The Perils of Progress: Why Improving Labor Markets Can Backfire*

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Abstract

We study the interplay between labor and product market power in frictional labor markets, focusing on how labor market policies shape firms' labor market power. We develop a tractable general equilibrium directed search model with multi-worker firms and monopolistic competition, featuring endogenous markups and markdowns. We show that an increase in matching efficiency or unemployment benefits affects labor market power through two opposing forces: a *shielding effect*, which strengthens workers' outside options and reduces markdowns, and a *congestion effect*, which induces firms to relocate toward less tight labor markets, increasing markdowns. The net effect depends critically on product market structure. Interestingly, when product markets exhibit strategic complementarities, the congestion effect dominates. Under constant markups, however, the shielding effect outweighs congestion. Using Hungarian administrative linked employer–employee data, we provide suggestive evidence consistent with the congestion effect dominating the shielding effect.

Keywords: Search frictions, unemployment, labor market power, product market power, markup, markdown.

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1 Introduction

Evidence on firms' market power in both labor and product markets across developed and developing countries is growing.[1] Given the substantial market power documented—particularly in labor markets—there is increasing interest in labor market policies from both equity and efficiency perspectives.[2] However, most analyses of these policies largely abstract from the role of product market structure.

This paper studies the interplay between labor and product market power in frictional labor markets. We show that the effects of labor market frictions, and the efficacy of labor market policies, depend critically on product market structure. In particular, improvements in labor market conditions—such as higher matching efficiency or more generous unemployment insurance—reduce labor market power (and markdowns) and increase welfare only in the absence of strategic complementarities in product markets. When product markets instead exhibit strategic complementarities and variable markups, such improvements can backfire, increasing markdowns and reducing welfare.

To this end, we develop a tractable general equilibrium directed search model with free entry. Firms choose wages and the number of vacancies to post, while job applicants observe posted wages and decide where to apply. Matching frictions prevent all workers from finding jobs, generating a markdown wedge between wages and the firm's marginal revenue product of labor.[3] At the same time, product markets are monopolistically competitive, so firms' vacancy posting decisions are mediated by the demand for their products. Unlike standard isoelastic demand systems, we allow for strategic complementarities in firms' decisions, giving rise to variable markups. In equilibrium, more productive firms locate in less tight labor markets, hire more workers, pay higher wages, and charge higher markups and markdowns.

Motivated by recent debates on improving workers' outside options to reduce firms' labor market power, we examine the effects of higher matching efficiency and more generous unemployment benefits in our environment. While these policies are unconventional tools for addressing labor market power, they are widely recognized as key determinants of wages and, therefore, potentially powerful instruments for limiting firms' markdowns.

We analytically show that higher matching efficiency or more generous unemployment benefits affect firms' labor market power through two opposing forces: a *shielding effect*, which reduces markdowns, and a *congestion effect*, which increases them. The shielding effect occurs because improvements in labor market conditions strengthen

[1] See, for example, De Loecker and Eeckhout (2018) and Amodio et al. (2024). Syverson (2024) provides a review of both literatures.

[2] See, for example, Azar and Marinescu (2024).

[3] We define markdowns as the ratio of workers' marginal revenue product to wages, with monopsony or labor market power referring to instances where markdowns exceed one.

workers' outside options against low-wage offers, reducing the labor market power firms can exert.[4] In contrast, the congestion effect arises because these same improvements encourage firms to relocate to less tight sub-markets, where lower job-finding rates increase their wage-setting power.

Whether the shielding or congestion effect dominates is ultimately an empirical question. To address this, we use the Simulated Method of Moments to calibrate the model's parameters under different product market structures and quantify the relative magnitudes of these forces through a series of counterfactual exercises. Our calibration targets moments of the markup and markdown distribution.

Our counterfactual exercises reveal two key properties of the shielding and congestion effects. First, when product markets feature strategic complementarities across firms, markdowns rise in response to higher unemployment benefits or improved matching efficiency, indicating that the congestion effect dominates the shielding effect.

Second, markups also respond to changes in labor market policies when strategic complementarities are present. Despite the large increase in firms' markdowns driven by these policies, the distribution of markups is largely insensitive. Nevertheless, this does not imply that product market power is unimportant; it is key to understanding why these labor market policies can backfire.

To isolate the role of product market power, we shut down strategic complementarities in product markets and repeat the counterfactual exercises. In the absence of variable markups, labor market power declines in response to higher unemployment benefits or improved matching efficiency, indicating that the shielding effect dominates the congestion effect in this case.

Why does the congestion effect dominate under strategic complementarities? Holding fixed the value of search in the labor market, an increase in unemployment benefits or matching efficiency lowers wages and, consequently, firms' marginal costs. In response, firms expand and relocate toward less tight labor markets to hire more workers, restoring equality between marginal revenue and marginal cost. When product markets exhibit strategic complementarities, this expansion also raises markups, which in turn increases the marginal revenue product of labor. As a result, a given reduction in marginal costs leads firms to expand more and shift further toward less tight labor markets under variable markups than under constant markups. This amplification explains why the congestion effect is stronger when product markets feature strategic complementarities.[5]

The response of markdowns to labor market policies matters not only for equity but also for efficiency. When these policies raise average markdowns, firms' production is

[4] A comparable argument concerning workers' outside options also applies in other contexts, such as self-employment, as discussed in Amodio, Medina and Morlacco (2025).

[5] Although this intuition is developed in partial equilibrium, it also holds in general equilibrium.

constrained, reducing consumer welfare. Under constant markups, however, welfare increases as these policies lower markdowns. Our results highlight both the effectiveness of labor market policies in limiting markdowns and the critical role of product market structure in shaping their impact. Specifically, in product markets without strategic complementarities, higher unemployment benefits or improved matching efficiency increase welfare by reducing labor market power. In contrast, when product markets feature variable markups, the same policies can backfire, suggesting that alternative interventions may be more desirable.

Finally, we use Hungarian administrative linked employer-employee data to provide suggestive evidence supporting the main implications of our model. Specifically, we look at the relationship between markdowns and incumbent workers' outside options. We proxy outside options by leveraging the Hungarian unemployment insurance system, in two ways: first by calculating the eligible unemployment insurance benefit amount of incumbent workers, then by exploiting an exogenous policy change that incentivizes unemployed individuals to exit unemployment faster. Our empirical exercises reveal that markdowns rise when incumbent workers' outside options increase. These results are in line with the congestion effect dominating the shielding effect.

Our paper contributes to the fast-growing literature on labor market power. Existing studies document sizable labor market power in various contexts.[6] In the literature, labor market power stems mainly from either idiosyncratic preferences for different jobs (Azar, Berry and Marinescu, 2022; Berger, Herkenhoff and Mongey, 2022*a*; Lamadon, Mogstad and Setzler, 2022; Card et al., 2018; Bhaskar, Manning and To, 2002) or search frictions (Burdett and Mortensen, 1998; Postel-Vinay and Robin, 2002; Manning, 2003; Galenianos, Kircher and Virag, 2011; Kaas and Kircher, 2015; Gottfries and Jarosch, 2023), with our paper belonging to the latter strand.[7] We contribute to this literature by showing that an increase in matching efficiency or unemployment benefits activates two opposing effects on firms' labor market power, and these policies can increase markdowns in product markets featuring strategic complementarities.[8]

We also contribute to the expanding literature examining joint market power in both labor and product markets (MacKenzie, 2021; Macedoni, 2022; Gutiérrez, 2022;

[6]See, for example, Webber (2015); Naidu, Nyarko and Wang (2016); Dube, Manning and Naidu (2018); Morlacco (2019); Dube et al. (2020); Felix (2021); Brooks et al. (2021); Alfaro-Ureña, Manelici and Vasquez (2021); Yeh, Macaluso and Hershbein (2022); Azar, Marinescu and Steinbaum (2022); Amodio, Medina and Morlacco (2025); Méndez and Van Patten (2022); Amodio and Roux (2022); Muralidharan, Niehaus and Sukhtankar (2023); Armangué-Jubert, Guner and Ruggieri (2023); Garcia-Louzao and Ruggieri (2023); Pham (2023); Amodio et al. (2024); Brummund and Makowsky (2024); Hoang, Mitra and Pham (2024).

[7]For comprehensive reviews on this literature, see Azar and Marinescu (2024), Card (2022), Manning (2021), and Sokolova and Sorensen (2021). Berger et al. (2024) develop a theory and quantify monopsony power with granular firms, preference heterogeneity, and search frictions.

[8]Burya et al. (2023) and Bassier (2023) study the empirical relationship between labor market power and unemployment.

Alviarez et al., 2023; Deb et al., 2023; Cali and Presidente, 2023; Van Reenan, 2024; Macedoni and Tyazhelnikov, 2024). In contrast to this literature, our main focus is on the effects of search frictions on labor market power.[9]

Our paper is also related to the literature on the effects of labor market policies in the presence of labor market power. For example, a strand of this literature shows that, due to firms' monopsony power, minimum wages do not necessarily reduce employment (Azar et al., 2023; Engbom and Moser, 2022; Okudaira, Takizawa and Yamanouchi, 2019) and can also increase welfare (Berger, Herkenhoff and Mongey, 2022*b*).[10] Estefan et al. (2024) show that a ban on outsourcing in Mexico reduced markdowns without lowering employment or output. We contribute to this literature by showing that the effects of labor market policies on markdowns and welfare crucially depend on the product market structure.

Our paper is also related to the literature studying macroeconomic effects of labor market policies. Chodorow-Reich, Coglianese and Karabarbounis (2019) show that unemployment benefits extensions during the Great Recession had only modest effect on macroeconomic outcomes. Acosta et al. (2023) find that the effects of unemployment benefits extensions on macroeconomic outcomes depend on the initial unemployment benefits durations, with substantial (small) effects when initial unemployment benefits durations are short (long). Hagedorn, Manovskii and Mitman (2015) document that a fall in unemployment benefits in 2013 led to employment and labor force growth, while Farber, Rothstein and Valletta (2015) find no significant effect on job finding rate and a reduction in labor force participation. Based on a review by Schmieder and Von Wachter (2016), the overall finding in the literature is that expansions in unemployment benefits increase labor supply, through which unemployment rises. Johnston and Mas (2018) and Karahan, Mitman and Moore (2019) find that cutting unemployment benefits increases workers' search efforts, with the latter documenting an increase in labor market tightness as well. Hagedorn et al. (2013) document that unemployment benefit extensions reduce employment and vacancy creation, and increase wages and unemployment.

The remainder of the paper is organized as follows. Section 2 presents a general equilibrium directed search model. Section 3 analytically characterizes markdown properties and how markdowns respond to changes in labor market conditions. Section 4 calibrates the model and performs counterfactual exercises. Section 5 provides supportive empirical evidence for the main implications of the model. Section 6 concludes.

[9] In a companion paper, we study how international trade impacts the interplay between unemployment, labor market power, and product market power.

[10] Dube, Naidu and Reich (2022) show that, in contrast to the model of compensating differentials, minimum wages do not reduce non-wage amenities.

2 Theoretical Framework

The economy consists of four types of agents: a unit measure of homogeneous individuals with linear consumption preferences, homogeneous final goods producers who combine differentiated intermediate varieties in production, producers of these differentiated varieties who hire labor in a market characterized by directed search frictions, and finally, a government that provides unemployment insurance benefits financed by lump-sum taxes.

2.1 Environment

Consumers Consumers have preferences over the final good C and face dis-utility from labor L_s. We assume a utility function of the form

$$U = \ln C - \chi \frac{L_s^{1+\xi}}{1+\xi}, \tag{1}$$

where $\xi \geq 0$ is the inverse Frisch elasticity of labor supply, and $\chi > 0$ is the weight on the dis-utility from working.

Their earning comes from either wages that they receive while working or unemployment insurance benefits while unemployed, net of lump-sum taxes that they pay to the government. Letting W denote the expected income for a consumer from its work, this preference structure implies the following labor-consumption decisions

$$W = \chi L_s^{\xi} C. \tag{2}$$

Final goods producers Final goods Y are produced in a perfectly competitive market using differentiated intermediate goods $\omega \in \Omega$. The production technology is defined implicitly by the Kimball aggregator

$$\int_0^M \Upsilon\left(\frac{y(\omega)}{Y}\right) d\omega = 1, \tag{3}$$

where $M = |\Omega|$ is the measure of available varieties and $\Upsilon(x)$ is a strictly increasing and strictly concave function satisfying $\Upsilon(1) = 1$. The constant elasticity of substitution (CES) technology that implies iso-elastic demand functions is nested by this specification and correspond to the case of $\Upsilon(x) = x^{\frac{\sigma-1}{\sigma}}$.

The production technology (3) implies the following demand function for variety ω[11]

$$p(\omega) = P \times D \times \Upsilon'\left(\frac{y(\omega)}{Y}\right), \tag{4}$$

[11] We relegate derivations to Appendix A.3.

where D is a demand shifter defined as

$$D = \left[\int_0^M \Upsilon' \left(\frac{y(\omega)}{Y} \right) \frac{y(\omega)}{Y} d\omega \right]^{-1}, \tag{5}$$

and P is the ideal price index which we use as the model's numeraire, i.e., $P = 1$.

We let $\epsilon(\omega)$ denote the demand elasticity of variety ω. Equation (4) implies that this elasticity is a function of the relative quantity consumed of variety ω, $x(\omega)$, and is given by

$$\epsilon(x) = -\frac{\Upsilon'(x)}{\Upsilon''(x)\, x}. \tag{6}$$

We assume that the demand system satisfies Marshall's second law of demand, i.e., the price elasticity of demand $\epsilon(x)$ falls with the relative quantity consumed $x(\omega)$.

Intermediate goods producers Producers of intermediate goods ω (firms, hereafter) sell their unique variety in a monopolistically competitive market. Firms are heterogeneous in terms of their productivity. The sole factor of production is labor and the production function is given by

$$y(\omega) = z\ell(\omega). \tag{7}$$

To operate, firms must pay a fixed entry cost f_e upon which they draw a productivity value z from a cumulative distribution function $G(z)$. Firms also face a fixed cost of production f. Entry and fixed operation costs are both in units of final goods.

Taking the demand schedule (4) into account, the revenue of a firm with productivity z and ℓ number of workers equals

$$R(\ell; z) = P \times D \times \Upsilon' \left(\frac{z\ell}{Y} \right) z\ell. \tag{8}$$

We assume that the revenue function satisfies two regularity conditions. First, we assume that the marginal revenue product of labor is decreasing in the units of labor. Second, we assume that the marginal revenue product of labor increases with firm productivity. With a CES production function both conditions are satisfied, however, these conditions are only true under certain parameter restrictions for common specifications of the Kimball aggregator.

Labor markets Labor markets feature directed search frictions. We build on the static version of Kaas and Kircher (2015) and Felbermayr, Impullitti and Prat (2018). Labor markets are segmented over a continuum of sub-markets indexed by their labor market tightness, i.e., the ratio of open vacancies to job seekers $\theta \equiv V(\theta)/S(\theta)$. The

matching function in each sub-market is given by

$$m\left(V(\theta), S(\theta)\right) = A \times \frac{V(\theta)S(\theta)}{V(\theta) + S(\theta)}, \tag{9}$$

where $A \in (0, 1]$ is a scale parameter representing the efficiency of the matching function.[12]

We let $q\left(\theta\right) \equiv m\left(V\left(\theta\right), S\left(\theta\right)\right)/V\left(\theta\right)$ denote the vacancy filling rate. Given the matching function (9), the vacancy filling rate in sub-market θ is given by

$$q(\theta) = A \times \frac{1}{\theta + 1}, \tag{10}$$

which is decreasing in θ. The job finding rate is given by $\theta q\left(\theta\right)$, which is increasing in the labor market tightness. We let $\eta(\theta)$ denote the elasticity of the vacancy filling rate with respect to market tightness θ, i.e., $\eta(\theta) = -q'\left(\theta\right)\theta/q\left(\theta\right)$. Given the matching function equation (9), this elasticity is given by

$$\eta(\theta) = \frac{\theta}{\theta + 1}, \tag{11}$$

which is increasing in θ.

Workers have information about wages in each sub-market, $w(\theta)$, prior to their search and decide which sub-market to search in. Hence, workers are indifferent across sub-markets in equilibrium. The expected income of a job seeker in market θ is given by

$$W = \theta q\left(\theta\right) w\left(\theta\right) + \left(1 - \theta q\left(\theta\right)\right) b_u, \tag{12}$$

where W is the value of search and b_u is the unemployment insurance benefit. We can rewrite equation (12) as

$$w\left(\theta\right) = \frac{W - b_u}{\theta q\left(\theta\right)} + b_u, \tag{13}$$

which implies that wages are decreasing in θ: Workers search in low-wage sub-markets only if these markets have a higher job finding probability.

Vacancy posting Firms decide in which sub-market θ to hire and how many vacancies ν to post. Given these two choices, firms can hire $\ell = q(\theta)\nu$ workers and pay wages according to equation (13). As we showed above, wages are lower in tighter labor markets. Hence, the key trade-off for firms in deciding which sub-market to operate in is about paying low wages $w\left(\theta\right)$ versus facing a low probability of filling vacancies $q\left(\theta\right)$.

[12]The matching function in equation (9) is known as the *Telephone-line* matching function (Stevens, 2007). We chose this specification because it generates vacancy filling rates and job finding rates that are between zero and one for all values of θ. This property is important since those rates correspond to probabilities in our static setup.

A firm with productivity z solves the following profit-maximization problem

$$\pi(z) = \max_{\theta,\nu} \{R\left(q(\theta)\nu; z\right) - w(\theta)q(\theta)\nu - P \times C(\nu) - P \times f\} \tag{14}$$
$$\text{s.t. } w(\theta) = \frac{W - b_u}{\theta q(\theta)} + b_u,$$

with $C\left(\nu\right)$ being the vacancy posting cost denoted in units of the final good.

Let $R_\ell(\cdot; z)$ denote the marginal revenue product of labor for a firm with productivity z. As Appendix A.1 shows, the first-order conditions for problem (14) imply the following two relationships for the number of vacancies and the choice of the sub-market

$$\frac{R_\ell\left(q\left(\theta\right)\nu; z\right)}{w\left(\theta\right)} = \mu_n(\theta), \tag{15}$$

and

$$C'(\nu) = \frac{W - b_u}{\theta} \frac{1 - \eta(\theta)}{\eta(\theta)}. \tag{16}$$

Equation (15) implies that wages that firms in sub-market θ pay are a markdown $\mu_n(\theta)$ below the marginal revenue product of labor, with the markdown given by

$$\mu_n(\theta) = \frac{1}{\eta(\theta)} - \frac{b_u}{w\left(\theta\right)} \frac{1 - \eta(\theta)}{\eta(\theta)}. \tag{17}$$

Intuitively, firms take advantage of search frictions to exercise monopsony power over workers.[13]

Equation (16) shows why non-linear vacancy posting costs are important to obtain wage and markdown dispersion in this model. To elaborate, if vacancy posting costs were linear and therefore $C'\left(\nu\right) = \lambda$, equation (16) would imply that all firms would choose the same sub-market θ and therefore pay the same wage $w(\theta)$. Therefore, with linear vacancy posting costs, there would be no markdown or wage dispersion in equilibrium, and therefore, differences in firms' productivity would translate into differences in employment levels only.[14] We summarize this result in the following proposition.

Proposition 1 *With linear vacancy posting costs, all firms choose to operate in the same sub-market θ. Therefore, the equilibrium features a degenerate distribution of wages $w(\theta) = w$ and markdowns $\mu_n(\theta) = \mu_n$. Differences in productivity levels z across firms translate into differences in employment levels only.*

The following proposition, which we prove in Appendix A.2, characterizes the prop-

[13] Section 3 will discuss markdown properties in detail.

[14] To have heterogeneous markdowns in equilibrium, while it is necessary to have non-linear vacancy posting costs, this condition is not sufficient: We further require positive unemployment insurance benefits or a variable elasticity of the vacancy filling rate with respect to market tightness.

erties of the vacancy posting problem as a function of firms' productivity.

Proposition 2 *If vacancy posting costs are strictly convex, then more productive firms* ($z' > z$)*: (i) post more vacancies* ($\nu' > \nu$) *and hire more workers* ($\ell' > \ell$)*, (ii) locate in less tight labor markets* ($\theta' < \theta$)*; (iii) pay higher wages* ($w' > w$)*; (iv) have higher markdowns* ($\mu_n' > \mu_n$)*; (v) charge higher markups; and (vi) earn higher profits* ($\pi' > \pi$)*.*

As Proposition 2 shows, profits are increasing in z. Hence, given the fixed production cost, there exists a productivity cutoff z^* below which firms will earn negative profits if they produce. Therefore, only firms with productivity draw $z \geq z^*$ operate in equilibrium.

Corollary 1 *There exists a productivity cut-off* z^* *such that all firms with* $z < z^*$ *do not operate in any sub-market.*

2.2 Equilibrium

This section closes the model by specifying the free entry condition, market clearing conditions, and the government budget constraint.

Free entry. Firms pay the entry cost f_e to draw their productivity z from distribution $G(z)$ with density function $g(z)$. As stated in Corollary 1, only firms with productivity $z \geq z^*$ decide to operate. The free entry condition ensures that entry occurs until expected profits are equal to the entry cost

$$\int_{z^*}^{\infty} \pi(z) g(z) dz = P \times f_e. \tag{18}$$

Labor supply. The total number of individuals searching for a job in equilibrium (left-hand side) is equal to the total labor supply

$$M \int_{z^*}^{\infty} \frac{\ell(z)}{\theta(z) q(\theta(z))} \phi(z) dz = L_s, \tag{19}$$

where $\ell(z)$ and $\theta(z)$ are the employment and choice of sub-market for a firm with productivity z, respectively, and $\phi(z)$ denotes the ex-post distribution of firm productivities given by

$$\phi(z) = \frac{g(z)}{1 - G(z^*)}, \quad z \geq z^*. \tag{20}$$

Final goods market clearing. Total output is used for household consumption, paying for entry and fixed costs of production, and creating vacancies

$$Y = C + M \times f + M_e \times f_e + M \times \int_{z^*}^{\infty} C(\nu(z)) \phi(z) dz, \tag{21}$$

where $M_e = \frac{M}{1-G(z^*)}$ is the number of entrants and $C = WL_s - T$ is household's consumption.

Government. The government collects lump-sum taxes T to finance unemployment insurance benefits b_u. The government has a balanced budget. In each sub-market, job seekers who cannot find a job become unemployed and collect b_u. The government's balanced budget condition then requires

$$T = Mb_u \int_{z^*}^{\infty} \left(\frac{1}{\theta(z)q(\theta(z))} - 1 \right) \ell(z)\phi(z)dz. \tag{22}$$

The equilibrium is a set of total output Y, consumption C, labor supply L_s, taxes T, measure of firms M, the measure of entrants M_e, cutoff productivity z^*, and firms' prices, sub-markets, and the number of vacancies that satisfy firms' profit-maximization problem, free entry condition, government's balanced budget constraint, and goods and labor market clearing conditions. Section 4, specifies functional forms and discusses the algorithm that we implement to solve for the equilibrium.

3 Markdown and Markup Properties

In what follows, we examine how changes in labor market characteristics influence labor market power. We also show that product market power plays a crucial role in how labor market frictions affect firm's markdowns. To perform these comparative statics, we consider the partial equilibrium of the model, taking aggregate equilibrium objects as given.

Consider a firm that optimally chooses sub-market θ. An increase in labor market characteristics b_u and A affects firms' labor market power through two opposing forces: (i) a *shielding effect*: given the choice of the sub-market, markdowns fall by strengthening worker's outside options; and (ii) a *congestion effect*: firms relocate to less tight sub-markets, leading to an increase in markdowns. We discuss these two channels in turn.

3.0.1 The shielding effect on markdowns

The *shielding effect* reflects that an increase in unemployment benefits provides a better outside option for workers against low-wage offers from firms, thereby reducing the labor market power exercised by firms.[15] This channel works within a sub-market.

[15] A similar argument regarding workers' outside options applies to other settings, for example, self-employment in Amodio, Medina and Morlacco (2025).

Formally, plugging equation (13) into equation (17) delivers

$$\mu_n(\theta) = \frac{1}{\eta(\theta)} - \frac{Ab_u(1-\eta(\theta))}{W - b_u(1 - A\eta(\theta))}, \tag{23}$$

and so, keeping fixed the firm's market decision θ to isolate the effect of b_u on the job finding rate in the market and the general equilibrium value of search W, we get that the effect of b_u on firm's markdowns is given by

$$\frac{\partial \mu_n(\theta)}{\partial b_u} = -\frac{A(1-\eta(\theta))W}{[W - b_u(1 - A\eta(\theta))]^2} < 0. \tag{24}$$

The negative sign in this derivative reflects the Shielding effect of the unemployment benefit: Firms' markdowns fall with unemployment insurance benefits.

Note that improving the efficiency of the matching function (increasing A) has a similar effect since the direct effect of an increase in A leads to a fall in markdowns. In this case, improving the efficiency of the matching function is similar to reducing the labor market frictions which is the reason behind firm's labor market power

$$\frac{\partial \mu_n(\theta)}{\partial A} = -\frac{b_u(1-\eta(\theta))(W - b_u)}{[W - b_u(1 - A\eta(\theta))]^2} < 0. \tag{25}$$

3.0.2 The congestion effect on markdowns

An increase in unemployment benefits or matching efficiency encourages firms to locate in less tight sub-markets. Low job finding probabilities in these sub-markets give more labor market power to firms since workers realize that offers are less frequent. We call this channel the *congestion effect*. In contrast to the shielding effect, the congestion effect operates by inducing firms to switch across sub-markets.

In this section, we first show that in response to an increase in unemployment benefits b_u or matching efficiency A, firms relocate to less tight labor markets. We then show that firms have more labor market power and markdowns in less tight labor markets. This channel shows that improving workers' outside options or matching efficiency does not necessarily reduce firms' labor market power and can indeed increase it.

Formally, the first-order condition for problem (14) with respect to the choice of the sub-market (see Appendix A.1) can be simplified to

$$R_\ell(q(\theta)\nu; z) = b_u + \frac{W - b_u}{A\eta(\theta)^2}. \tag{26}$$

Appendix A.1 shows that θ falls with either b_u or A:

$$\frac{\partial \theta}{\partial b_u} < 0, \ \frac{\partial \theta}{\partial A} < 0. \tag{27}$$

The intuition behind this result is as follows. An increase in b_u or A reduces wages in each sub-market (see equation (13)). This in turn reduces firms' marginal costs, prompting them to expand production. To hire more workers, firms need to locate in less tight labor markets (see Appendix A.2).

As discussed above, an increase in unemployment benefits or matching efficiency pushes firms to locate in less tight sub-markets. Using equation (23), we can show that markdowns are smaller in tighter labor markets:

$$\frac{\partial \mu_n(\theta)}{\partial \theta} = -\frac{(w(\theta) - b_u)\left(b_u\left(1 - \eta(\theta)\right) + w(\theta)\right)}{\left[(\theta+1)\eta(\theta)w(\theta)\right]^2} < 0. \tag{28}$$

The Congestion effect reflects that in response to an increase in b_u or A, firms relocate to less tight labor markets with lower job finding rates. This in turn increases firms' labor market power since workers are willing to accept lower wages since offers are less frequent.

Furthermore, the congestion effect of b_u on markdowns is stronger in a less efficient labor market with a lower A. In particular, Appendix A.1 shows that

$$\frac{\partial^2 \theta}{\partial b_u \partial A} > 0, \tag{29}$$

and

$$\frac{\partial^2 \mu_n(\theta)}{\partial \theta \partial A} > 0, \frac{\partial^2 \mu_n(\theta)}{\partial \theta \partial b_u} > 0. \tag{30}$$

The first result, equation (29), implies that, in a less efficient labor market, an increase in unemployment benefits reduces labor market tightness to a larger extent. This result stems from the fact that, as discussed above, a reduction in b_u prompts firms to increase their production by locating in less tight labor markets. With a less efficient matching process, firms need to locate in even less tight labor markets with a higher vacancy filling probability to be able to expand their production.

The second result, equation (30), states that, in a less efficient labor market, variation in markdowns across sub-markets is larger, that is $\partial \mu^n(\theta)/\partial \theta$ is more negative. The intuition is straightforward. Less efficient labor markets have lower job finding probabilities, thereby increasing firms' labor market power, especially in less tight labor markets with already low job finding rates.

3.0.3 Total effect on markdowns and the role of product market power

An increase in unemployment benefits or matching efficiency has then two opposing effects on firms' markdowns: a shielding effect that reduces markdowns and a congestion effect that increases them. In general, the total effect of unemployment benefits on markdowns can be written as

$$\frac{d\mu_n(\theta)}{db_u} = \underbrace{\frac{\partial \mu_n(\theta)}{\partial b_u}}_{<0} + \underbrace{\frac{\partial \mu_n(\theta)}{\partial \theta}}_{<0} \times \underbrace{\frac{\partial \theta}{\partial b_u}}_{<0},$$

and similarly for the effects of matching efficiency on markdowns. Whether the shielding or congestion effect dominates is an empirical question, depending on the initial level of b_u and A, the sub-market θ, and the product market structure.

Importantly, whether the total effect of b_u or A on markdowns is positive or negative largely depends on the product market structure. As equation (26) shows, the response of θ to either b_u or A, and therefore the strength of the congestion effect, depends on how diminishing the marginal product of labor is, which itself largely depends on the product market structure. The congestion effect is stronger under variable markups compared to constant markups. To elaborate, an increase in either b_u or A reduces the marginal cost of firms (the right-hand side of equation (26)). The left-hand side of this equation, which reflects the marginal revenue product of labor, is increasing in θ, and is flatter under variable markups compared to constant markups. This is because an increase in θ reduces $q(\theta)$, employment, and production. A fall in employment raises the marginal revenue product of labor because of a downward-sloping demand, whereas a fall in production reduces markups, which in turn puts downward pressure on the marginal revenue product of labor. A flatter marginal revenue product of labor then implies that the same shock to the marginal cost reduces θ to a larger extent, magnifying the congestion effect. Figure D.1 plots the marginal revenue product of labor against employment to confirm that it is flatter under variable markups compared to constant markups.[16]

The intuition provided here is based on a partial equilibrium insight in which aggregate equilibrium objects (e.g., W) are given. However, Section 4 shows that this insight carries over to the general equilibrium, and our calibrated model in this section shows that markdowns fall and welfare rises with matching efficiency when product markets feature constant markups, whereas markdowns increase and welfare falls with A under variable markups.

[16] To this end, we used the Kimball aggregator specified in Section 4.

3.0.4 The effect on markups

The effect of labor market conditions A or b_u on markups depends on how these conditions influence firms' perceived demand elasticities, which in turn depends on firms' sizes. As discussed above, an increase in either A or b_u incentivizes firms to locate in less tight labor markets where they hire more labor, which in turn increases firms' sizes. As a result, markups tend to rise with an improvement in either A or b_u.

4 Calibration and counterfactual exercises

Thus far, our analysis has relied on partial equilibrium by fixing aggregate equilibrium objects. This section solves for the general equilibrium, calibrates the model, and performs counterfactual exercises. Appendix C.1 discusses the algorithm that we implement to solve for the general equilibrium of the model.

To quantify the model, we work with specific functional forms for the vacancy posting cost and the demand schedule. In particular, we assume vacancy posting cost is iso-elastic, i.e., $C(\nu) = \lambda\nu^{\alpha}$ with $\alpha > 1$ and $\lambda > 0$. On the demand side, we follow Klenow and Willis (2016)'s specification and assume an aggregator of the form

$$\Upsilon(x) = 1 + (\sigma - 1)\exp\left(\frac{1}{\varepsilon}\right)\varepsilon^{\frac{\sigma}{\varepsilon}-1}\left[\Gamma\left(\frac{\sigma}{\varepsilon}, \frac{1}{\varepsilon}\right) - \Gamma\left(\frac{\sigma}{\varepsilon}, \frac{x^{\frac{\varepsilon}{\sigma}}}{\varepsilon}\right)\right], \tag{31}$$

with $\sigma > 1$ and $\varepsilon \geq 0$ and where $\Gamma(\cdot,\cdot)$ is the upper incomplete gamma function.[17] Under this specification, the demand elasticity takes the following form

$$\epsilon(x) = \sigma x^{-\frac{\varepsilon}{\sigma}}. \tag{32}$$

Setting $\varepsilon = 0$ would reduce the demand system to the CES case.[18] This demand system has a choke price $\bar{p}$ common to all varieties ω such that for all prices $p(\omega) \geq \bar{p}$ we have $y(\omega) = 0$. Equations (4) and (31) imply that:

$$\bar{p} = P \times D \times \frac{\sigma - 1}{\sigma}\exp\left(\frac{1}{\varepsilon}\right). \tag{33}$$

Under the CES demand system, i.e., $\varepsilon \to 0$, we have $\bar{p} \to \infty$.

[17] Appendix A.3 shows that this demand structure satisfies the properties of the revenue function and demand structure that we have assumed thus far.

[18] Notice that a profit-maximizing firm facing the demand equation (4) would not increase x to a point where the demand elasticity falls below one, and therefore in equilibrium, we have $x < \sigma^{\frac{\sigma}{\varepsilon}}$ and $\epsilon(x) > 1$.

Table 1. Calibrated parameters

Parameter	Notation	Value
Panel A: Calibrated parameters to match data moments		
Demand elasticity parameter	σ	8.81
Demand elasticity parameter	ε	7.27
Vacancy posting cost (elasticity)	α	1.01
Vacancy posting cost (scale)	λ	1.11
Panel B: Fixed parameters		
Pareto distribution (scale)	z_m	1
Pareto distribution (shape)	κ	2.1
Fixed entry cost	f_e	0.1
Fixed production cost	f	0
Matching function efficiency	A	0.5
Unemployment benefit	b_u	0
Inverse Frisch elasticity of labor supply	ξ	1
Disutility from working	χ	1

Note: This table presents the calibrated parameters in the model. Panel A presents the parameters calibrated by moment matching. Panel B reports the parameters that we fix in the calibration process.

Table 2. Targeted Moments

Moments	Data	Model
Median markdown	1.36	1.33
Average markdown	1.53	1.58
Sales-weighted median markup	1.2	1.16
Sales-weighted average markup	1.6	1.52

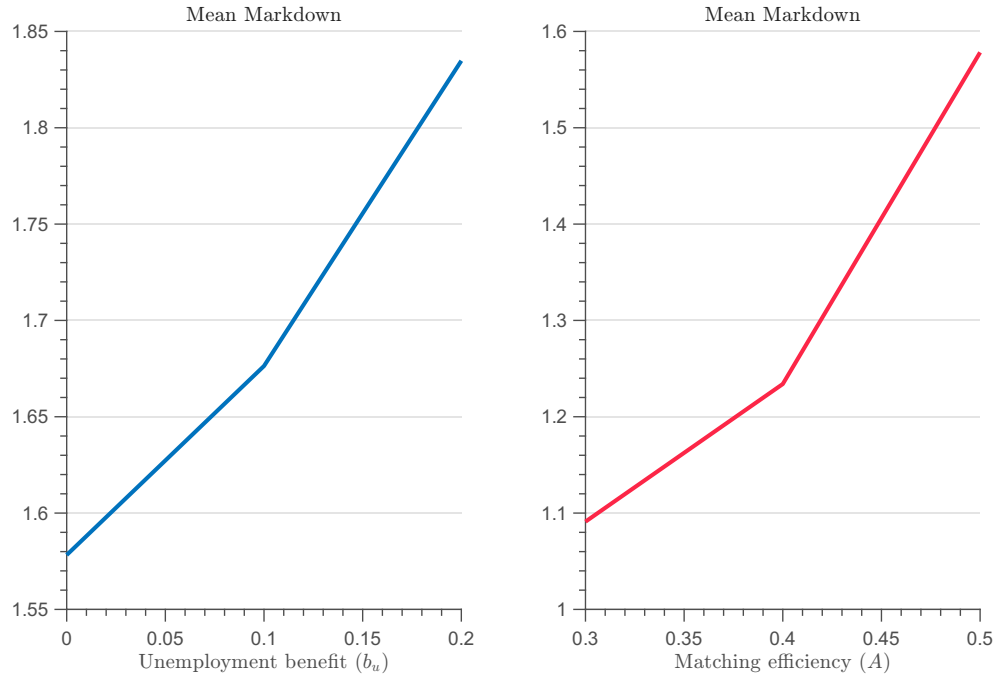
Note: This table reports the targeted data moments and their model counterparts.

4.1 Calibration

We use Simulated Method of Moments to calibrate the model. To elaborate, we solve for the general equilibrium of the model and choose parameters to minimize the distance between a set of model moments and their data counterparts. We jointly calibrate four parameters in Panel A of Table 1 to match four moments presented in Table 2. Our targeted moments include moments of the markup and markdown distribution in the U.S. In particular, we target the median and mean of markdowns using the estimates in Yeh, Macaluso and Hershbein (2022). Moreover, we target the sales-weighted average and median markups in the U.S. estimated in De Loecker, Eeckhout and Unger (2020).

Although all parameters of the model are jointly calibrated, a particular set of mo-

Figure 1. Mean Markdown



ments play a key role in estimating each particular parameter. To elaborate, demand elasticity parameters σ and ε govern the distribution of markups. In addition, as discussed in Proposition 1, the vacancy positing cost elasticity α influences the dispersion of markdowns (and markups), whereas the scale of the vacancy posting cost function, λ, governs the level of markdowns.

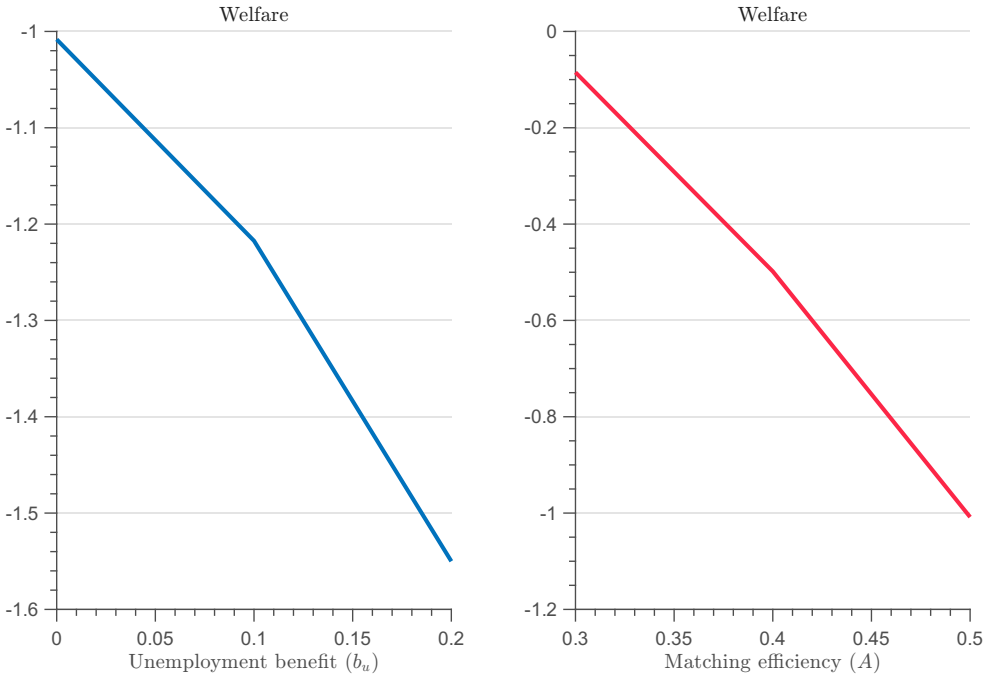
4.2 Counterfactual exercises

To examine model mechanisms in the general equilibrium, we employ our calibrated model, solve for the general equilibrium, and investigate how changes in labor market conditions b_u and A affect markdowns and welfare.

Figure 1 shows how the average markdown respond to changes in unemployment insurance benefits b_u and matching efficiency A. Both panels show that an improvement in either b_u or A increases the average markdown, suggesting that the congestion effect dominates the shielding effect. Appendix Figures D.2 and D.3 plot the median markdown and sales-weighted average markdowns, respectively, and show that both of these measures also rise in response to an increase in either unemployment benefits or matching efficiency.

The responses of markdowns to labor market conditions also influence consumers' welfare. In particular, the rise in markdowns in response to an increase in either matching efficiency or unemployment benefits implies that firms constrain their production

Figure 2. Welfare



in response to these policies, which has implications for welfare and consumption. As Figure 2 presents, welfare falls in response to these policies, and this fall is in part coming from a fall in consumption, as Figure 3 shows. We note that although welfare falls with an improvement in matching efficiency, unemployment falls in response to an increase in A, as Appendix Figure D.4 shows.

4.3 The role of product market power

As discussed in Section 3, the strength of the congestion effect depends on the product market structure. In this section, we show that in product markets that do not feature strategic complementarity, markdowns fall with an increase in either b_u or A, because the shielding effect dominates the congestion effect. We perform this exercise in two different ways. First, we simply shut down the variable markup channel in our calibrated baseline model, leaving all other parameters fixed. In particular, we set $\varepsilon = 0$ but employ other parameters as in Table 1. Figure 4 shows that in this model markdowns fall in response to an increase in either b_u or A. This reduction in markdowns leads to higher welfare, as Figure 5 presents.

In the exercise above, because we did not re-calibrate the model, the model generates markdowns that are larger than those in the data and in our baseline model. To avoid this issue, in the second exercise, we impose constant markups and recalibrate the model. In particular, we set $\varepsilon = 0$ and recalibrate the rest of the parameters in Panel

Figure 3. Consumption

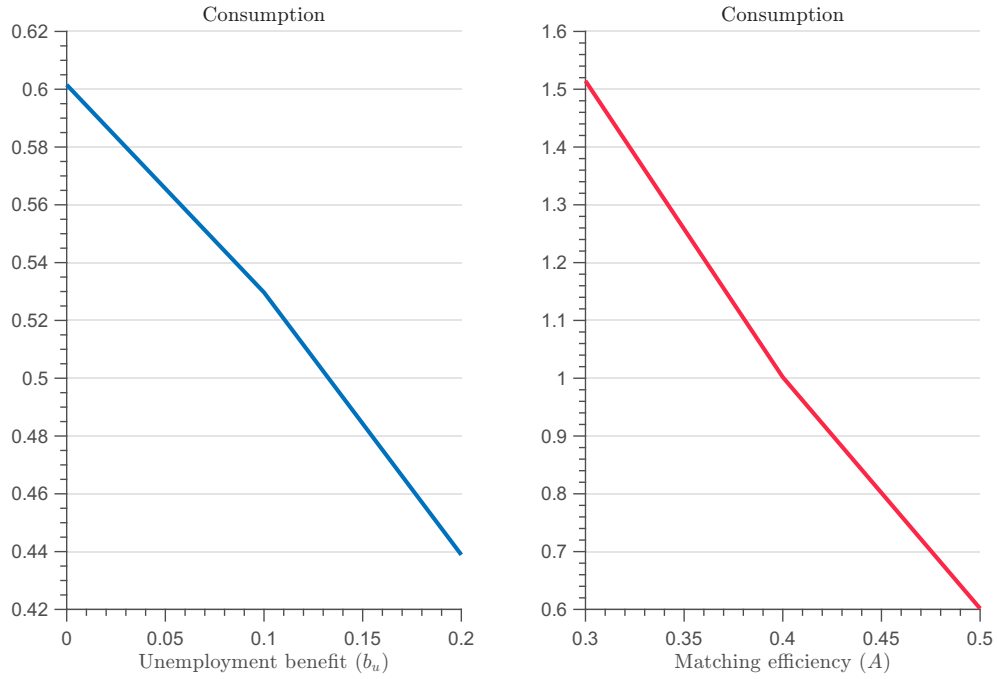
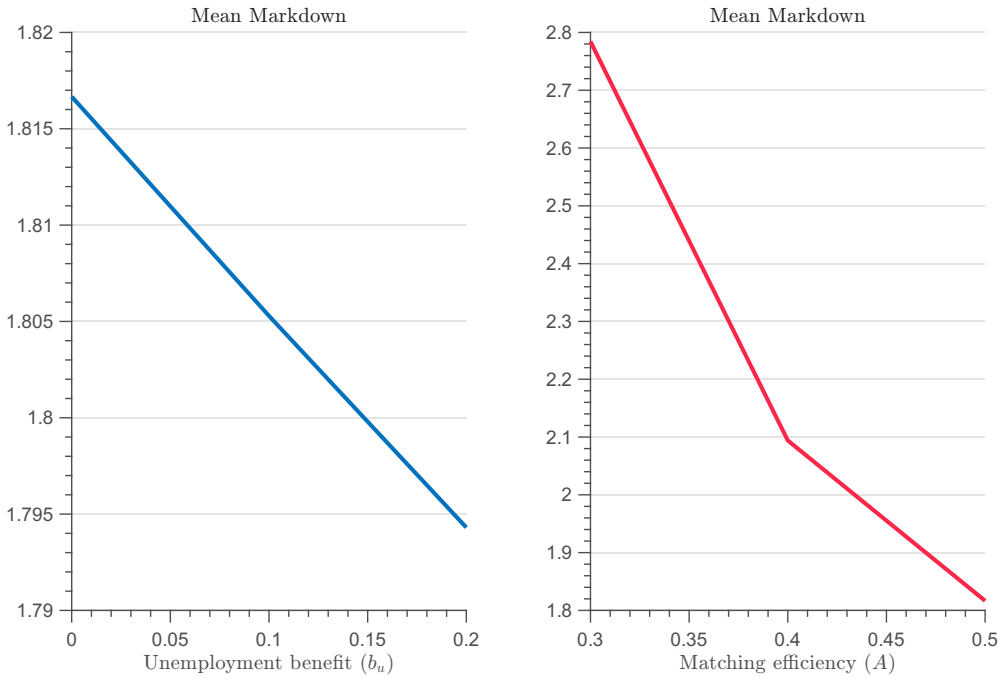


Figure 4. Markdowns (constant markups)



A of Table 1 to match the following three moments in Table 2: median and mean of markdowns as well as sales-weighted mean of markups. Figures 6 and 7 show that our main results still hold: without strategic complementarities in product markets,

Figure 5. Welfare (constant markups)

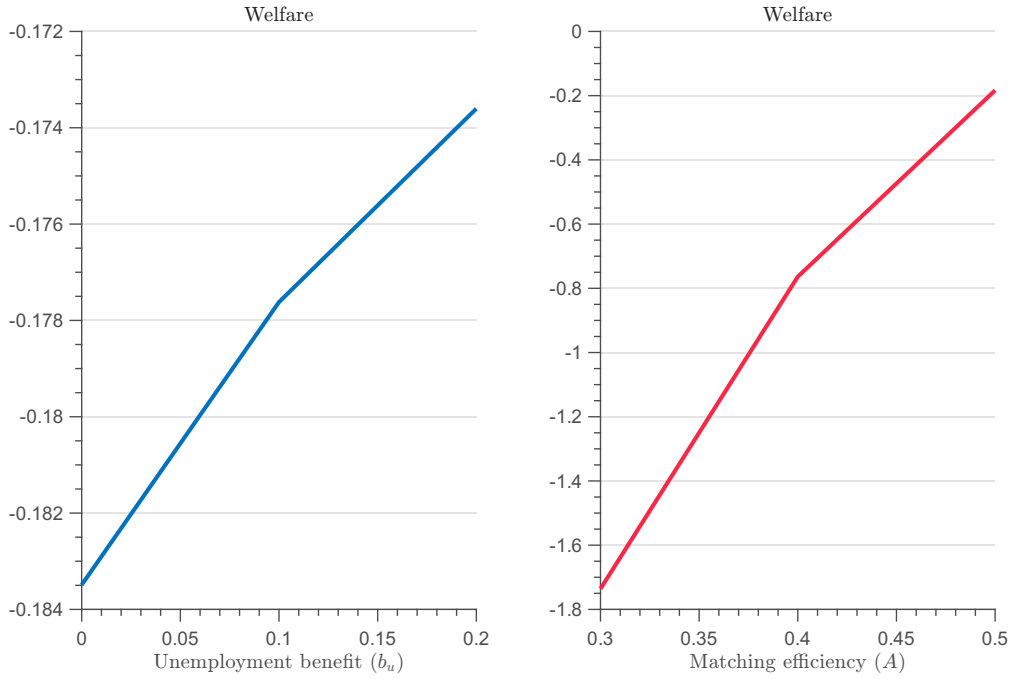
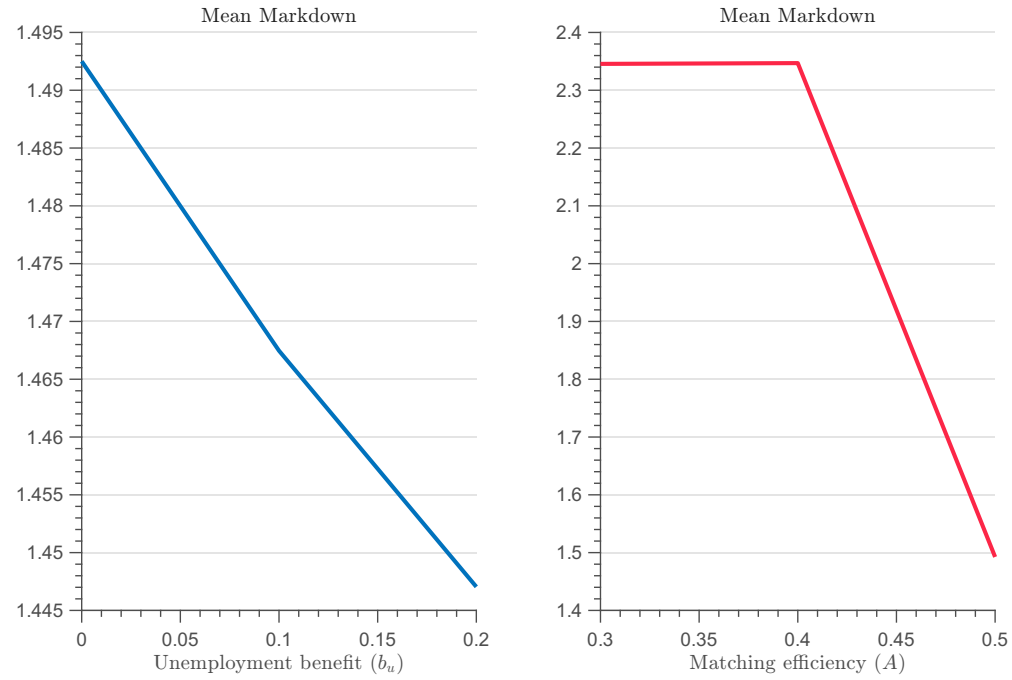


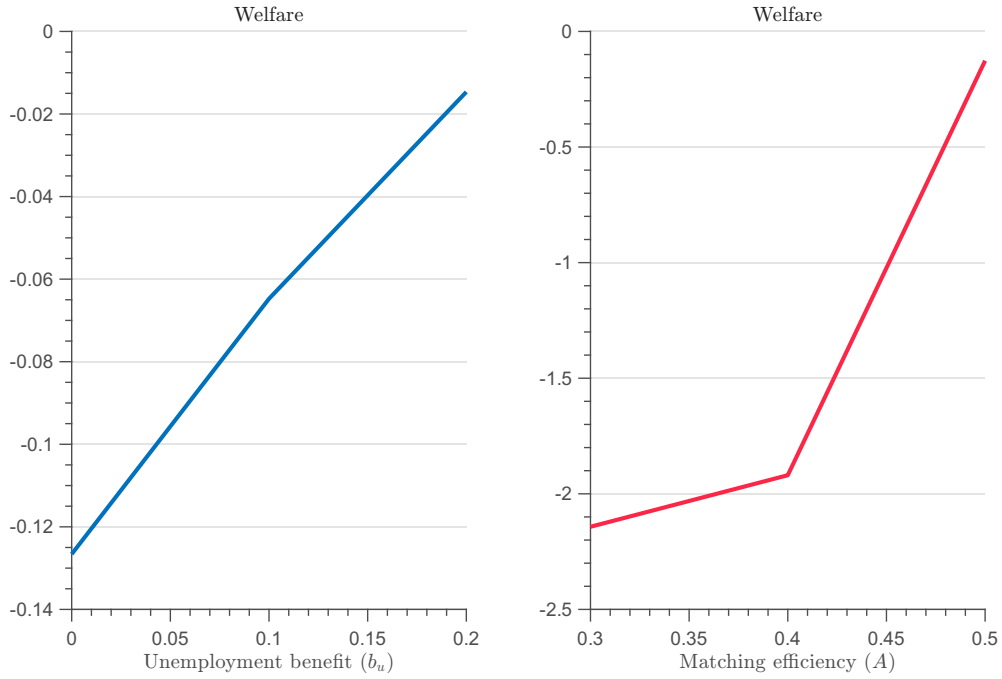
Figure 6. Markdowns (constant markups with recalibration)



markdowns fall and welfare rises with an increase in either unemployment insurance benefits or matching efficiency.

Our results, therefore, shed light on the effectiveness of labor market policies aimed

Figure 7. Welfare (constant markups with recalibration)



at reducing markdowns and increasing welfare, and highlight the importance of product market structure in designing such policies. Specifically, through the lens of our model, increasing unemployment insurance policies or matching efficiency is a welfare-improving policy that reduces labor market power only in product markets without strategic complementarities.

5 Empirical evidence

We now provide empirical evidence supporting our theoretical analysis. We show, through the lens of three empirical exercises, that markdowns increase with outside options. These results are in line with the congestion effect dominating the shielding effect.

5.1 Data and policy setting

We use administrative linked employer-employee data from Hungary. The data include employment and benefit take-up histories of half of the country's population from 2003 to 2017.[19] We observe individuals' employers, wages, occupations, unemployment and

[19]Complete histories of individuals born on 01-01-1927, 01-03-1927, and every other day thereafter are observed. DellaVigna et al. (2017) calls this sampling scheme "de facto random."

social assistance benefits, and demographic characteristics (gender, age, and geographical location) on a monthly basis. These data allow us to calculate the amount of unemployment insurance benefits (UIB) that individuals are eligible for: we calculate this amount as 60 percent of workers' mean wage in the preceding three years, capped at the minimum wage.[20] We use this eligible UIB amount as a proxy for the outside option of incumbent workers.

On the employer side, we have annual balance sheet data including input and output measures (such as headcount, wage bill, capital, and sales) as well as the industry and geographical location of firms. For now, we use sales/wage bill as a proxy for firms' markdowns.[21]

We exploit an exogenous change in the UI system for some of our empirical exercises. The UI system changed from a one-tier to a two-tier system in Nov 2005. While the total UIB amount remained the same, the benefit path was frontloaded: unemployed individuals received benefits with a flat replacement rate for nine months before the policy change, but higher benefits for the first three months and a lower amount for the remaining six months after the policy change (see DellaVigna et al., 2017, for further details). This change provides exogenous, policy-induced variation in the outside option of workers before vs. after Nov 2005. As DellaVigna et al. (2017) shows, unemployed individuals exit unemployment at a faster rate when benefits are about to run out; therefore, incumbent workers expect to stay out of a job for a shorter amount of time after the policy change, which effectively increases their outside option of employment.

5.2 Results

We now provide three pieces of evidence that support the implications of our model. First, we look at the overall relationship between markdowns (calculated as sales over wage bill) and outside options (proxied by eligible unemployment insurance benefits). Table 3 shows that markdowns increase with eligible UIB: we measure an elasticity of 22.6 percent in our preferred specification (Column 5).

Although this evidence suggests a positive relationship, one might be concerned about wage endogeneity: markdowns and eligible UIB amounts are both determined by the wages of incumbent workers. To dispel this concern, we zoom in on outside options around the exogenous change in Hungary's UI system in Nov 2005. We perform two additional exercises: how wages of newly entering workers change around the policy and how markdowns change at the firms they enter. Both of these exercises follow a regression discontinuity (RD) design with a two month window around the policy

[20] While there are further nuances in the Hungarian unemployment insurance system, this approximation of the eligible UIB amount is roughly correct; see the Hungarian Labor Market Yearbook series (starting in 2000) for details.

[21] We will more systematically estimate markdowns following Yeh, Macaluso and Hershbein (2022).

Table 3. Markdowns increase with eligible UIB amount

Dep. var.: Log markdown	(1)	(2)	(3)	(4)	(5)
Log eligible UIB	0.142***	0.212***	0.249***	0.197***	0.226***
	(0.028)	(0.039)	(0.027)	(0.038)	(0.026)
N obs	169,809,649	169,809,649	169,808,213	169,103,475	169,102,039
Year FE (14 years)		Y	Y	Y	Y
Industry FE (17 industries)			Y		Y
Location FE (198 locations)				Y	Y
R^2	0.003	0.007	0.195	0.017	0.205
Within R^2	0.003	0.006	0.009	0.005	0.008

Notes: ***: p<0.001, **: p<0.01, *: p<0.05. Heteroskedasticity-robust standard errors clustered at the firm level in parentheses. Sample covers all workers from Jan 2003 to Dec 2017. *Source:* HUN–REN CERS, authors' own calculations.

Table 4. Wages rise in response to better policy-induced outside options

Dep. var.: Log wage	(1)	(2)	(3)	(4)	(5)
1(post)	0.326***	0.323***	0.263***	0.311***	0.254***
	(0.020)	(0.019)	(0.017)	(0.019)	(0.016)
Log headcount	0.056***	-0.058***	-0.076***	-0.046***	-0.062***
	(0.009)	(0.013)	(0.009)	(0.012)	(0.009)
Log sales		0.096***	0.092***	0.090***	0.086***
		(0.012)	(0.008)	(0.011)	(0.007)
Log capital		0.009	0.013*	0.007	0.010
		(0.009)	(0.006)	(0.008)	(0.006)
N obs	61,030	60,479	60,479	59,716	59,716
Industry FE (15 industries)			Y		Y
Location FE (198 locations)				Y	Y
R^2	0.066	0.096	0.198	0.124	0.221
Within R^2	0.066	0.096	0.066	0.093	0.062

Notes: ***: p<0.001, **: p<0.01, *: p<0.05. Heteroskedasticity-robust standard errors clustered at the firm level in parentheses. Sample covers workers who entered employment after being out of a job for at least two months between Sep 2005 and Dec 2005. *Source:* HUN–REN CERS, authors' own calculations.

Table 5. Markdowns rise in response to better policy-induced outside options

Dep. var.: Log markdown	(1)	(2)	(3)	(4)	(5)
1(post)	0.156***	0.120***	0.080***	0.120***	0.080***
	(0.040)	(0.023)	(0.017)	(0.022)	(0.016)
Log headcount	-0.068*	-0.874***	-0.813***	-0.874***	-0.812***
	(0.028)	(0.015)	(0.016)	(0.015)	(0.015)
Log sales		0.791***	0.727***	0.791***	0.736***
		(0.016)	(0.014)	(0.015)	(0.014)
Log capital		-0.044***	-0.031***	-0.043***	-0.031***
		(0.011)	(0.009)	(0.010)	(0.008)
N obs	101,750	101,640	101,640	100,430	100,430
Industry FE (15 industries)			Y		Y
Location FE (198 locations)				Y	Y
R^2	0.021	0.758	0.798	0.762	0.800
Within R^2	0.021	0.758	0.730	0.754	0.724

Notes: ***: p<0.001, **: p<0.01, *: p<0.05. Heteroskedasticity-robust standard errors clustered at the firm level in parentheses. Sample covers workers who entered employment after being out of a job for at least two months between Sep 2005 and Dec 2005. *Source:* HUN–REN CERS, authors' own calculations.

change, from Sep to Dec 2005.

In our second exercise, we compare the wages of workers who entered employment after being out of a job for at least two months right before vs. after the policy change. Intuitively, if unemployed individuals receive higher wages after the policy change, this is indicative of increased outside options for incumbent workers. Table 4 confirms this: wages are indeed higher after the policy change, by 25.4 percent after controlling for various firm characteristics (Column 5). Our third empirical exercise performs the same RD for markdowns instead of wages: Table 5 shows that unemployed individuals enter firms with 8.0 percent higher markdowns after the policy change (Column 5).

All three pieces of our empirical evidence point to markdowns increasing when workers have better outside options. These results are in line with the congestion effect dominating the shielding effect. The key implication of our model is that this happens under the presence of strategic complementarities in product markets, implying variable markups.

6 Conclusion

This paper examines the interplay between labor and product market power in frictional labor markets and shows that the effects of labor market frictions and policies on labor market power largely depend on the extent of product market power. We develop a tractable general equilibrium directed search model with multi-worker firms, incorporating cross-firm heterogeneous markups and markdowns. We analytically show

that an increase in unemployment benefits or matching efficiency affects firms' labor market power through two opposing forces: (i) a *shielding effect* reflecting that an improvement in labor market conditions provides a better outside option for workers, thereby reducing markdowns; and (ii) a *congestion effect* stemming from that these policies encourage firms to locate in less tight sub-markets, giving firms more labor market power due to low job finding probabilities in these sub-markets. We show that in the presence of strategic complementarities in product markets, the congestion effect is strong enough that markdowns rise in response to improved labor market conditions, resulting in welfare losses. In contrast, markdowns consistently decline and welfare rises with these policies when markups are constant. Our results therefore shed light on the effectiveness of labor market policies that aim to reduce markdowns for equality or efficiency reasons and point to the importance of product market structure in designing such policies. In particular, increasing matching efficiency is an effective policy to reduce labor market power in product markets that do not feature strategic complementarities, whereas the opposite policy is desirable in variable-markup product markets.

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Appendices

A Theory Appendix

A.1 Details of Firms' Vacancy Posting Problem

This section solves the profit-maximization problem (14). We start by writing the first-order-conditions with respect to the number of vacancies ν and the choice of sub-market θ for a firm with productivity z. These are given by:

$$\{\nu\} : R_\ell\left(q\left(\theta\right)\nu; z\right) q\left(\theta\right) = \frac{W - b_u\left(1 - \theta q(\theta)\right)}{\theta} + C'\left(\nu\right) \tag{34}$$

$$\{\theta\} : R_\ell\left(q\left(\theta\right)\nu; z\right) q'\left(\theta\right) = \frac{b_u(1 + \theta^2 q'(\theta)) - W}{\theta^2}, \tag{35}$$

where $R_\ell(\cdot)$ is the firm's marginal revenue product of labor.

We use equation equation (12) to eliminate W from equation equation (35), and then divide both side by $w(\theta)$ to obtain:

$$\frac{R_\ell\left(q\left(\theta\right)\nu; z\right)}{w\left(\theta\right)} = \frac{1}{\eta(\theta)} - \frac{b_u}{w\left(\theta\right)}\frac{1 - \eta(\theta)}{\eta(\theta)}. \tag{36}$$

Equation (36) shows that firms paid workers wages that are a markdown on their MRPL.

We combined equations equation (34) and equation (35), we obtain:

$$\theta = \frac{W - b_u}{C'(\nu)}\frac{1 - \eta(\theta)}{\eta(\theta)}. \tag{37}$$

Equations (36) and (37) jointly determined the optimal choices of ν and θ.

Properties of the choice of sub-market θ Take equation (35), and simplify terms to obtain

$$R_\ell\left(q\left(\theta\right)\nu; z\right) = b_u + \frac{W - b_u}{A\eta\left(\theta\right)^2}. \tag{38}$$

Given that $A \leq 1$ and $\eta(\theta) < 1$, an increase in b_u reduces the right-hand. Therefore, the left-hand side of this equation must fall too.

As Appendix A.2 shows, firm's employment $q(\theta)\nu$ falls with θ. Hence, since $R_{\ell\ell}(.) < 0$, for the left-hand side to fall we must have θ falling. Therefore, we can conclude that θ is decreasing in b_u. A similar argument proves that θ also falls with matching efficiency A.

We note that the argument above implies that the response of θ to either b_u or A

depends on how the marginal revenue product of labor varies with employment, which depends on the product market structure.

We note that the choice of sub-market θ satisfies $\frac{\partial^2 \theta}{\partial b_u \partial A} > 0$. This property is important when computing the *shielding* and *congestion* effects.

As we showed before, the reason why θ falls with either A or b_u is that the right-hand side of equation (38) falls with either of these parameters. The fall in the right-hand side of equation (38) with A (b_u) is larger when b_u (A) is smaller:

$$\frac{\partial^2 \left(b_u + \frac{W - b_u}{A\eta(\theta)^2} \right)}{\partial A \partial b_u} = \frac{1}{A^2 \eta(\theta)^2} > 0. \tag{39}$$

Properties of the firm markdown. We show that the markdown function satisfies the following properties:

$$\frac{\partial^2 \mu^n(\theta)}{\partial \theta \partial A} > 0, \quad \frac{\partial^2 \mu^n(\theta)}{\partial \theta \partial bu} > 0.$$

First, we take the derivative of equation (23) with respect to θ, we obtain:

$$\frac{\partial \mu^n(\theta)}{\partial \theta} = \frac{-1}{\theta^2} + \frac{A b_u \eta'(\theta)(W - b_u(1 - A))}{[W - b_u(1 - A\eta(\theta))]^2}. \tag{40}$$

Taking the derivative with respect to A delivers

$$\frac{\partial^2 \mu_n}{\partial \theta \partial A} = \frac{b_u \left(W - b_u\right) \eta'(\theta) \left[W - b_u + b_u A \left(2 - \eta(\theta)\right) \right]}{[W - b_u(1 - A\eta(\theta))]^3} > 0, \tag{41}$$

where we use that $\eta'(\theta) = \frac{1}{(\theta+1)^2} > 0$, $W > b_u$, and $\eta(\theta) < 1$.

Taking the derivative of equation (40) with respect to b_u, we obtain:

$$\frac{\partial^2 \mu_n}{\partial \theta \partial b_u} = \frac{A\, W\, \eta'(\theta) \left[W - b_u + b_u A \left(2 - \eta(\theta)\right) \right]}{[W - b_u(1 - A\eta(\theta))]^3} > 0. \tag{42}$$

A.2 Proof of Proposition 2

We start by proving that more productive firms operate in less tight labor markets. For this we use the functional form of $\eta(\theta)$, equation (11), into equation (37), we obtain:

$$C'(\nu) = \frac{W - b_u}{\theta^2}. \tag{43}$$

With a strictly convex vacancy posting cost function, this equation implies an inverse relationship between the number of vacancies posted by firms and the tightness of the labor market in which they choose to operate. Furthermore, since the vacancy filling rate $q(\theta)$ also falls with θ, we have that firms that choose to locate in tighter labor

markets (higher θ) hire fewer workers, $\ell = q(\theta)\nu$.

Take now equation (38). Since the MRPL is a decreasing function of the number of workers, the left-hand side of this equation is an increasing function of θ. The right-hand side of this equations instead decreases with θ. Hence, if a solution for θ exists, it is unique. Because the marginal revenue product of labor increases with z, equation (38) implies that θ falls with z. We can therefore conclude that more productive firms operate in less tight labor markets.

From equation equation (13) we know that wages are decreasing in θ, and therefore more productive firms pay higher wages too.

Furthermore, since both the vacancy filling rate and the number of vacancies decrease as θ increases, more productive firms hire more workers and produce more output.

To analyze the relationship between firm productivity and market power we note that our demand system satisfy Marshall's second law of demand, and because more productive firms produce more output it follows that they also charge higher markups.

Markdowns are given by equation (17). Substituting in equation equation (11) and the labor supply equation, we obtain:

$$\mu^n(\theta) = \frac{\frac{(\theta+1)(W-b_u)}{A}\frac{\theta+1}{\theta} + \theta b_u}{\frac{(\theta+1)(W-b_u)}{A} + \theta b_u}, \tag{44}$$

which is decreasing in θ. Since more productive firms choose a less tight labor market, they have more monopsony power and higher markdowns.

To conclude the proof, we examine how firms' profits vary with z. The profits of a firm with productivity z are given by

$$\pi(z) = R(\ell; z) - w\ell - C(\nu). \tag{45}$$

We use the first-order condition with respect to ν, equation (34), to eliminate the wage bill, and operate with the revenue function to re-write profits as[22]

$$\pi(z) = \frac{1}{\epsilon\left(\frac{z\ell}{Y}\right)} R(\ell; z) + C'(\nu)\nu - C(\nu). \tag{47}$$

Because more productive firms generate higher revenues and produce more output the first term in equation (47) rises with z. Moreover, the vacancy cost function is convex which implies that the sum of the second and third term increase with ν, and therefore with the productivity level z.

[22] We use that the firm revenue can be written as

$$R_\ell(\ell; z) = \frac{R(\ell; z)}{\ell}\left(1 - \frac{1}{\epsilon\left(\frac{z\ell}{Y}\right)}\right). \tag{46}$$

A.3 Deriving the Kimball Demand System

The demand for intermediate inputs is the solution to the problem:

$$\max_{y_\omega, Y} \quad PY - \int_{\omega\in\Omega} p_\omega y_\omega d\omega, \qquad \text{s.t.} \quad 1 = \int_{\omega\in\Omega} \Upsilon\left(\frac{y_\omega}{Y}\right) d\omega$$

The first-order conditions of this problem with respect to good variety ω and total output are:

$$P = \frac{\gamma}{Y}\int_{\omega\in\Omega} \Upsilon'\left(\frac{y_\omega}{Y}\right)\frac{y_\omega}{Y} d\omega \tag{48}$$

$$p_\omega = \gamma \Upsilon'\left(\frac{y_\omega}{Y}\right)\frac{1}{Y} \tag{49}$$

where γ denotes the Lagrange multiplier.

Define the demand shifter D as,

$$D \equiv \left[\int_{\omega\in\Omega} \frac{y(\omega)}{Y}\Upsilon'\left(\frac{y(\omega)}{Y}\right) d\omega\right]^{-1}. \tag{50}$$

Then, combining equations (48) and (49) and using the definition of D, we obtain the following demand function:

$$y_\omega = H\left(\frac{p_\omega}{P\times D}\right) Y, \tag{51}$$

where $H(\cdot) \equiv [\Upsilon']^{-1}(\cdot)$.

Note now, that multiplying both side of equation (49) by y_ω and integrating across all varieties ω, we obtain

$$\int_{\omega\in\Omega} p_\omega y_\omega d\omega = PY.$$

Therefore, the demand shifter D and the price P jointly solves:

$$P = \int_{\omega\in\Omega} p_\omega H\left(\frac{p_\omega}{P\times D}\right) d\omega, \tag{52}$$

$$1 = \int_{\omega\in\Omega} \Upsilon\left(H\left(\frac{p_\omega}{P\times D}\right)\right) d\omega.$$

With CES production function, $\Upsilon(x) = x^{\frac{\sigma-1}{\sigma}}$, and so equation (52) reduces to:

$$P^{1-\sigma} = \left(\frac{\sigma-1}{\sigma}D\right)^{\sigma}\int_{\omega\in\Omega} p_\omega^{1-\sigma} d\omega, \qquad 1 = \left(\frac{\sigma-1}{\sigma}D\right)^{\sigma-1}\int_{\omega\in\Omega}\left(\frac{p_\omega}{P}\right)^{1-\sigma},$$

The solution to these equations is clearly $D = \frac{\sigma}{\sigma-1}$ with P being the standard ideal price index. Since final good producers are perfectly competitive, the price of the final goods equals its marginal cost of production.

The elasticity of demand is defined as:

$$\epsilon_\omega \equiv -\left[\frac{\partial p_\omega}{\partial y_\omega}\frac{y_\omega}{p_\omega}\right]^{-1}.$$

Using the functional form in equation (4) it follows that:

$$\epsilon_\omega = -\frac{\Upsilon'\left(\frac{y_\omega}{Y}\right)}{\Upsilon''\left(\frac{y_\omega}{Y}\right)\frac{y_\omega}{Y}}.$$

We note that for each variety ω the demand elasticity is a function of the relative quantity $x_\omega \equiv y_\omega/Y$. Therefore, we abuse notation and from now on we write the demand elasticity as in equation (6):

$$\epsilon(x) = -\frac{\Upsilon'(x)}{\Upsilon''(x)\,x}. \tag{53}$$

Klenow and Willis (2016)'s Specification. In Section 4, we work with Klenow and Willis (2016) specification of demand equation (31).[23] Under this preferences we have

$$\Upsilon'(x) = \frac{\sigma-1}{\sigma}\exp\left(\frac{1}{\varepsilon}\right)e^{-x^{\frac{\varepsilon}{\sigma}}{}_{\varepsilon}}, \qquad \Upsilon''(x) = -\frac{\sigma-1}{\sigma}\frac{1}{\sigma}\exp\left(\frac{1}{\varepsilon}\right)e^{-x^{\frac{\varepsilon}{\sigma}}{}_{\varepsilon}}x^{\frac{\varepsilon}{\sigma}-1}. \tag{54}$$

Substituting this back into equation (53) yields equation (32)

$$\epsilon(x) = \sigma x^{-\frac{\varepsilon}{\sigma}}. \tag{55}$$

Furthermore, under the Klenow and Willis (2016) specification the demand equation has a choked-price $\bar{p}$, such that $y(\bar{p}) = 0$. The choked-price is given by:

$$\bar{p} = P \times D \times \frac{\sigma-1}{\sigma}\exp\left(\frac{1}{\varepsilon}\right). \tag{56}$$

Finally, it is straightforward to show that whenever $\varepsilon \to 0$ the demand elasticity converges to $\epsilon(x) \to \sigma$ for all values of x, the demand shifter converges to $D = \frac{\sigma}{\sigma-1}$ while the choke-price converges to $\bar{p} \to +\infty$ consistent with a CES demand system.

[23] The upper incomplete gamma function is given by,

$$\Gamma(s,x) = \int_x^\infty t^{s-1}e^{-t}dt.$$

A.4 Properties of the Marginal Revenue Product of Labor

In this section, we prove two properties of the marginal revenue product of labor (MRPL) under Klenow and Willis (2016) demand specification. We show that the MRPL is (i) decreasing in the units of labor hired by the firm ℓ; and (ii) is increasing in the firm productivity value z for range of values of the firm relative output x. This second property is at odds with more standard production functions where the marginal revenue product of labor is strictly increasing in z.

(i) MRPL falls with ℓ. Using the demand schedule and the definition of demand elasticity, the marginal revenue product of labor for a firm with productivity z can be written as

$$R_\ell(\ell; z) = PDz\left[1 - \frac{1}{\epsilon(x)}\right]\Upsilon'(x), \tag{57}$$

where $x = z\ell/Y$, and $\Upsilon'(x)$ and $\epsilon(x)$ are given by equation (54) and (55), respectively.

First, we note that $\Upsilon'(x) > 0$ for all values of x. Therefore the MRPL becomes non-positive for all $x \geq \sigma^{\frac{\sigma}{\varepsilon}}$. However, a monopolist would never choose to produce in the region where $\epsilon(x) < 1$, so from now on we focus on the range $x \in \left[0, \sigma^{\sigma/\varepsilon}\right]$. In this range of values $R_\ell(\ell; z) > 0$.

The derivative of the marginal revenue product of labor with respect to labor is given by

$$R_{\ell\ell}(\ell; z) = -\frac{PD}{Y}z^2\Upsilon'(x)\frac{1}{\epsilon(x)}\frac{1}{x}\left(1 - \frac{1}{\sigma}x^{\frac{\varepsilon}{\sigma}} + \frac{\varepsilon}{\sigma}\right). \tag{58}$$

Since $1 - \frac{1}{\sigma}x^{\frac{\varepsilon}{\sigma}} + \frac{\varepsilon}{\sigma} > 0$ for all $x < \sigma^{\frac{\sigma}{\epsilon}}$ we have that $R_{\ell\ell}(\ell; z) < 0$ for all values of ℓ. We conclude that the marginal revenue product of labor decreases with ℓ.

(ii) MRPL rises with z, for low values of x. Taking the derivative of the marginal revenue product of labor in equation (57) with respect to z delivers[24]

$$R_{\ell z}(\ell; z) = -\frac{D}{\sigma}\Upsilon'(x)\left(-\sigma + \frac{2\sigma + \varepsilon}{\sigma}x^{\frac{\varepsilon}{\sigma}} - \frac{1}{\sigma}x^{2\frac{\varepsilon}{\sigma}}\right). \tag{59}$$

The sign of equation (59) depends on the sign of the term inside the bracket. Let $w \equiv x^{\frac{\varepsilon}{\sigma}}$, and define the function $h(w)$ as:

$$h(w) = -\sigma + \frac{2\sigma + \varepsilon}{\sigma}w - \frac{1}{\sigma}w^2. \tag{60}$$

The function $h(w)$ is a concave parabola that satisfies: (i) since $x \in [0, \sigma^{\sigma/\varepsilon}]$, its domain is bounded between $w \in [0, \sigma]$; (ii) it attains its maximum at $w_{max} = \sigma + \frac{\varepsilon}{2} > \sigma$, and therefore $h(w)$ is increasing in its domain; and (iii) there exists $w_0 \in (0, \sigma)$ such that

[24] We used that $z\frac{\partial x}{\partial z} = x$, and the formula for the demand elasticity in equation (55).

$h(w_0) = 0$.[25] It follows that the MRPL decreases with z for all $x \in [w_0^{\sigma/\varepsilon}, \sigma^{\sigma/\varepsilon}]$.

B Empirical Appendix

[TBD]

C Quantitative Appendix

C.1 Computing the closed-economy equilibrium

The following steps describe the algorithm we use to find the equilibrium of the model. We normalize $P = 1$ and start by guessing values for the number of entrants M_0^e, the demand shifter D_0, total production in the final good sector Y_0, and the value of search W_0.

Step 1: The first step is to find the cut-off productivity above which firms decide to produce, z^*. We guess a value z^* and solve for the optimal choices for a firm with productivity z^*.

1. We first solve for the sub-market that this firm chooses. The profit-maximization problem delivers the following FOC:

$$R_\ell(\ell; z^*) = b_u + \frac{W_0 - b_u}{A\eta(\theta)^2}, \tag{61}$$

where $\ell = q(\theta)\nu$, and ν is given by

$$\nu = \left(\frac{W_0 - b_u}{\alpha\lambda\theta^2}\right)^{\frac{1}{\alpha-1}}. \tag{62}$$

The LHS and RHS of equation (61) are increasing and decreasing in θ, respectively. As θ goes from zero to infinity, the RHS goes from infinity to $\frac{W_0+(A-1)b_u}{A}$. For the LHS, as Appendix A.4 shows, the marginal revenue product of labor can be written as

$$R_\ell(\ell; z) = D_0\Upsilon'(x)\frac{\epsilon(x) - 1}{\epsilon(x)}z. \tag{63}$$

As $\theta \to 0$, ℓ and x go to infinity and therefore $\epsilon(x)$ falls below one, making the MRPL negative. As θ goes to infinity, $\ell \to 0$, so $x \to 0$, so $\epsilon(x) \to \infty$, so $R_\ell(\ell; z) \to D_0 z^* \frac{\sigma-1}{\sigma}\exp(1/\varepsilon)$. Hence, if $D_0 z^* \frac{\sigma-1}{\sigma}\exp(1/\varepsilon) < \frac{W_0+(A-1)b_u}{A}$, the LHS

[25] Note that $h(0) = -\sigma$ and $h(\sigma) = \varepsilon$. The value of w_0 is given by $w_0 = \frac{(2\sigma+\varepsilon)-\sqrt{\varepsilon(4\sigma+\varepsilon)}}{2} > 0$.

and RHS do not intersect and we hence set a high $\theta(=1e8)$, which results in $y^* = 0$. Otherwise, we solve equation (61) for θ using a bisection method as we discuss below.

2. Given θ, we can compute firm's employment and output level using equation (62), and firm's price using the inverse demand equation.

3. Given these choices, we compute the profits using equation (14). If profits are equal to zero, we have found the productivity cutoff. Otherwise, we update our guess of z^* and iterate.

Step 2: We construct the grid of productivity values $z \geq z^*$ as outlined in Appendix C.2. For each grid value $z \geq z^*$ we compute the firm's optimal choices following similar steps outlined in **Step 1**.

Step 3: Construct aggregate variables using numerical integration:

$$\begin{aligned} T_1 &= M_0^e b_u \int_{z^*}^{\infty} \left(\frac{1}{\theta(z) q(\theta(z))} - 1 \right) \ell(z) g(z) dz, \\ C_1 &= W_0 L - T_1, \\ M_1 &= M_0^e (1 - G(z^*)). \end{aligned}$$

Step 4: We found an equilibrium if we satisfy our equilibrium conditions:

$$\begin{aligned} 0 &= L - M_0^e \int_{z^*}^{\infty} \frac{\ell(z)}{\theta(z) q(\theta(z))} g(z) dz \\ 0 &= P \times f_e - \int_{z^*}^{\infty} \pi(z) g(z) dz, \\ 0 &= D_0 - \left[M_0^e \int_{z^*}^{\infty} \Upsilon'(x(z)) x(z) g(z) dz \right]^{-1}, \\ 0 &= Y_0 - \left(C_1 + M_1 \times f + M_0^e \times f_e + M_0^E \times \int_{z_1^*}^{\infty} C(\nu_1(z)) g1(z) dz \right). \end{aligned}$$

Otherwise, we update (M_0^e, D_0, Y_0, W_0) and iterate.

C.2 Discretizing the Pareto distribution

To discretize the Pareto distribution and compute moments in the model we use the following procedure.

- We use the quantile function of Pareto distribution to construct the grid of values. Let num_q be the number of quantiles p we consider, i.e., the number of equally

spaced values between 0 and 1. Then the grid of values z_{grid} is given by:

$$z_{grid} = (1-p)^{-\frac{1}{\phi}} z_m,$$

where $\phi > 2$ and $z_m > 0$ are the shape and scale parameter.

- We use the p.d.f. of the truncated Pareto distribution to compute the density at each grid value, denoted with μ_{grid}.

D Additional Tables and Figures

Figure D.1. Marginal revenue product of labor: variable versus constant markups

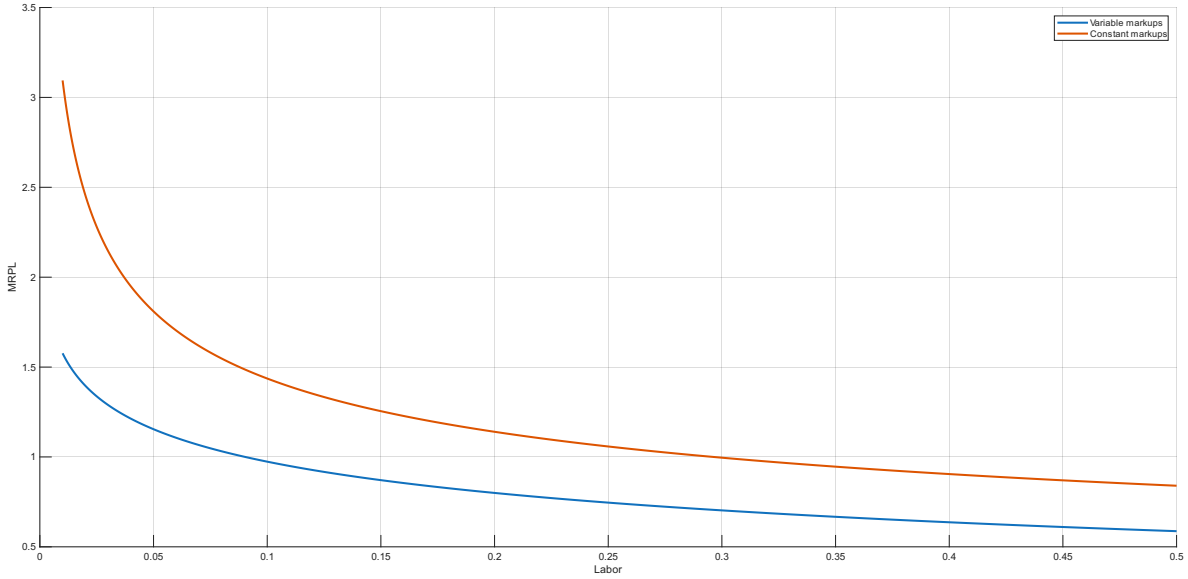


Figure D.2. Median Markdown

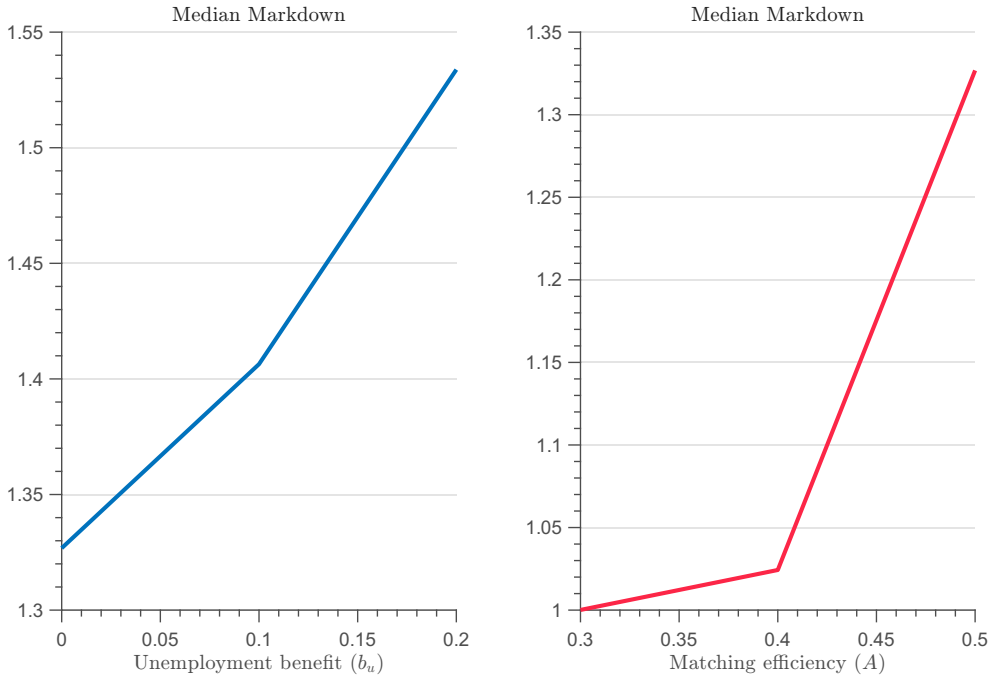


Figure D.3. Mean Markdown (sales weighted)

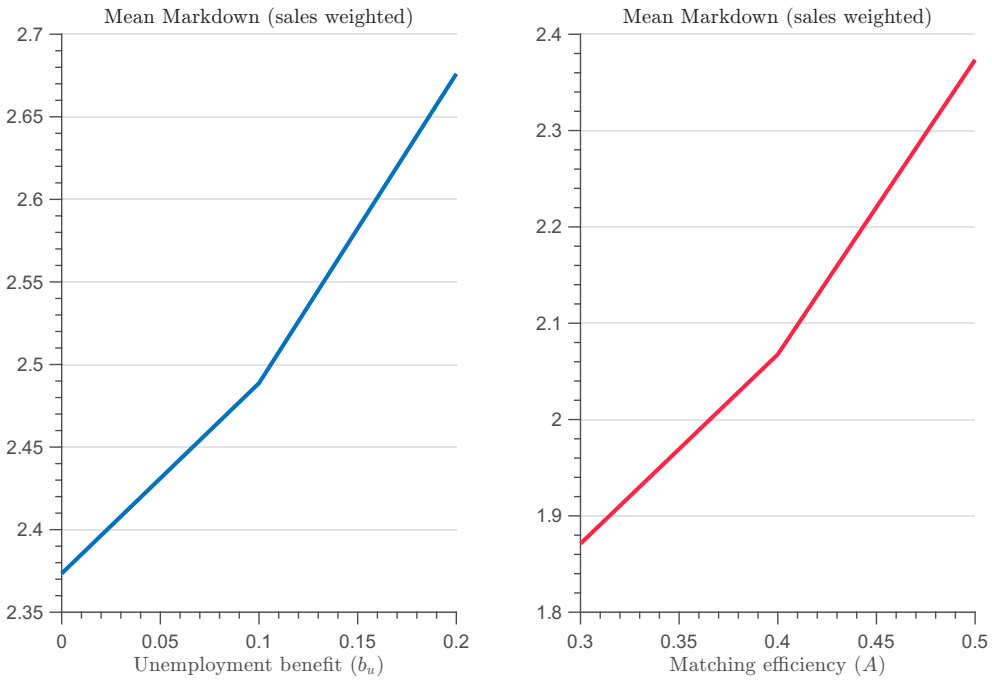


Figure D.4. Unemployment

