a contribution to the pension system. Hence, it contains all labor market events (such as contract activations and terminations) with some information on demographics (gender, age) and a large amount of information on the job, such as total yearly earnings, the number of days worked within the year, the type of contract (permanent or temporary), whether it is a full- or part-time job, and others. This allows us to derive complete job histories for the workers covered in the sample, as well as to distinguish their periods of employment and non-employment.[33] Crucially for our analysis, the dataset also contains firm identifiers, which allow us to estimate the AKM equation.

We select our sample by focusing on individuals aged 25-64. We do this to avoid capturing the latest phase of education in labor market careers. Importantly, we do *not* exclude women nor part-time workers from our sample. We claim that this is potentially important for our analysis: given these groups of workers are overall paid less than average, they therefore constitute a relevant share of the population directly affected by a minimum wage reform.

Finally, we end up with a sample of about 34 million yearly observations, covering 2,6 million distinct workers and 2,3 million distinct firms. Table 7 reports summary statistics of the main variables that we use in our analysis.

Table 7: Summary statistics of main variables

	Statistics			
	Mean	SD	Min	Max
Age	37.90	10.70	20	64
Female	0.37	0.48	0	1
Earnings (€)	13,735.99	12,024.65	65	70,075
Days worked	197.50	117.68	0	365
N	33,898,735			

Source: INPS matched employer-employee data (1990-2018).

B.2 AKM estimation

For each worker, we first select the dominant job spell within each year. We pick this by maintaining the contract with the highest level of earnings within the year. As a second

[33] Notice that in this sample we only observe periods of employment as employees in the private sector and we consider periods of non-employment also periods potentially spent working as self-employed or as employee in the public sector. Transitions from self employment (or public sector employment) to payroll private employment and vice versa are however very low, as estimated from the Italian Labor Force Survey.

criterion, for jobs with equal earnings, we pick the one in which the worker worked more days. We then compute average hourly wages by taking the ratio of yearly earnings and the imputed number of hours worked (obtained multiplying the number of days worked by 8 or 4, depending on whether the job is full or part-time). Finally, we estimate a classical AKM equation, that is a log-linear wage regression with worker and firm fixed effects:

$$\log w_{it} = \beta X_{i,t} + \alpha_i + \phi_j + \epsilon_{i,t}, \tag{B.1}$$

where $X_{i,t}$ represents a vector of time-varying controls, α_i's are the workers' fixed effects and ϕ_j's are the firms' fixed effects. We estimate Equation B.1 without controls, in order to be consistent with the model, where the only source of heterogeneity is a fixed unobserved productivity component. Importantly, for the AKM estimation we use the longest possible time span in our data, which is the period 1990-2018. It is important that we can estimate the wage equation on such a long period, as this allows us to minimize the risk of capturing temporary shocks to workers' careers. We replicate the same steps with our model-generated data, including all selection criteria.

B.3 Worker transitions

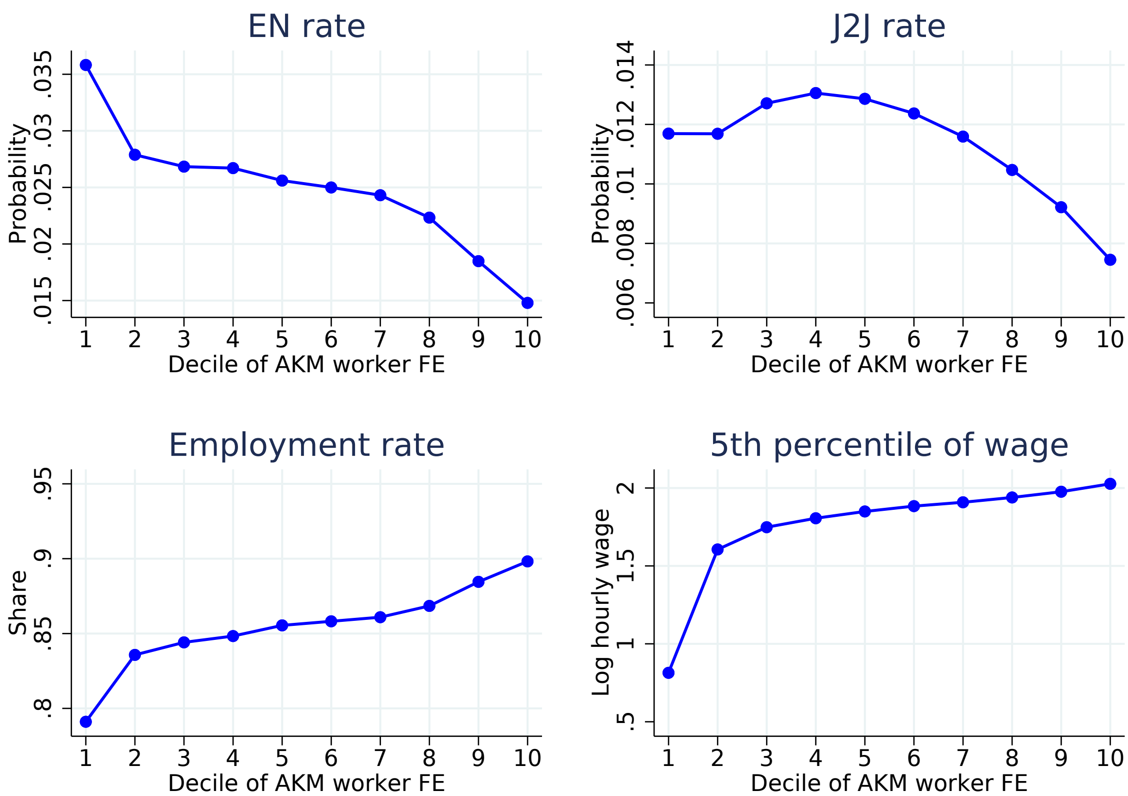
Having estimated worker fixed effects, we partition our sample in ten subsamples, each of which corresponds to a decile of the estimated AKM worker fixed effects distribution. We then turn to measure worker transitions separately for each subgroup. In particular, we measure the EN rate as the monthly probability of moving from employment to non-employment, and the job-to-job (J2J) rate as the monthly probability of switching employer without a period of unemployment. As explained in the main text, we do not estimate job-finding (NE) rates by worker type, and we instead target the overall unemployment rate in our estimation.[34] Figure B.1 shows the estimates of average worker transition probabilities, along with their average employment rates and the 5^{th} percentiles of their log wage distribution. Interestingly, the data show that the separation (EN) rate is strongly decreasing in worker productivity, ranging between 3.5% to about 1.5%. These are large differences, that drive most of the differentials in the employment rate across worker types, which rises from less than 79% to about 90% (panel c).[35] Regarding the job-to-job (J2J) transitions, we uncover a mild hump-shape profile, that starts at about 1.2% for the lowest type, peaks at about 1.3% for the 4^{th} decile and then declines to

[34]Estimating job-finding rates with this type of administrative data is bound to give unrealiable estimates of transition probabilities, due to the absence of any information on job search or on the willingness to accept a job.

[35]We have also investigated the profile of the NE rate in our data, finding that is only weakly increasing in worker type.

less than 0.8% for the last decile. Overall, differences in the J2J rate are less marked than differences in the EN rate. Finally, panel d of the Figure shows that the 5^{th} percentile of the log hourly wage distribution features a large positive gradient with worker productivity. In our model, this will imply that reservation wages are much higher for high-productivity types.

Figure B.1: Labor market statistics by worker type



Source: INPS matched employer-employee data (2016-2018). *Note*: Worker monthly transition probabilities (EN stands for employment to non-employment transition; J2J stands for transitions across employers), average employment rate and 5^{th} percentile of the log hourly wage distribution. The AKM equation is estimated on the period 1990-2018 (see Appendix B.2 for details).

B.4 Invertion of the Wage Distributions

Condition for admissibility. Let us start from the Equation

$$\gamma_j(\tilde{z}) = \frac{h'_j(\tilde{z})}{M}\frac{V_j}{v_j(\tilde{z})}. \tag{B.2}$$

From the definition of the h_j function, it follows that $h_j'(\tilde{z}) = w'(\tilde{z})\, f(w(\tilde{z}))$. Let us first characterize the first term $w_j'(\tilde{z})$. If we $K(\tilde{z})$ denote the wage policy function ($K_j(\tilde{z}) = w(\tilde{z})$), then using the FOC for the wage we can write

$$K_j^{-1}(w) = w + \frac{\delta_j + s_j\lambda(\theta_j)(1 - F_j(w))}{2s_j\lambda(\theta_j)f_j(w)}.$$

Using the derivations in Appendix A.1, we can rewrite this as a function of the observed wage distribution G_j and its density g_j:

$$K_j^{-1}(w) = w + \frac{u_j + s_j(1-u_j)G_j(w)}{2s_j(1-u_j)g_j(w)},$$

where we also have used steady-state relationships for u_j. Taking the derivative of this expression yields

$$\left(K_j^{-1}\right)'(w) = \frac{3s_j(1-u_j)g_j^2(w) - g_j'(w)\left[u_j + s_j(1-u_j)G_j(w)\right]}{2s_j(1-u_j)g_j^2(w)}.$$

Let us now note that $w_j'(\tilde{z}) = K_j'\left[K_j^{-1}(w)\right] = \frac{1}{\left(K_j^{-1}\right)'(w)}$. Using this fact, along with the previously found expression for the derivative of K_j^{-1} and expressing again f_j as a function of g_j and G_j, one derives the following expression for $h_j'(\tilde{z})$:

$$\begin{aligned} h_j'(\tilde{z}) &= \frac{2s_j(1-u_j)g_j^2(w)}{3s_j(1-u_j)g_j^2(w) - g_j'(w)\left[u_j + s_j(1-u_j)G_j(w)\right]} \frac{(\delta_j + s_j\lambda(\theta_j))(1-u_j)u_j g_j(w)}{\lambda(\theta_j)\left[u_j + s_j(1-u_j)G_j(w)\right]^2} \\ &= \frac{2s_j u_j(\delta_j + s_j\lambda(\theta_j))(1-u_j)^2\, g_j^3(w)}{3s_j\lambda(\theta_j)(1-u_j)g_j^2(w)\left[u_j + s_j(1-u_j)G_j(w)\right]^2 - \lambda(\theta_j)g_j'(w)\left[u_j + s_j(1-u_j)G_j(w)\right]^3}. \end{aligned} \tag{B.3}$$

Turning back to Equation B.2, one can notice that $\gamma_j(\tilde{z}) \geq 0 \iff h_j'(\tilde{z}) \geq 0$, provided that $v_j(\tilde{z}) > 0$. Inspection of the FOC for the vacancies reveals that, in equilibrium, posted vacancies are always strictly positive:

$$v_j(\tilde{z}) = \left[\frac{\tilde{z} - w_j(\tilde{z})}{\bar{c}_j} \frac{\delta_j\lambda(\theta_j)}{\theta_j\left[\delta_j + s_j\lambda(\theta_j)(1 - h_j(\tilde{z}))\right]^2}\right]^{\frac{1}{\eta}}.$$

Vacancies are positive as long as the posted wage piece rate is below the firm's marginal product revenue, which must hold in equilibrium (otherwise firms are making a loss). This implies that in order to have $\gamma_j(\tilde{z}) \geq 0$, we need Equation B.3 to be non-negative, which in turn requires its denominator to be non-negative:

$$3s_j(1-u_j)g_j^2(w) \geq g_j'(w)\left(u_j + s_j(1-u_j)G_j(w)\right), \tag{B.4}$$

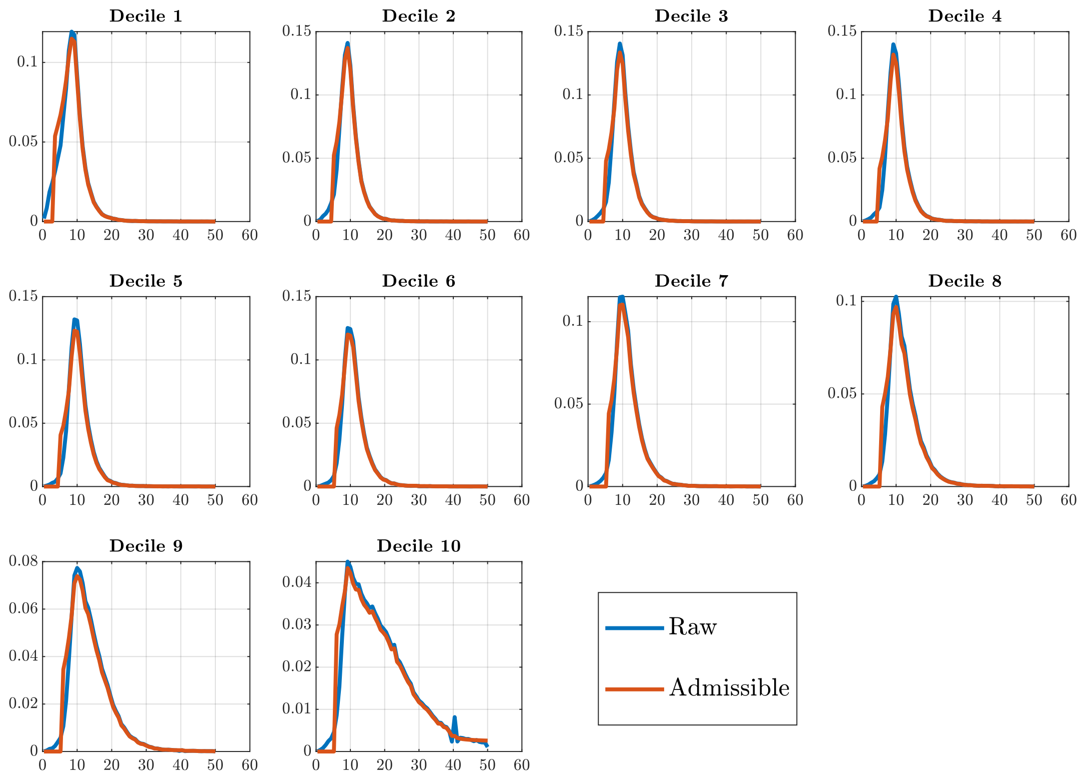
which corresponds to the expression reported in the main text.

Implementation. Before operating the invertion, that is applying Equation B.2, we need to ensure that Equation B.4 is verified in our data. For each worker type j identified in our data, i.e. for each decile of the AKM worker fixed effects distribution, we check the condition, and find that are a few points of the empirical wage distributions for which this condition is not met. Essentially, the condition fails when the wage density grows *too quickly*, which in some cases happens in our data in the left part of the distributions. We work around this by applying the simple following algorithm. Let $G_j^D(w)$ be the discretized version of our wage distributions, that takes values on grid points $[w_1, w_2, ...w_N]$. We proceed as follows:

1. We identify the first grid point i^Y for which the admissibility condition holds, in the left part of the distribution.
2. Starting from w_1, we move mass from the lowest grid points to the $i^Y - 2$ grid point, until the condition for $i^Y - 1$ is met. If during the process the mass of w_1 runs out, then we move to w_2.
3. When the condition for $i^Y - 1$ is met, then we turn to move mass towards $i^Y - 3$.
4. We stop when the first grid point for which the admissibility condition holds is the second one with non-zero mass.
5. At the end of this, we check again the condition over the whole distribution. For all points for which this is not verified, we progressively add mass to the previous grid points, removing it from all other points of the distribution.

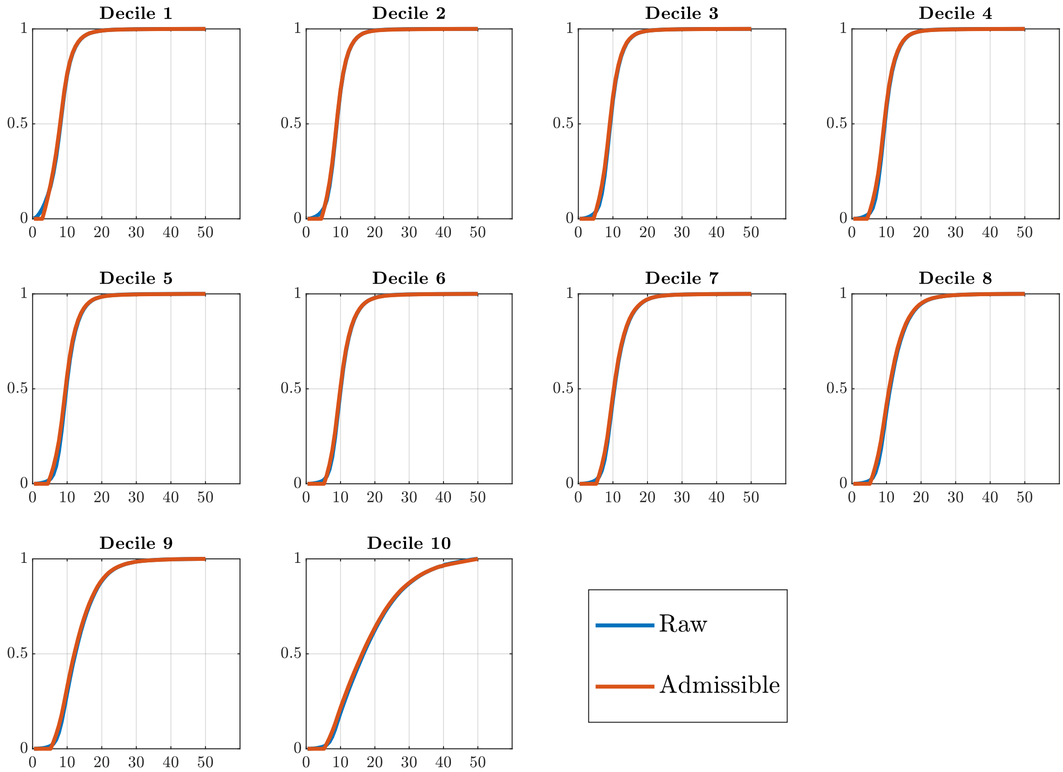
In fact, the main adjustment happens to take place in the left part of the distributions, where rapidly growing density functions cannot be generated by the model. However, as shown in Figure B.2, the distance between the empirical wage distributions and the ones that the model can generate is overall very small. In particular, these differences appear virtually irrelevant for the cumulative distribution functions, as shown in Figure B.3. Hence, we claim that the failure of the admissibility conditions for some data points does not represent a major issue for our analysis.

Figure B.2: Effects of the adjustment of the wage distribution (PDF) by worker type



Source: INPS matched employer-employee data (2016-2018) and own calculations. *Note*: the blue lines represent the density of hourly wage by worker AKM fixed effects decile. The AKM equation is estimated on the period 1990-2018 (see Appendix B.2 for details). The red lines represent the *admissible* (i.e. exactly replicable by the model) wage density function, by worker type.

Figure B.3: Effects of the adjustment of the wage distribution (CDF) by worker type



Source: INPS matched employer-employee data (2016-2018) and own calculations. *Note*: the blue lines represent the distribution (CDF) of hourly wage by worker AKM fixed effects decile. The AKM equation is estimated on the period 1990-2018 (see Appendix B.2 for details). The red lines represent the *admissible* (i.e. exactly replicable by the model) wage distribution (CDF) function, by worker type.

B.5 Firm assignment to product markets

We identify the sectoral product markets in our model with 4-digit sectors in the data. Our social security data allow us to observe in which sector workers are employed at a more aggregated level, namely at 1-digit. In what follows we describe how to make use of such piece of information to discipline firm assignment to product markets. Henceforth, we refer to 4-digit sectors simply as *sectors* and to 1-digit sectors as *industries*. Industries observed in the data correspond to a collection of sectors in the model. Upon inverting the observed industry- and worker-type-specific wage distributions according to the procedure described in Appendix B.4, we derive labor-market-specific MRP distributions for each industry. We make use of SBS data to compute the joint distribution of market structure (i.e., number of firms per sector) and employment share within each actual industry (source: Istat data). For each industry, we take such a joint distribution as data generating process and sample *(market structure, employment share)* pairs from it until the sum of the sampled market structures equals the number of firms populating the industry (which is fixed from the previous estimation stage). We exploit the correlation structure between sectoral market structure and employment share to discipline the assignment of single firms (MRP/employment draws) to sectors. Specifically, we define the ratio between sectoral market structure and total number of firms at the (industry x labor market) level as firm share and compute an *employment concentration index* ι for each sector as the ratio between its employment share and firm share. Since firm employment is increasing in MRP, the employment concentration index is informative of the average MRP of firms in the sector relative to the average MRP of firms in the industry. The more dispersed employment concentration indexes, the farther from random assignment from their industry-specific distribution the actual MRP levels are. Despite being helpful to replicate firm selection patterns into sectors, the employment concentration index is not informative of the within-sector heterogeneity of employment (MRP) across firms. Therefore, we complement it with a measure of employment dispersion within sectors, namely the weighted standard deviation of log value added across sectors. We define a parametric *sampling function* $\phi(\iota; \Sigma, \Theta) : (0, \infty) \to [0, 1]$ which maps the sectoral employment concentration index to a subsample of the industrial MRP distribution to draw from. Specifically, the location Σ of the subsample is informed by the employment concentration index (how far from random assignment should the sampling be?), the scale Θ by the standard deviation of employment (how dispersed should the MRP draws be?). We partition the industrial MRP distribution in quartiles and assign the location of the subsample to them according to the order of magnitude of the employment concentration index (e.g., an employment concentration index of 1 maps into the industrial average; an index of 10 into the third quartile, and so on). Given that firms' value added depends on their markup policy, we identify the scale parameter, i.e., the width of the sampling window, jointly with the elasticities of demand via SMM. We finally check that the randomness in the specific draws from the joint distribution of market structure and employment share does not affect the optimized scale significantly. Taking stock, sectoral market structures are drawn from their empirical industry-specific distribution. Firm assignment to sectoral markets is disciplined by targeting the correlation between market structure and employment shares at industry level and the empirical weighted standard deviation of log value added across sectors.

B.6 Algorithm to solve the model

We solve the model over 10 grid points for worker types and 72 grid points for the MRP ($\tilde{z}$). The number of $\tilde{z}$-grid points is set to replicate the number of wage-grid points used in the calibration. Similarly, the values of $\tilde{z}$-grid points are labor-market (worker-type) specific and correspond to a denser grid than that implied by the calibration, since wage-grid points with zero mass from the calibration are reallocated midway between the $\tilde{z}$-grid points that are farthest away from each other. Due to the strong connection between wages and MRP, we therefore allow for a maximum approximation error as high as the width of the wage bins chosen in the calibration.

The model is solved by guess and verify for the collection of MRP functions $\tilde{z}_{jk}(z)$. Although the same solution concept applies to a broader range of counterfactual experiments, this section will focus on an increase in the minimum wage.
To initialize the solution routine, it is convenient to use the collection of MRP functions from the calibrated model as initial guess. If the experiment being carried out involves a minimum wage higher than some $\tilde{z}$-grid point with a positive number of firms, one should adjust any such points upward until they all exceed the minimum wage. This preliminary adjustment amounts to conjecturing that all the firms that are currently active keep on producing in response to the minimum wage rise. In this respect, we leverage the theoretical insight that the presence of market power on both the labor market and the product market guarantees that all firms make positive gross profits for *any* minimum wage level. Since fixed operating costs do not affect firms' policy functions in any way, we can therefore find a proposed equilibrium for any set of active firms. To discipline the extensive margin of adjustment (firms' exit) in response to a minimum wage rise, we check ex-post whether the proposed equilibrium is sustainable, i.e., whether any firm is making negative profits at that equilibrium, and, if not, gradually removing firms from the market.

Upon initializing the solution routine as just described, we solve the model according to the $\tilde{z}$ guess. This is performed in two steps:

1. Solve for the equilibrium in each labor market $j = 1, \ldots, J$ as follows:

   – Construct a labor-market-specific $\tilde{z}$-guess by sorting all the distinct $\tilde{z}$-values pertaining to that labor market and compute the number of firms at each $\tilde{z}$-value as a share of the number of potential firms (which is set equal to the number of active firms in the calibrated model) to identify the discretized counterpart of $\gamma(\tilde{z})$.

   – Find the labor-market-specific equilibrium job finding rate by solving the system of differential equations (A.12): this can be performed efficiently by first identifying a lower bound and an upper bound to the equilibrium job finding rate corresponding to too much job creation, i.e., $\lim_{\tilde{z}\to\bar{\tilde{z}}} h_j(\tilde{z}) > 1$, and too little job creation, i.e., $\lim_{\tilde{z}\to\bar{\tilde{z}}} h_j(\tilde{z}) < 1$, respectively, and then applying a bisection algorithm within such bounds.

   – Compute the labor-market-specific policy functions $\{w_j(\tilde{z}), v_j(\tilde{z}), \ell_j(\tilde{z}), \Psi_j(\tilde{z})\}$ and assign them to each firm, i.e., to each combination of product market k and physical productivity populating that labor market.

2. Solve for the equilibrium in each product market $k = 1, \ldots, K$ as follows:

   – Compute sectoral, i.e., product-market specific, output by aggregating up firm-specific output policies $y_{jk}(z) = a_j z \ell_{jk}(z)$ according to (15), and total output by aggregating up sectoral outputs according to (14). For consistency with the assumption of continuum of measure one of sectors, we remove love-of-variety effects from the discretized CES aggregator, that is, total output reads:

$$Y^{\text{discr}} = K^{-\frac{1}{\rho-1}} \left(\sum_{k=1}^{K} Y_k^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}.$$

   – Compute firm-specific price policies by making use of the demand constraint (25), as well as sectoral price indexes by aggregating up firm-level prices.

   – Thanks to the oligopolistically-competitive product market structure and nested CES preferences, firm-level prices are sufficient for pinning down each firm's market share by

$$\hat{s}_{ki} = \frac{p_{ki}^{1-\sigma}}{\sum_{n=1}^{N_k} p_{kn}^{1-\sigma}}$$

   and markup policy by (35).

   – Compute firm-specific profits and implied $\tilde{z}$'s by making use of the MRP definition, i.e.,

$$\tilde{z}_{jk}(z) \equiv \frac{p_{jk}(z)}{\mu_{jk}(z)} z.$$

Upon solving the model conditional on the $\tilde{z}$ guess, we proceed by verifying and potentially updating such a guess. To do so, the solution algorithm goes through the following steps:

1. Impute implied $\tilde{z}$ values to their nearest $\tilde{z}$-grid point and compute the number of nonconverging $\tilde{z}$-grid points (*extensive margin error*), along with the difference between guessed and implied values (*intensive margin error*). Construct a *convergence indicator* as the normalized average wedge in the optimal pricing equation (32), which constitutes the most meaningful metric to assess the relevance of the approximation error.

2. If the extensive margin error is greater than zero, the model solution is stored as candidate approximate equilibrium. Then, the algorithm goes through a cycle of updates on the initial $\tilde{z}$ guess:

   – For each repetition of the updating cycle, the original $\tilde{z}$ guess is updated by assigning a weight $w \in [0, 0.025, 0.05, \ldots, 0.5]$ to the implied $\tilde{z}$ of the first/baseline scenario. The updating weight operates at the intensive margin if guessed and discretized implied $\tilde{z}$'s are more than one $\tilde{z}$-grid point apart from each other, i.e., the updated grid point is assigned the closest grid point to the convex combination between guessed and implied $\tilde{z}$'s. Otherwise, the updating weight operates at the extensive margin, meaning that a fraction w of nonconverging $\tilde{z}$-grid points is assigned their implied value, where the pecking order is pinned down by the respective ranking of the intensive margin errors sorted in decreasing order.

   – At the end of the updating cycle, the best $\tilde{z}$ guess in terms of convergence indicator is selected: if it corresponds to the baseline scenario, then it is picked as approximate equilibrium; if not, it replaces the current baseline scenario and a new updating cycle is initiated. In this way, we make sure to reach the best approximate equilibrium conditional on a common updating function across all nonconverging grid points.

3. If the extensive margin error is zero or an approximate equilibrium in the sense of 2. has been reached, the algorithm checks that no firm is making negative profits in the proposed equilibrium. If it is the case, the proposed equilibrium is sustainable and the model is solved. Otherwise, an extensive margin adjustment needs to be enacted:

– By adopting the equilibrium refinement device of Berry (1992), the firm making lowest profits is removed from the market. Since our model features a large number of product markets (formally, a continuum of them) and firms are atomistic in their labor market, the same allocation as the one-by-one exits obtains by removing the worst loss-making firms in more than one product market at the same time. We check that it is the case by adjusting nine-tenth of the product markets with some firm making negative profits at a time in our quantitative exercise.

The algorithm delivers a good approximation to the equilibrium by limiting the approximation error in the pricing FOC to an order of magnitude of -4.

B.7 Aggregation

In this section we describe how to compute aggregate statistics from our model economy at different level of aggregation.

Sector level.

$$P_kY_k = \sum_i p_iy_i \tag{B.5}$$

$$Y_k = \left(\sum_i y_i^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \tag{B.6}$$

$$P_k = \left(\sum_i p_i^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{B.7}$$

$$L_k = \sum_i \ell_i \tag{B.8}$$

$$w_k = \frac{\sum_i w_i\ell_i}{L_k} \tag{B.9}$$

$$v_k = \sum_i v_i \tag{B.10}$$

$$\mathcal{M}_k = \frac{\sum_i \mathcal{M}_iw_i\ell_i}{w_kL_k} \tag{B.11}$$

$$\mu_k = \frac{\sum_i \mu_iw_i\ell_i}{w_kL_k} \tag{B.12}$$

$$\Psi_k = \left(\frac{\sum_i \Psi_i^{-1}w_i\ell_i}{w_kL_k}\right)^{-1} \tag{B.13}$$

$$Z_k = \mathcal{M}_k\frac{w_k}{P_k} \tag{B.14}$$

$$a_k = \frac{Y_k}{Z_kL_k} \tag{B.15}$$

$$\Pi_k = P_kY_k - W_kL_k - a_kc_k(v_k) - N_k\kappa_k \tag{B.16}$$

$$LS_k = \frac{W_kL_k}{\Pi_k + W_kL_k} \tag{B.17}$$

where $W_k \equiv a_kw_k$ and $\Pi_k \equiv a_k\pi_k$. From 32 and B.5, we show that the model-consistent weighting factor to aggregate market power indexes is the wage bill. We notice that the sectoral market power index equals the ratio between sectoral markup and markdown plus their covariance term:

$$\mathcal{M}_k = \frac{\mu_k}{\Psi_k} + \mathbf{Cov}[\mu_k, \Psi_k^{-1}] \tag{B.18}$$

Hence, the more correlated labor and product market power are, the higher the sectoral market power index is.

Aggregate level.

$$PY = \int_0^1 P_k Y_k \, dk \tag{B.19}$$

$$Y_k = \left(\int_0^1 Y_k^{\frac{\rho-1}{\rho}} \, dk \right)^{\frac{\rho}{\rho-1}} \tag{B.20}$$

$$P = \left(\int_0^1 P_k^{1-\rho} \, dk \right)^{\frac{1}{1-\rho}} \tag{B.21}$$

$$L = \sum_0^1 L_k \, dk \tag{B.22}$$

$$w = \frac{\int_0^1 w_k L_k \, dk}{L} \tag{B.23}$$

$$v = \int_0^1 v_k \, dk \tag{B.24}$$

$$\mathcal{M} = \frac{\int_0^1 \mathcal{M}_k W_k L_k \, dk}{WL} \tag{B.25}$$

$$\mu = \frac{\int_0^1 \mu_k W_k L_k \, dk}{WL} \tag{B.26}$$

$$\Psi = \left(\frac{\int_0^1 \Psi_k^{-1} W_k L_k \, dk}{WL} \right)^{-1} \tag{B.27}$$

$$Z = \mathcal{M} \frac{W}{P} \tag{B.28}$$

$$a = \frac{Y}{ZL} \tag{B.29}$$

$$\Pi = PY - WL - ac(v) - N\kappa \tag{B.30}$$

$$LS = \frac{WL}{\Pi + WL} \tag{B.31}$$

B.8 Robustness: No Extensive Margin Adjustment

Table 8: Policy experiments, no fixed costs

Variable	Baseline	Small reform (.68 Kaitz index)	Large reform (.92 Kaitz index)
Panel a. Aggregate statistics			
Value added	1.000	1.034	1.098
Aggregate welfare	1.000	1.033	1.096
Unemployment rate	0.107	0.117	0.134
Output per worker	1.000	1.034	1.108
Average wage	11.032	12.000	13.445
Log wage variance	0.132	0.093	0.074
Average firm size	4.051	3.892	3.712
Panel b. Distributional statistics			
Labor share	0.649	0.656	0.660
Profit share	0.351	0.344	0.340
Profit share (product market)	0.149	0.149	0.151
Profit share (labor market)	0.194	0.187	0.180
Panel c. Market power statistics			
Average mpi	2.107	2.062	2.030
Average markup	1.122	1.124	1.127
Average markdown	0.536	0.549	0.560
Misallocation index (mpi std dev)	0.544	0.524	0.506
Panel d. Labor market transitions			
Job-finding rate	0.207	0.186	0.160
Job-to-job flow rate	0.013	0.013	0.012
Job-separation rate	0.025	0.025	0.025

Source: Model. *Note*: the value of the variables Value Added, Aggregate Welfare and Output per worker is normalized to 1 in the baseline equilibrium.

C Additional Tables

Table 9: The Effect of Minimum Wages on the Determinants of the Labor Share

	(1) Log avg wage	(2) Log size	(3) Log value added	(4) Log profits
Log wage floor	0.369***	0.948***	0.308***	-1.145***
	(0.010)	(0.021)	(0.032)	(0.059)
Log wage floor × HHI (4-digit)	-0.010	-1.700***	-0.329***	2.064***
	(0.010)	(0.022)	(0.033)	(0.060)
Time × Industry (2-digit) FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
N	6,155,191	6,158,901	5,774,132	4,915,300
R^2	0.932	0.988	0.978	0.952

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: CERVED (2005-2020), INPS and Istat data. *Note*: Linear regressions of log average wage, log firm size, log value added and log profits (EBITDA). Regression models in all columns also control for the industry-specific level of HHI.

Table 10: Policy experiments, monopolistic competition

Variable	Baseline	Small reform (.68 Kaitz index)	Large reform (.92 Kaitz index)
Panel a. Aggregate statistics			
Value added	1.000	1.044	1.105
Aggregate welfare	1.000	1.042	1.102
Unemployment rate	0.107	0.118	0.135
Output per worker	1.000	1.042	1.114
Average wage	11.032	12.035	13.498
Log wage variance	0.132	0.091	0.074
Average firm size	4.051	4.082	4.190
Panel b. Distributional statistics			
Labor share	0.650	0.658	0.663
Profit share	0.350	0.342	0.337
Profit share (product market)	0.170	0.168	0.166
Profit share (labor market)	0.180	0.174	0.171
Panel c. Market power statistics			
Average mpi	2.127	2.073	2.038
Average markup	1.140	1.140	1.140
Average markdown	0.536	0.550	0.560
Misallocation index (mpi std dev)	0.528	0.511	0.486
Panel d. Labor market transitions			
Job-finding rate	0.207	0.185	0.158
Job-to-job flow rate	0.013	0.013	0.012
Job-separation rate	0.025	0.025	0.025

Source: Model. *Note*: the value of the variables Value Added, Aggregate Welfare and Output per worker is normalized to 1 in the baseline equilibrium.

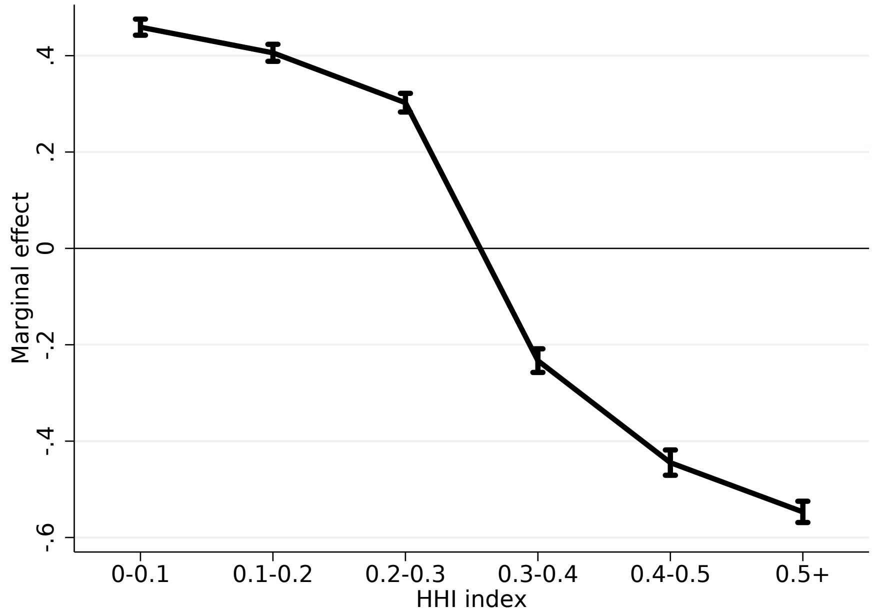
Table 11: Policy experiments, *markupless* economy

Variable	Baseline	Small reform (.68 Kaitz index)	Large reform (.92 Kaitz index)
Panel a. Aggregate statistics			
Value added	1.000	1.078	1.246
Aggregate welfare	1.000	1.076	1.242
Unemployment rate	0.107	0.120	0.148
Output per worker	1.000	1.087	1.315
Average wage	11.032	12.165	14.337
Log wage variance	0.132	0.098	0.090
Average firm size	4.051	4.422	6.776
Panel b. Distributional statistics			
Labor share	0.777	0.777	0.760
Profit share	0.223	0.223	0.240
Profit share (product market)	0.000	0.000	0.000
Profit share (labor market)	0.223	0.223	0.240
Panel c. Market power statistics			
Average mpi	1.865	1.853	1.922
Average markup	1.000	1.000	1.000
Average markdown	0.536	0.540	0.520
Misallocation index (mpi std dev)	0.463	0.462	0.453
Panel d. Labor market transitions			
Job-finding rate	0.207	0.181	0.141
Job-to-job flow rate	0.013	0.012	0.010
Job-separation rate	0.025	0.025	0.025

Source: Model. *Note*: the value of the variables Value Added, Aggregate Welfare and Output per worker is normalized to 1 in the baseline equilibrium.

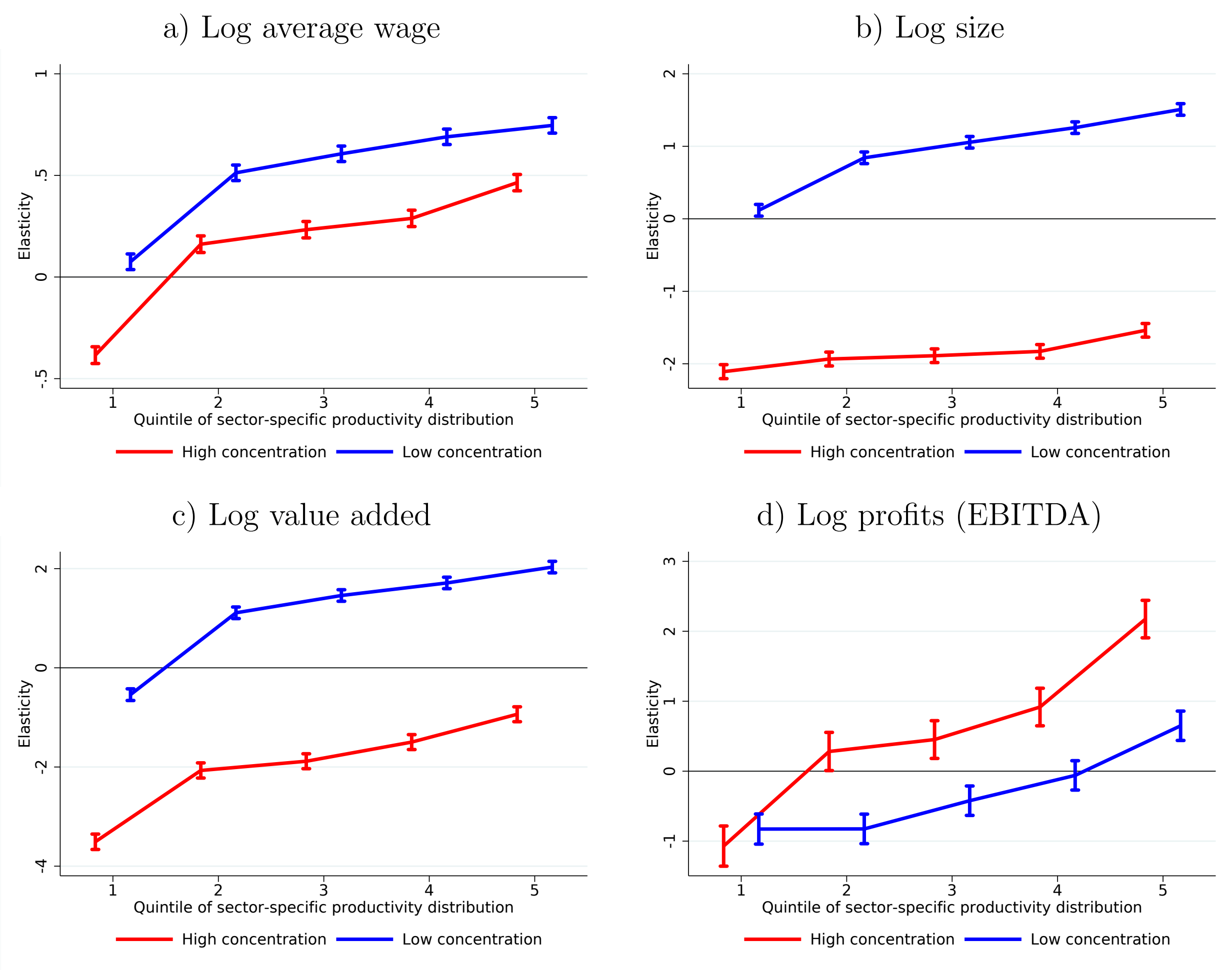
D Additional Figures

Figure D.1: The Effect of Minimum Wages on the Labor Share by HHI



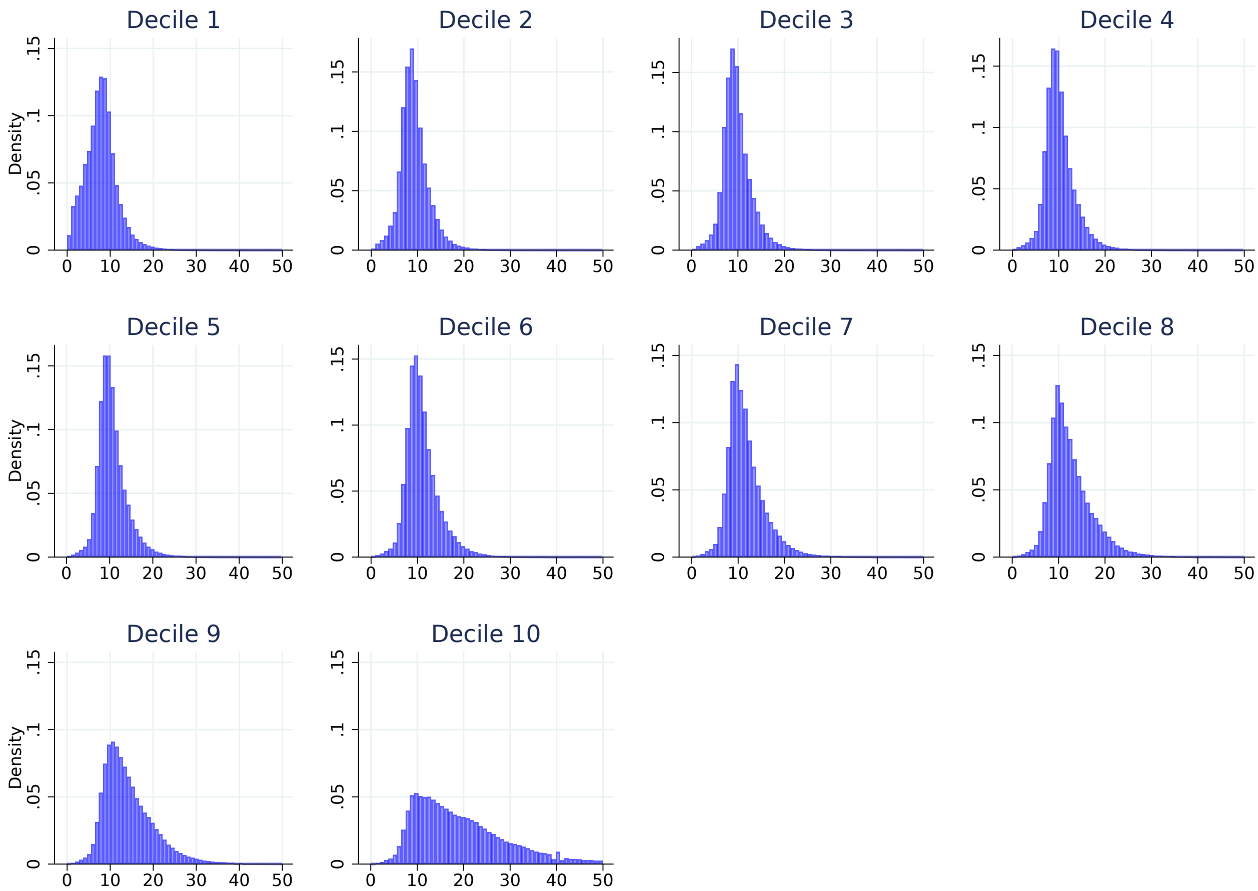
Source: CERVED (2005-2020), INPS and Istat data. *Note*: linear regressions of labor share (see Table 1 in the main text), defined as the ratio between total labor costs and value added; the graph plots the estimated coefficients of interaction term between the binned level of HHI and the natural logarithm of wage floor. All regression models also control for the industry-specific binned level of HHI.

Figure D.2: The Heterogeneous Effect of Minimum Wages on the Determinants of the Labor Share



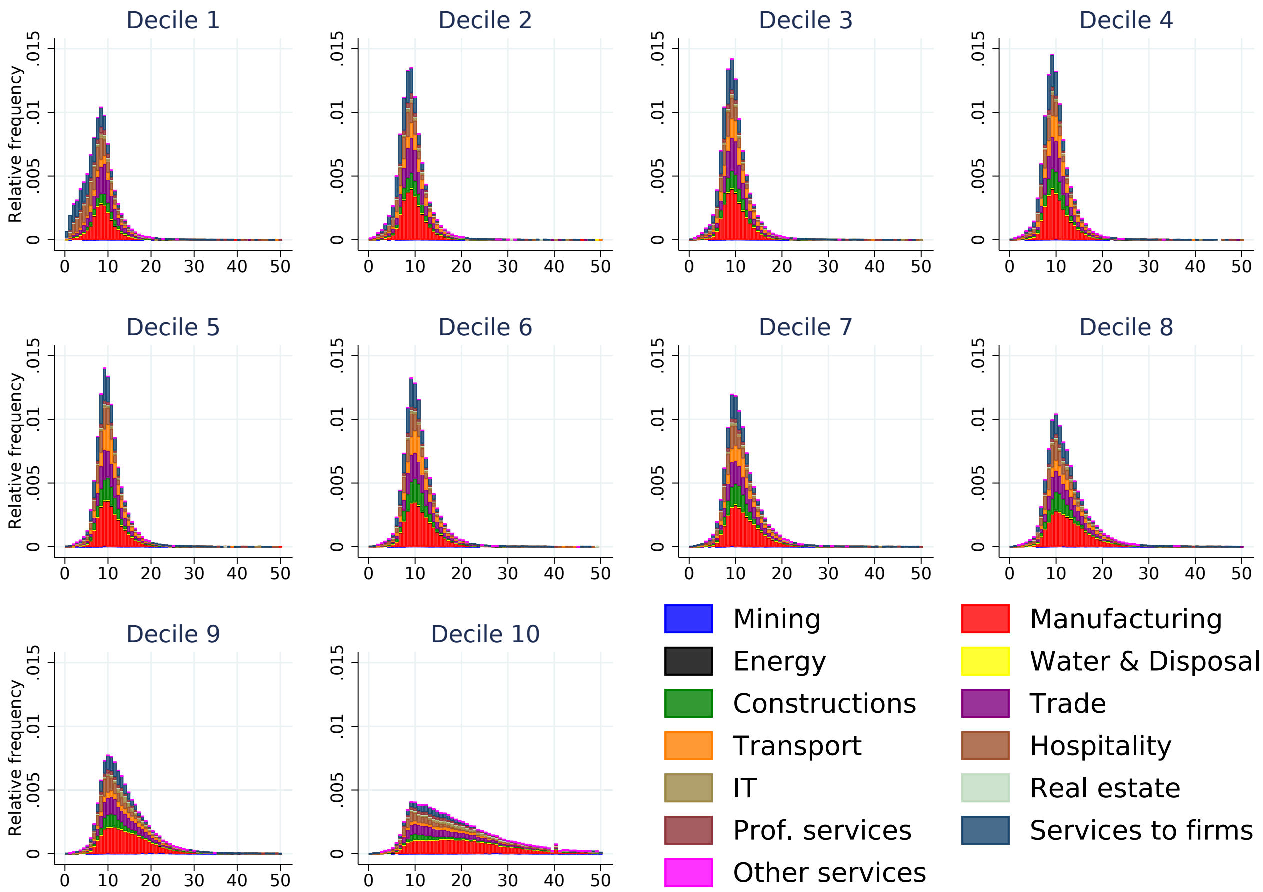
Source: CERVED (2005-2020), INPS and Istat data. *Note*: linear regressions of log average wage, log firm size, log value added and log profits (EBITDA). All panels plot the estimated coefficients of interaction terms between the quintile of the sector-specific productivity distributions and the natural logarithm of wage floor for separate regressions that include only industries above (or below) the weighted average of HHI.

Figure D.3: Wage distribution by worker type



Source: INPS matched employer-employee data (2016-2018). *Note*: Distributions of hourly wage by worker AKM fixed effects decile and industry. The AKM equation is estimated on the period 1990-2018 (see Appendix B.2 for details).

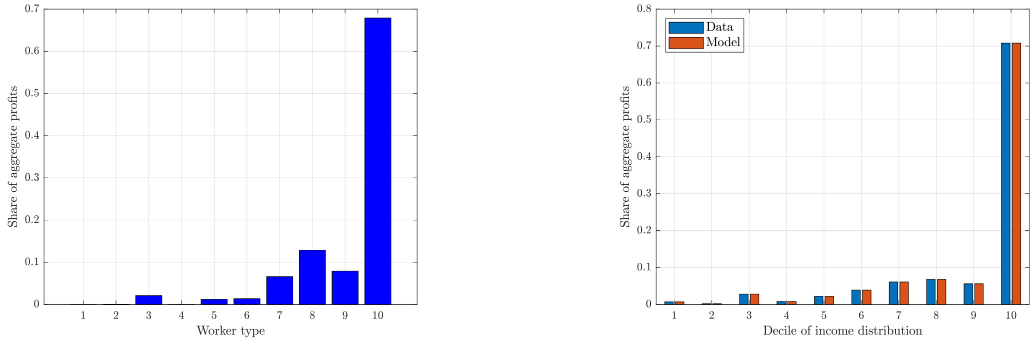
Figure D.4: Wage distribution by worker type and industry



Source: INPS matched employer-employee data (2016-2018). *Note*: Distributions of hourly wage by worker AKM fixed effects decile. The AKM equation is estimated on the period 1990-2018 (see Appendix B.2 for details).

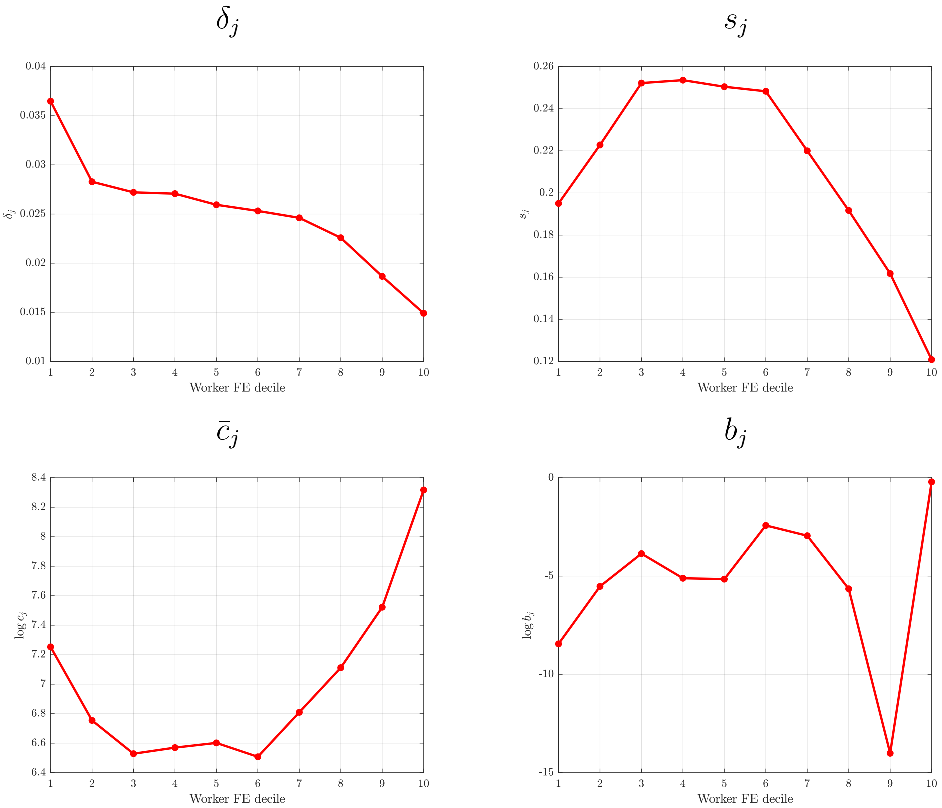
Figure D.5: Profits distribution

a) Across worker types (Π_j) b) Along the income distribution (model vs. data)



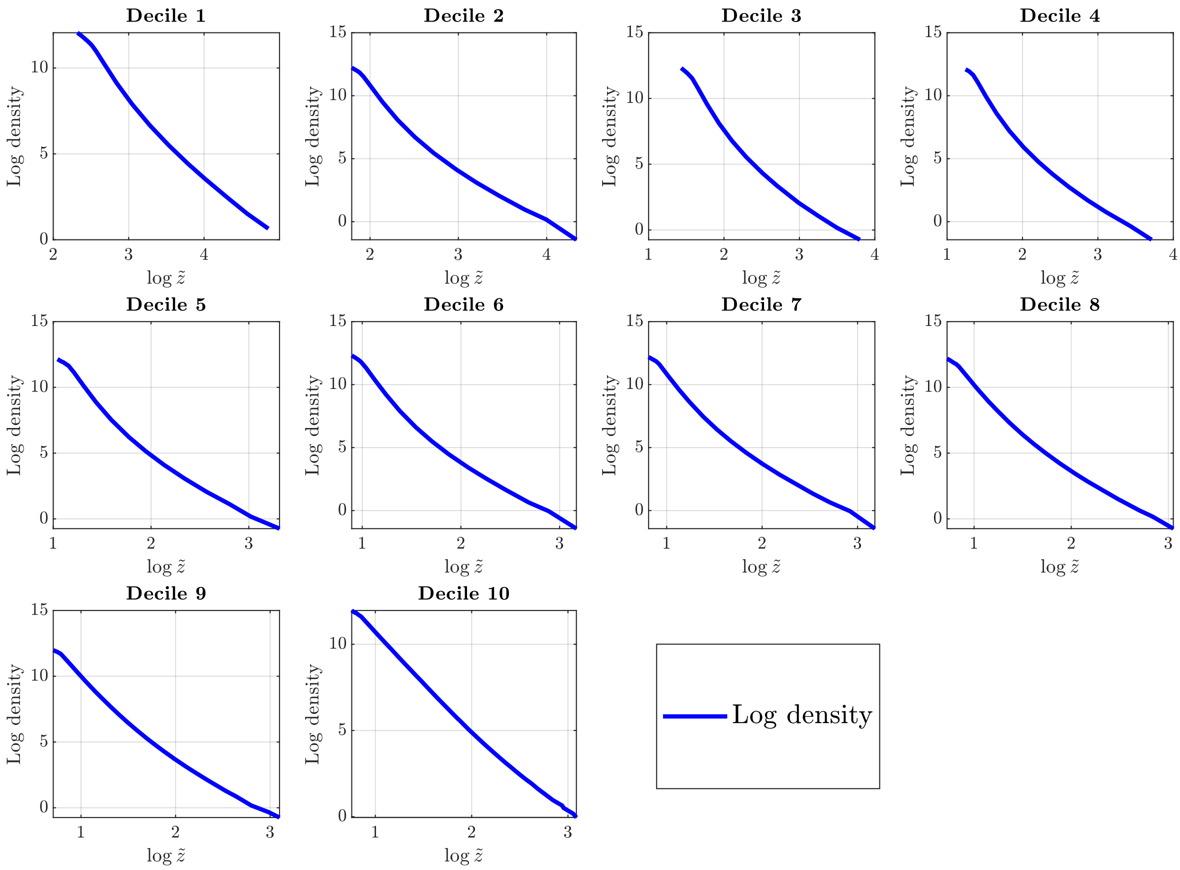
Source: Model. *Note*: panel a plots the estimates of the shares of aggregate profits accruing to each worker type; panel b plots the shares of aggregate profits accruing to each income decile (targets of the estimation), in the data and in the model.

Figure D.6: Labor market parameter estimates by worker type



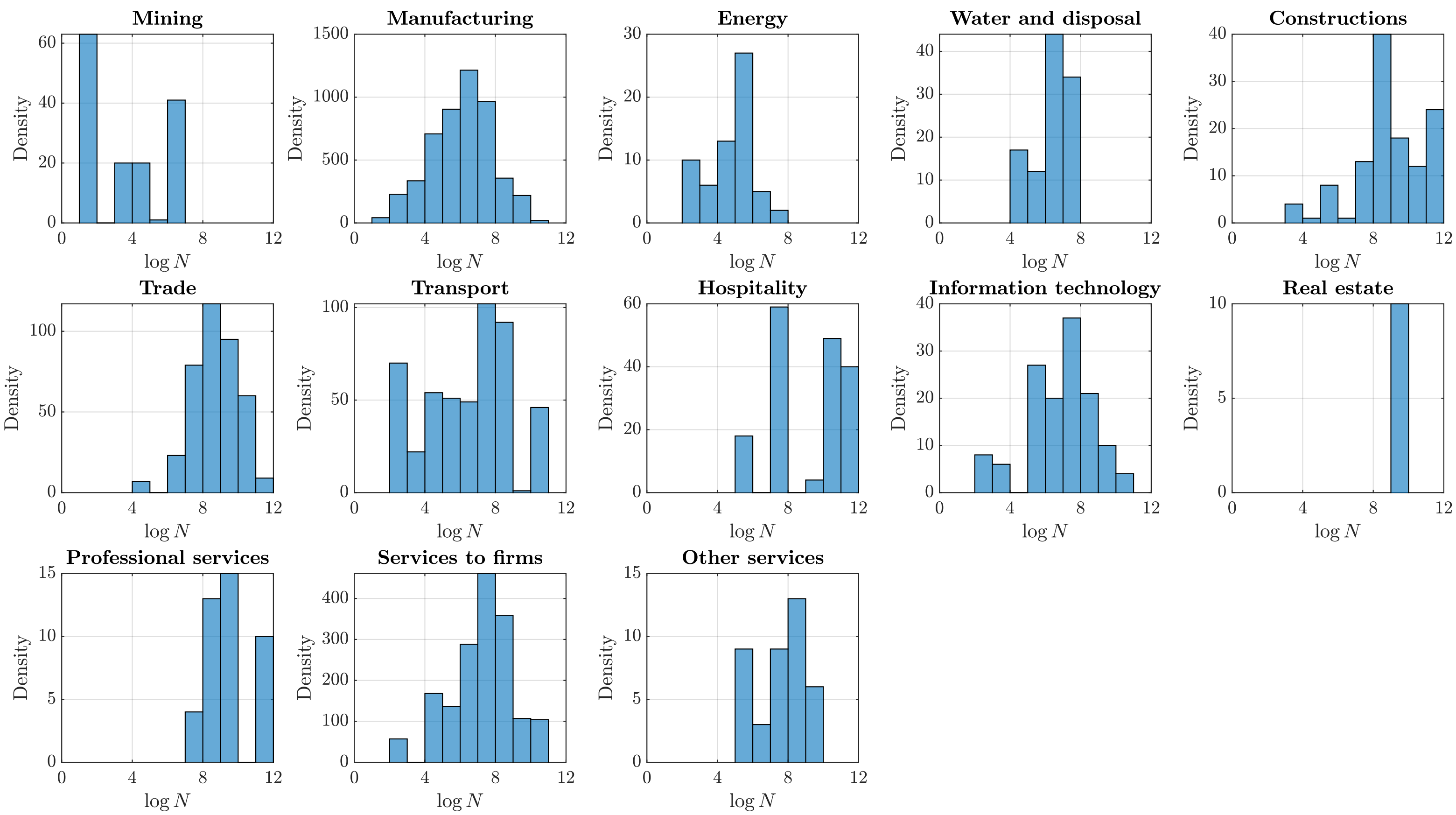
Source: Model. *Note*: the charts plot the estimates of the key model parameters that vary across labor markets, each of which corresponds to a worker type identified as a decile of the AKM worker fixed effects distribution.

Figure D.7: Marginal revenue productivity distribution by labor market



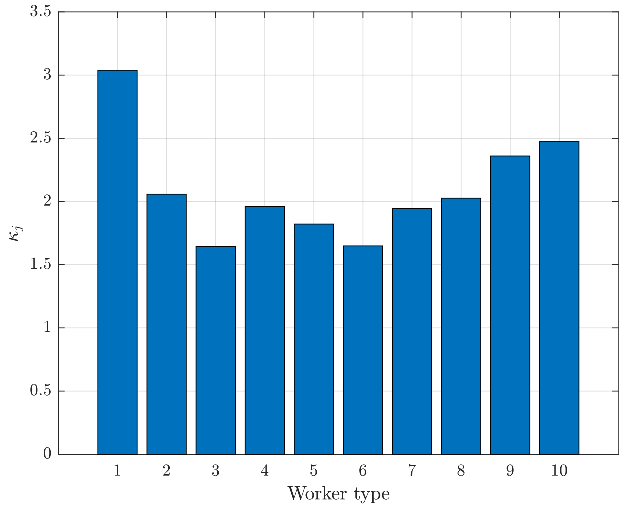
Source: Model. *Note*: the charts plot the estimates of the marginal revenue productivity distribution across labor markets, each of which corresponds to a worker type identified as a decile of the AKM worker fixed effects distribution.

Figure D.8: Product markets size by industry



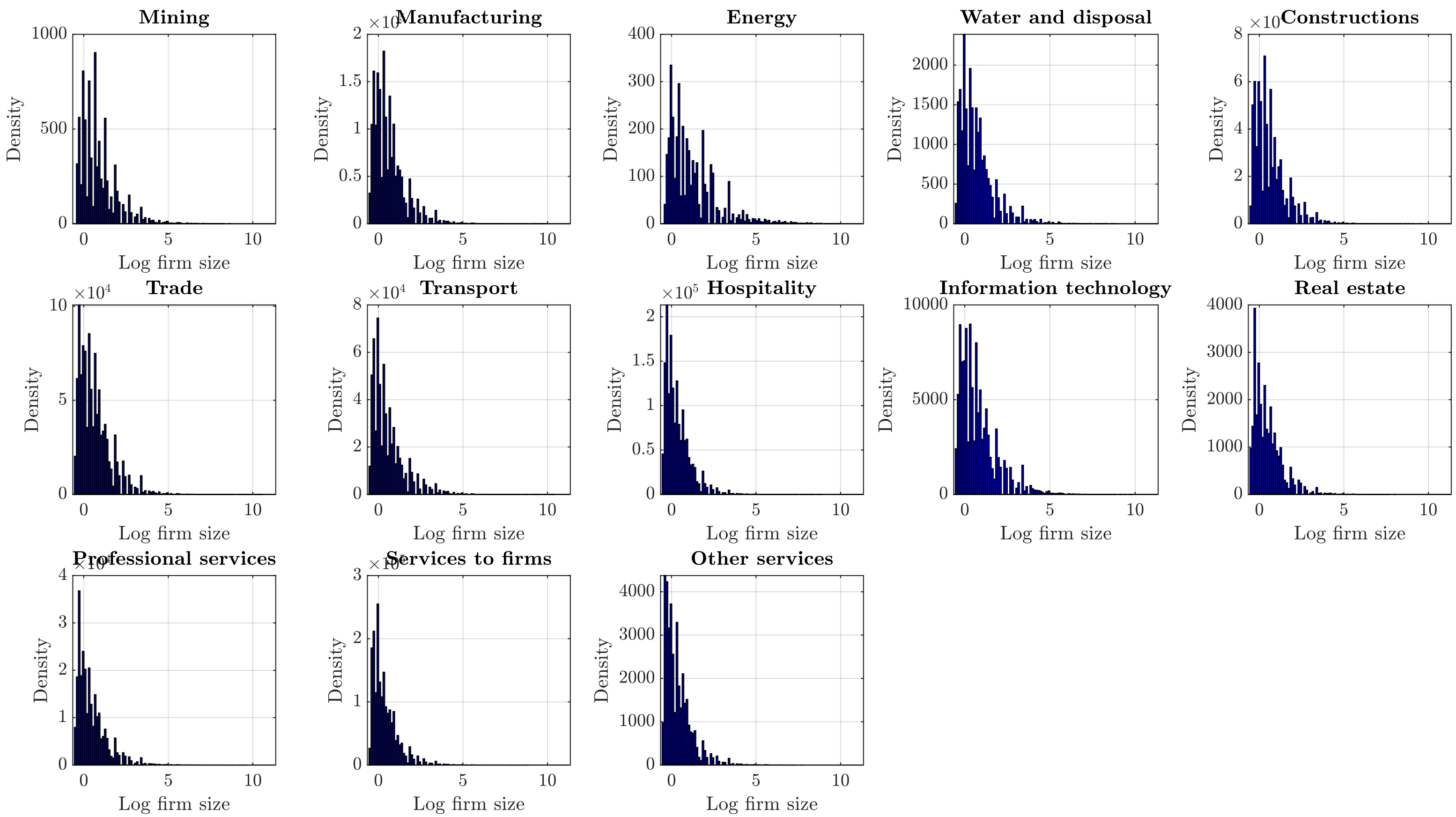
Source: Structural Business Statistics (Istat, 2019).

Figure D.9: Overhead costs by labor market



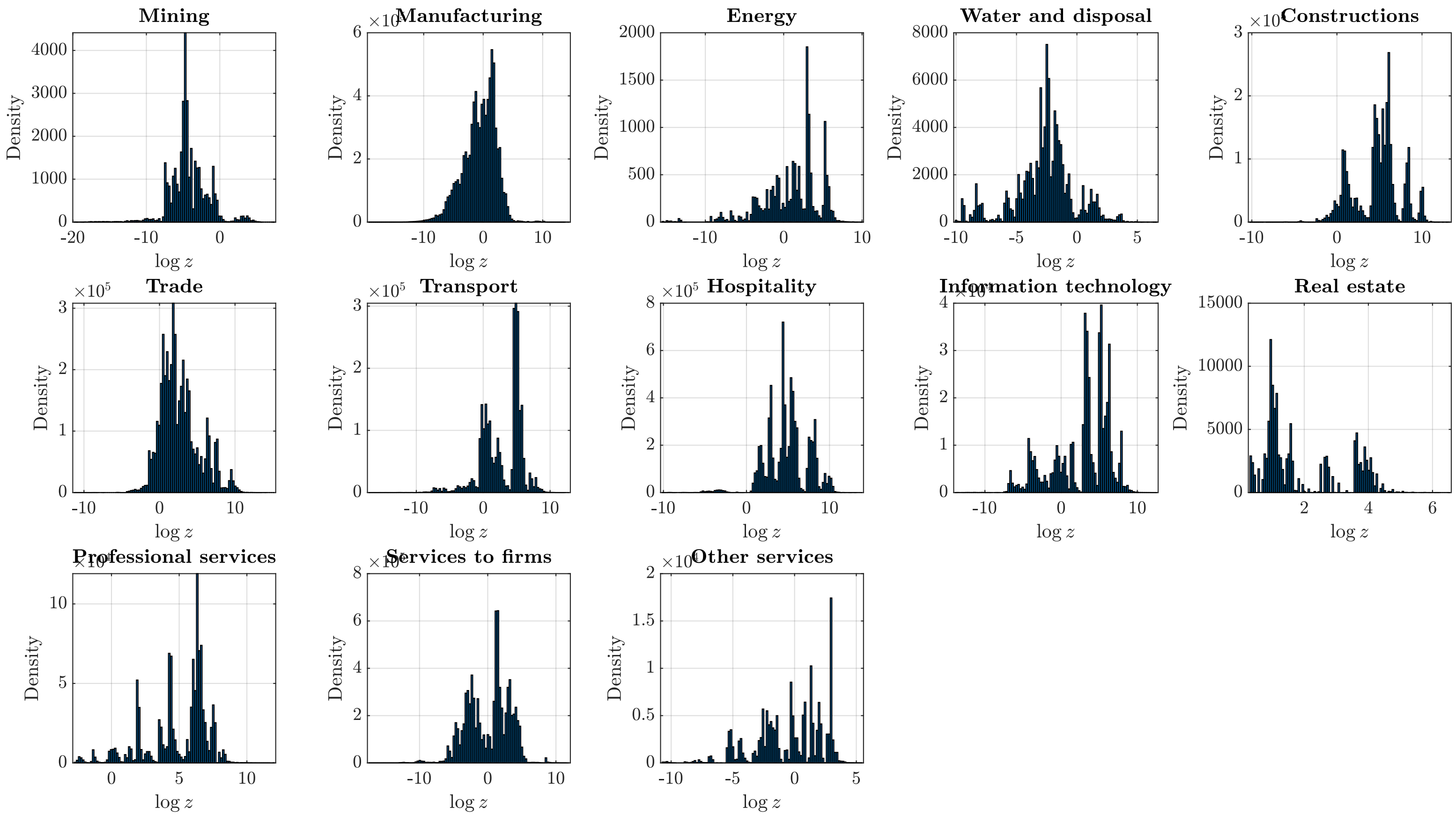
Source: Model. *Note*: the charts plot the estimates of overhead costs by labor markets.

Figure D.10: Firm size distribution by industry



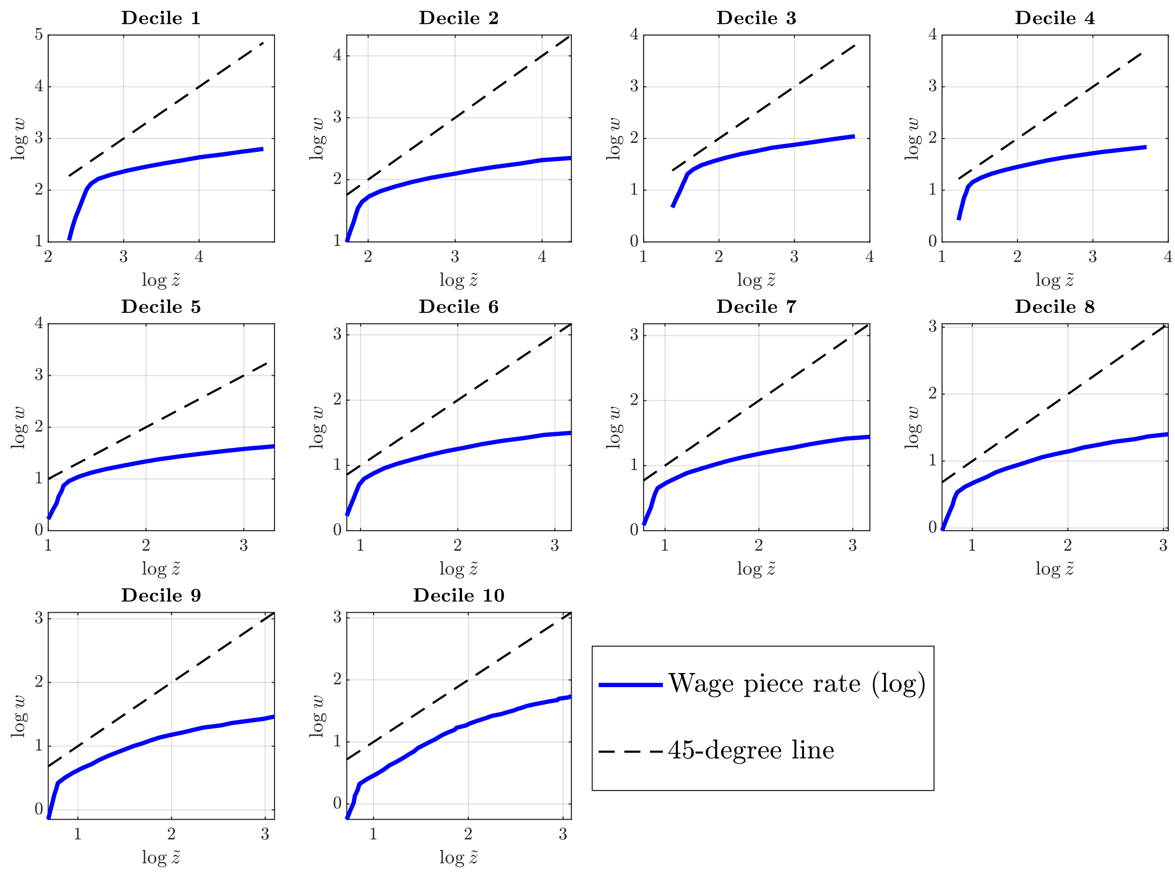
Source: Model. *Note*: the charts plot the firm size distribution across industries (Ateco classification), as implied by the model estimates.

Figure D.11: Physical productivity distribution by industry



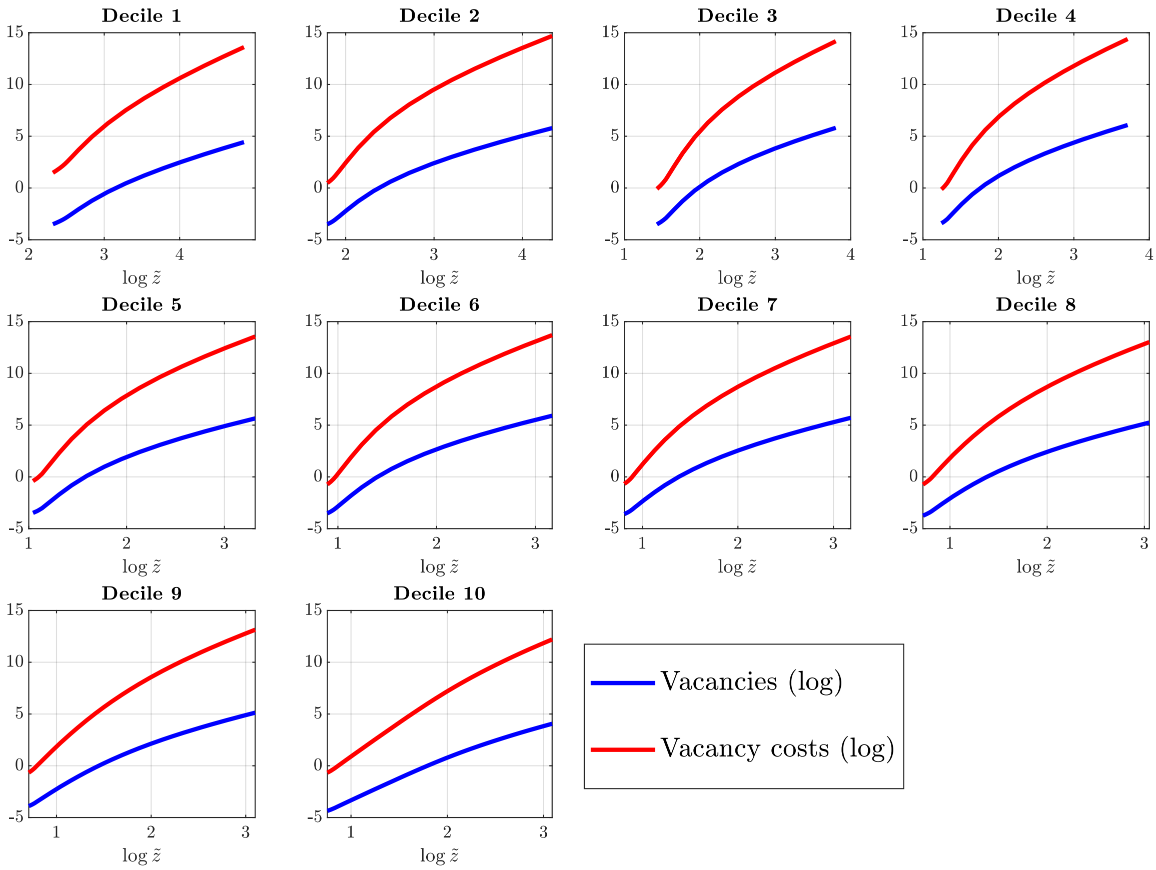
Source: Model. *Note*: the charts plot the physical productivity distribution across industries (Ateco classification), as implied by the model estimates.

Figure D.12: Wage policy function by labor market



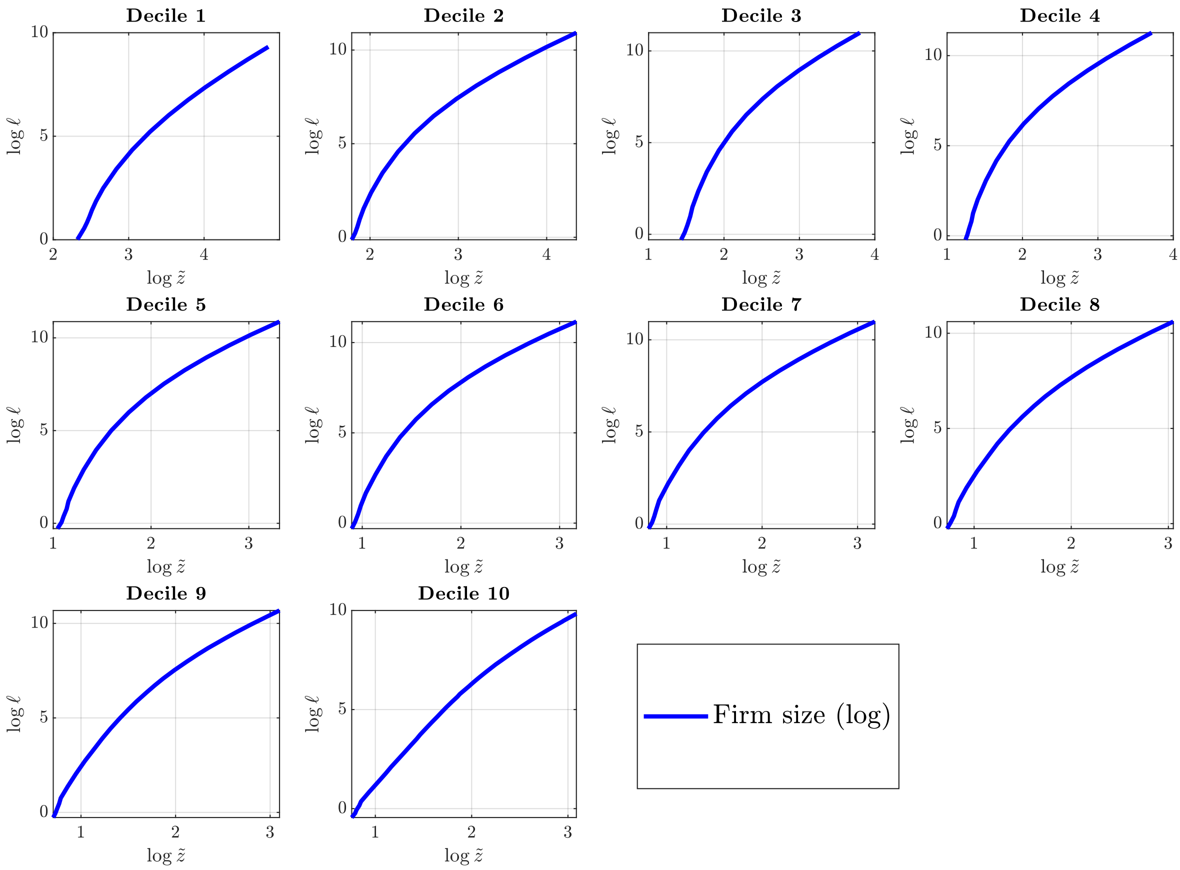
Source: Model. *Note*: the charts plot the wage policy function across labor markets, each of which corresponds to a worker type identified as a decile of the AKM worker fixed effects distribution.

Figure D.13: Vacancy policy function by labor market



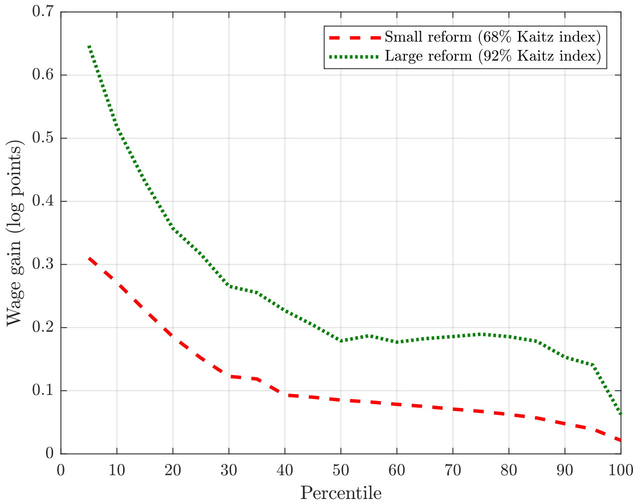
Source: Model. *Note*: the charts plot the vacancy policy function across labor markets, each of which corresponds to a worker type identified as a decile of the AKM worker fixed effects distribution.

Figure D.14: Equilibrium firm size by labor market



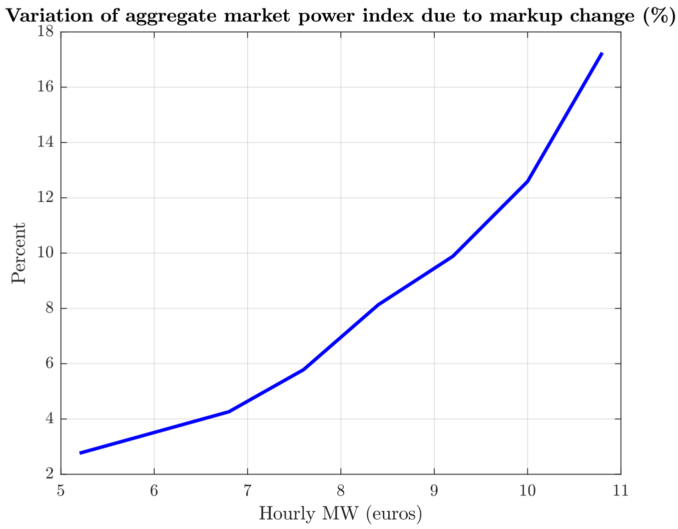
Source: Model. *Note*: the charts plot the equilibrium firm size across labor markets, each of which corresponds to a worker type identified as a decile of the AKM worker fixed effects distribution.

Figure D.15: Equilibrium effects of minimum wage reforms by percentile



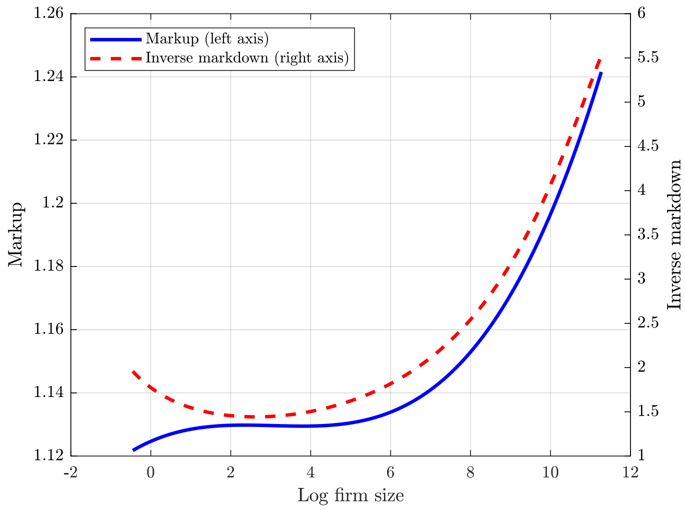
Source: Model. *Note*: the red dashed line represents the wage gains after the small reform (targeting the 10^{th} percentile), the green dotted line represents the wage gains after the large reform (targeting the 25^{th} percentile).

Figure D.16: Role of markup change in overall change of MPI



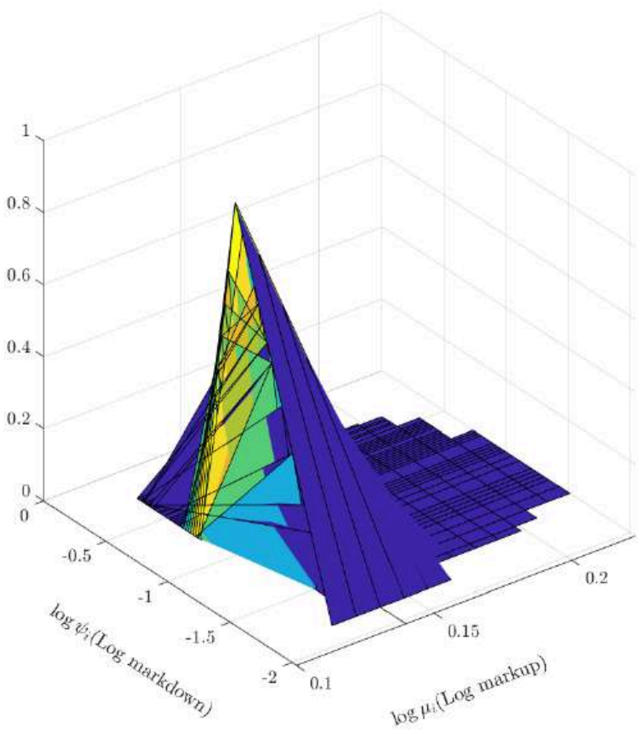
Source: Model. *Note*: the line represents the absolute value of the share of the overall variation of the aggregate market power index due to the markup change for different MW values.

Figure D.17: Market power indexes along the firm size distribution



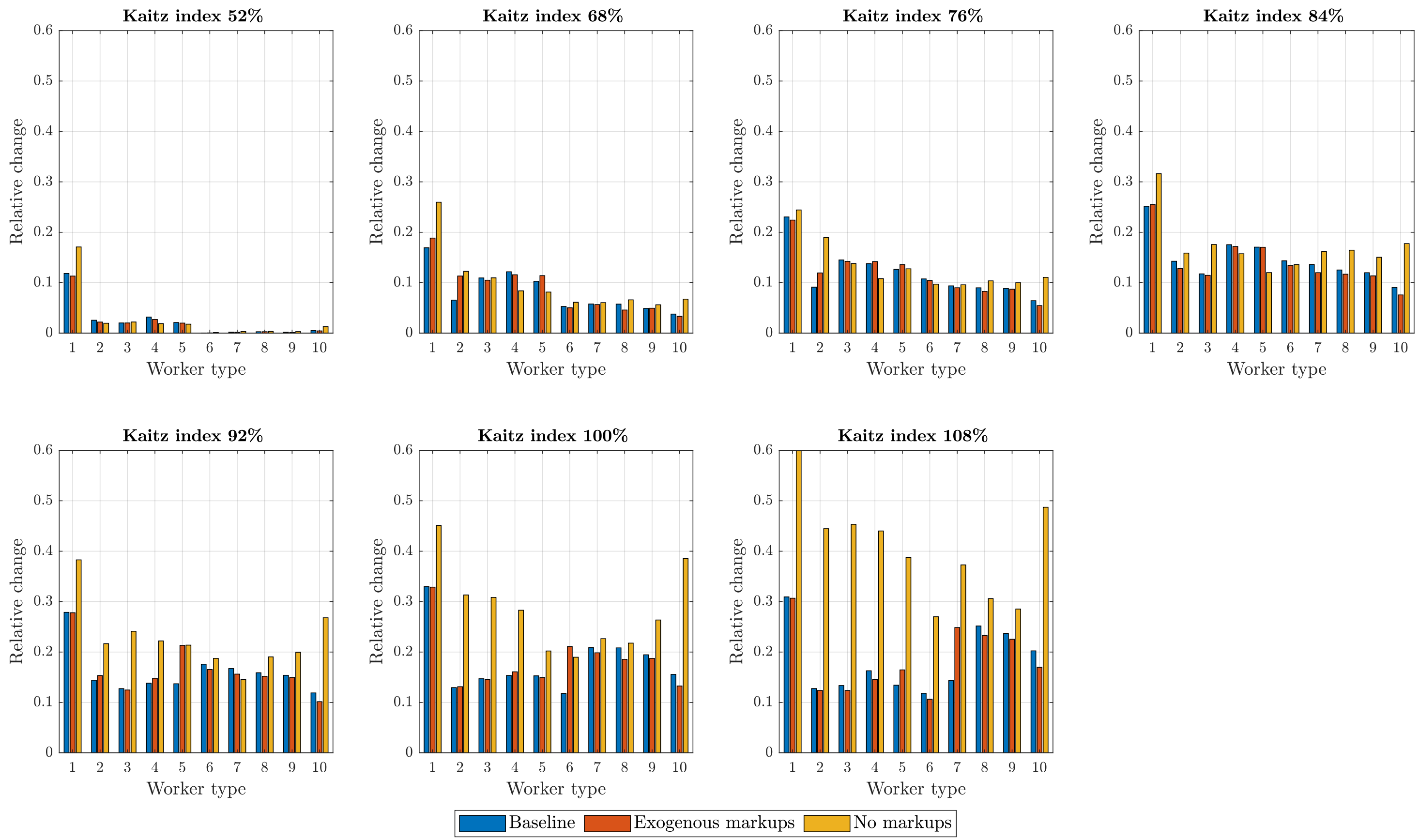
Source: Model. *Note*: the lines represent the average markup and inverse markdown for different levels of firm size.

Figure D.18: Exit response after MW reform



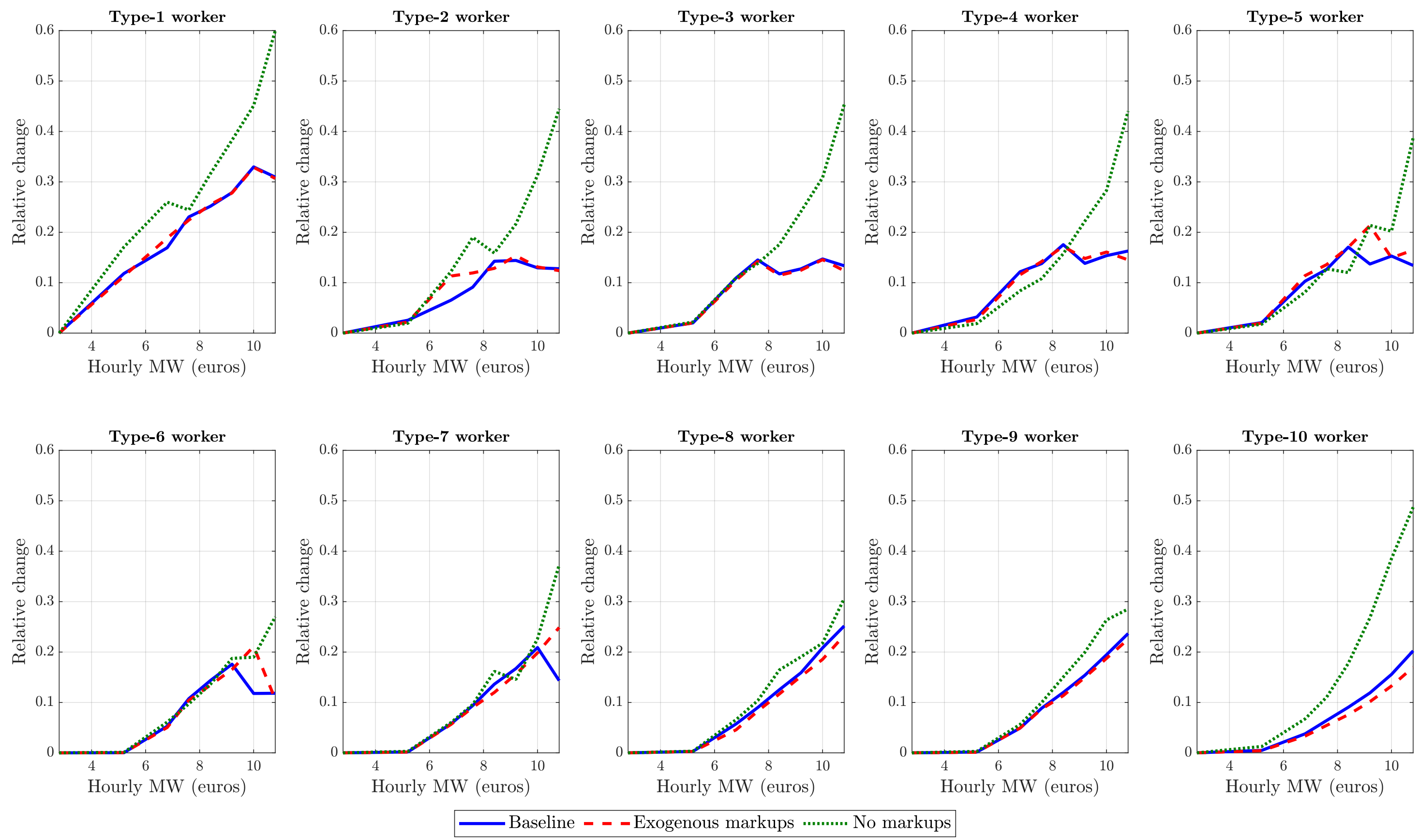
Source: Model. *Note*: the distribution represent the employment-weighted average of the exit decision (a dummy that takes value 1 if the firm is no longer active in the market after the reform) by markup and markdown of the baseline equilibrium.

Figure D.19: Distributional impact of MW reforms across economies - Effect on welfare



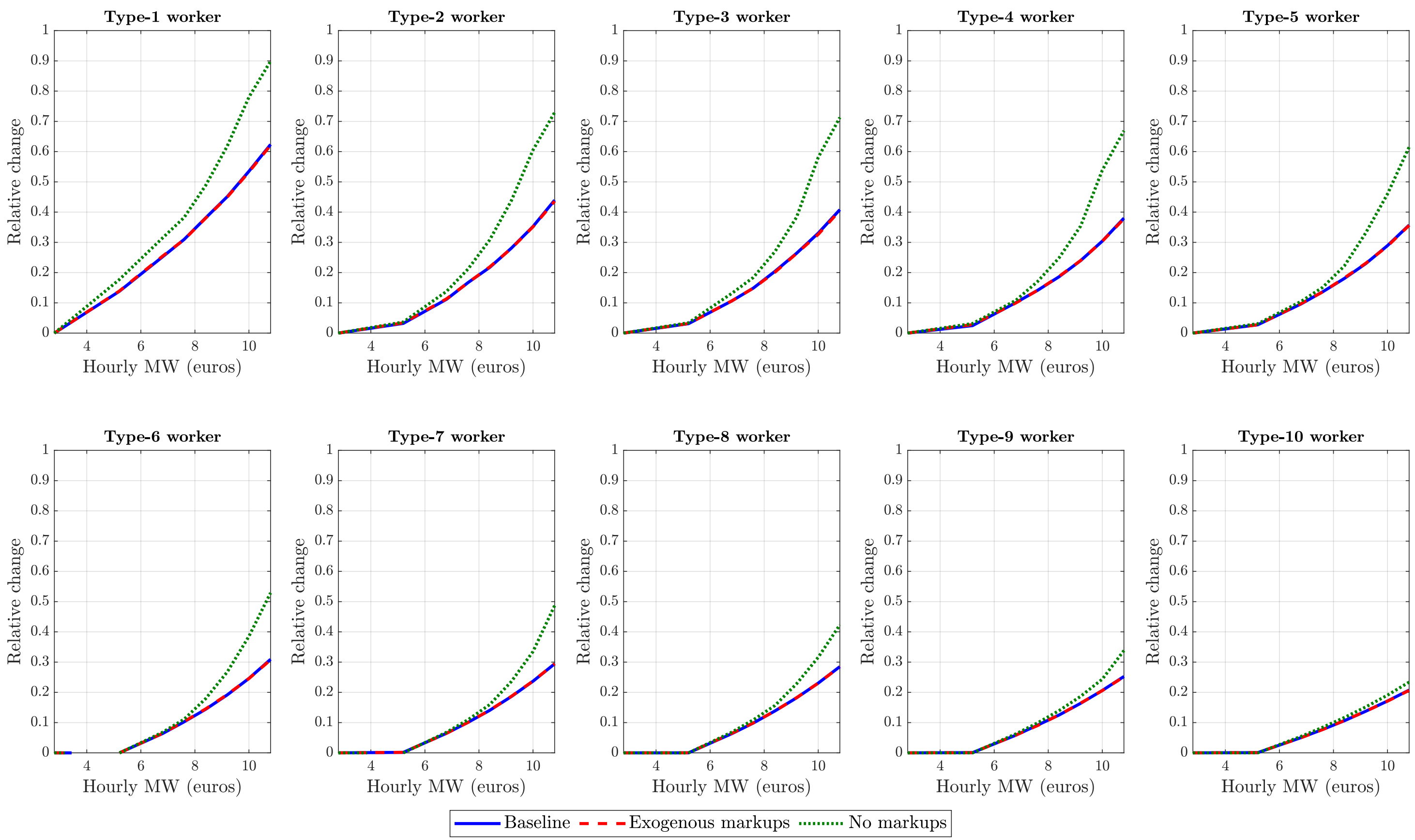
Source: Model. *Note*: the bars represent the change in welfare of each worker type under different MW levels, across alternative economies (baseline, constant markup economy, no markup economy).

Figure D.20: Distributional impact of MW reforms across economies - Effect on welfare



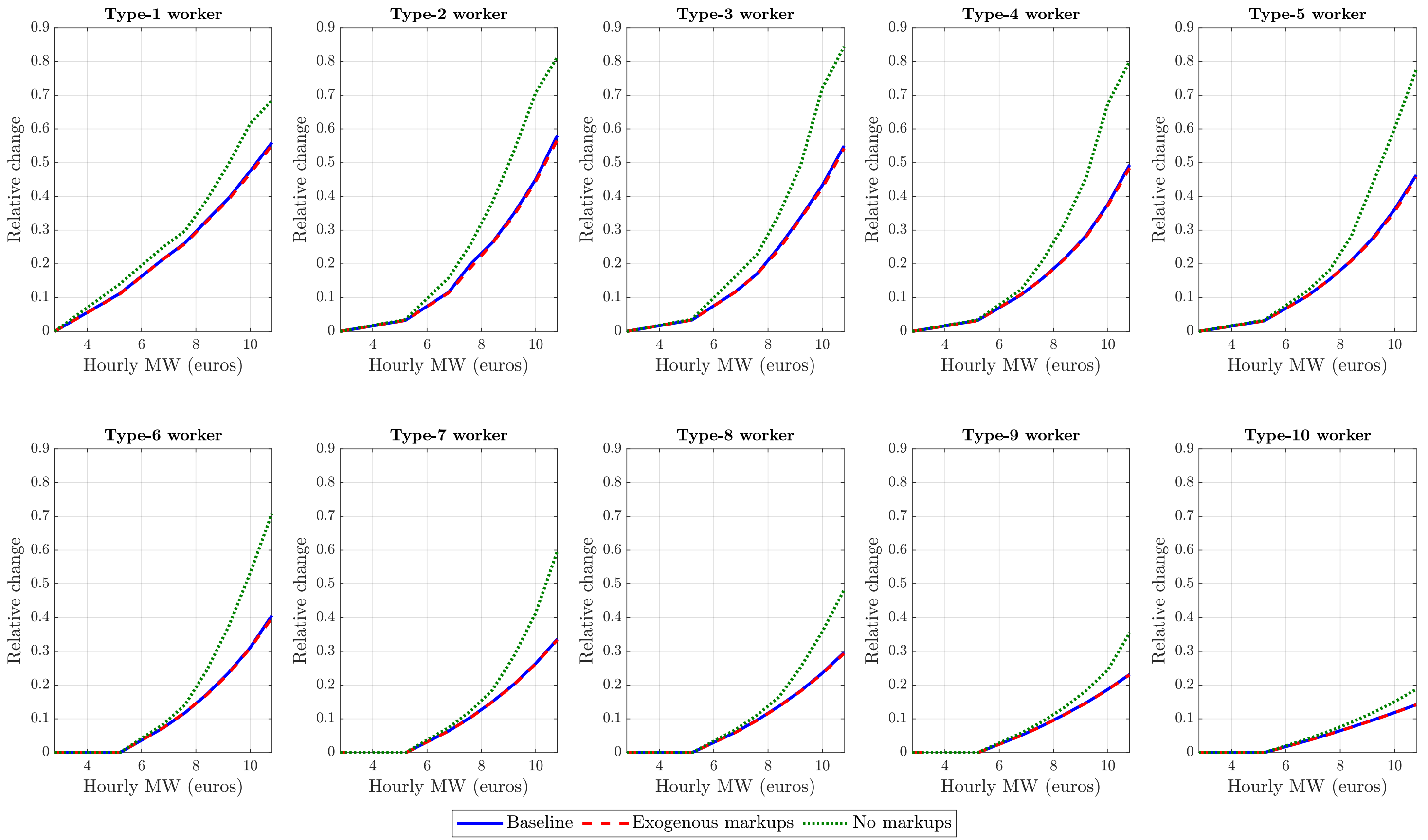
Source: Model. *Note*: the lines represent the change in welfare of each worker type under different MW levels, across alternative economies (baseline, constant markup economy, no markup economy).

Figure D.21: Distributional impact of MW reforms across economies - Effect on average wages



Source: Model. *Note*: the lines represent the change in the average wage of each worker type under different MW levels, across alternative economies (baseline, constant markup economy, no markup economy).

Figure D.22: Distributional impact of MW reforms across economies - Effect on unemployment



Source: Model. *Note*: the lines represent the change in the unemployment rate of each worker type under different MW levels, across alternative economies (baseline, constant markup economy, no markup economy).