Labor and Product Market Power: Labor Market Policies in Frictional Markets*

Hamid Firooz† Agustín Gutiérrez‡

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Abstract

This paper examines the interplay between labor and product market power in frictional labor markets, focusing on the impact of labor market policies on firms' labor market power. We develop a tractable general equilibrium directed search model with multi-worker firms and monopolistic competition, with endogenously variable markups and markdowns. We analytically show that changes in matching efficiency or unemployment benefits influence firms' labor market power through two opposing forces: a *shielding effect*, which reduces markdowns by strengthening workers' outside options, and a *congestion effect*, which increases markdowns by encouraging firms to relocate to less tight labor markets. Our findings suggest that the efficacy of these policies in reducing labor market power depends critically on the product market structure. Specifically, in product markets with constant markups, increasing matching efficiency effectively reduces labor market power and increases welfare, while markdowns *rise* and welfare *falls* with matching efficiency when product markets feature strategic complementarities.

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

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†Federal Reserve Bank of San Francisco; email address: hmdfirooz@gmail.com

‡University of Wisconsin-Madison; email address: gutierrez25@wisc.edu

1 Introduction

Evidence on firms' market power in both labor and product markets across developed and developing countries is expanding.[1] Given the relatively large market power documented especially in the labor market, there is growing interest in labor market policies from both equality and efficiency perspectives.[2] This paper examines 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 on labor market power largely depend on the extent of product market power.

To this end, we develop a tractable general equilibrium directed search model with multi-worker heterogeneous firms, monopolistic competition, and free entry. Our model features heterogeneous markups and markdowns in product and labor markets, respectively.[3] Firms decide about wages and the number of vacancies to post. Job applicants observe posted wages and decide where to apply. Given a convex vacancy posting cost, more productive firms in equilibrium are located in less tight labor markets, hire more workers, pay higher wages, and charge higher markups as well as higher markdowns.

We investigate how changes in labor market characteristics influence labor market power, with a focus on the crucial role of product market power. Motivated by recent debates on the positive effects of improving workers' outside options to reduce firms' labor market power, we examine the impact of changes in either matching efficiency or unemployment benefits on firms' labor market power. Although matching efficiency or unemployment benefits are unconventional tools for addressing labor market power, they are widely recognized as key determinants of wages and, as such, potentially powerful instruments against firms' markdowns.

We analytically show that an increase in matching efficiency or unemployment benefits affects firms' labor market power through two opposing forces: a *shielding effect*, which reduces markdowns, and a *congestion effect*, which increases them. The shielding effect arises because improvements in labor market conditions, such as enhanced matching efficiency or higher unemployment benefits, strengthen workers' outside options against low-wage offers from firms, thereby reducing the labor market power that firms can exert.[4] The congestion effect, in contrast, stems from that an increase in matching efficiency or unemployment benefits incentivizes firms to locate in less tight sub-markets, where lower job-finding probabilities grant firms greater labor market power. Additionally, we show that both the shielding and congestion effects of in-

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

[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 with markdowns larger than one.

[4] A comparable argument concerning workers' outside options also applies in other contexts, such as self-employment, as discussed in Amodio, Medina and Morlacco (2022).

creased unemployment benefits are more pronounced in a less efficient labor market.

Whether the shielding or congestion effect dominates is an empirical question. To address this, we calibrate our model and perform counterfactual exercises. Specifically, we use the Simulated Method of Moments and target the median and mean of the markup and markdown distributions in the U.S. economy. Our model closely replicates these targeted moments and, although not explicitly targeted, produces an unemployment rate similar to that observed in the data. Counterfactual exercises reveal that, under our calibration, markdowns indeed rise with an increase in matching efficiency, indicating that the congestion effect dominates the shielding effect.

Importantly, we show that whether the congestion effect dominates the shielding effect—and, consequently, the overall impact of improving labor market conditions on markdowns—largely depends on the product market structure. Specifically, we shut down strategic complementarities in product markets and perform the same counterfactual exercises. Our results show that, in the absence of variable markups, labor market power declines with an improvement in matching efficiency, indicating that the shielding effect dominates the congestion effect. Furthermore, unemployment rate falls with matching efficiency regardless of the product market structure.

Our results indicate that the congestion effect is stronger under variable markups and dominates the shielding effect under our calibration. The intuition behind this result is as follows. An increase in matching efficiency or unemployment benefits puts upward pressure on wages and downward pressure on markdowns since workers have a better outside option—either due to higher matching efficiency, which makes finding a job easier, or due to higher unemployment benefits. This is the shielding effect of labor market conditions on markdowns. In response to this increase in marginal costs, firms relocate to less tight labor markets to save on vacancy posting costs, which constitutes the congestion effect. In product markets with strategic complementarities and variable markups, firms, especially larger ones, try to maintain their market shares by reducing their vacancy posting costs to a greater extent, leading them to relocate to less tight labor markets compared to firms in a constant-markup environment. This amplifies the congestion effect, causing it to dominate the shielding effect under our calibration.

Finally, the response of markdowns to labor market characteristics is important not only from an equality perspective but also from an efficiency standpoint. Specifically, in our baseline model with variable markups, the rise in markdowns in response to an increase in matching efficiency constrains firms' production and therefore reduces welfare. Under constant markups, however, welfare increases with matching efficiency due to a decline in markdowns.

Our results, therefore, shed light on the effectiveness of labor market policies aimed at reducing markdowns and highlight the importance of product market structure in designing such policies. Specifically, through the lens of our model, increasing matching

efficiency is a welfare-improving policy that reduces labor market power in product markets without strategic complementarities. In contrast, in variable-markup product markets, the opposite policy may be more desirable.

Our paper contributes to the fast-growing literature on labor market power. Existing studies document sizable labor market power in various contexts.[5] 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), with our paper belonging to the latter strand.[6] 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.[7]

We also contribute to the expanding literature examining joint market power in both labor and product markets (MacKenzie, 2021; Macedoni, 2022; Gutiérrez, 2022; 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.[8]

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*).[9] 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

[5]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 (2022); 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).

[6]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.

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

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

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

product market structure.

Our paper is also related to the literature studying macroeconomic effects of unemployment benefits extensions. 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).

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 concludes.

2 The model

2.1 Environment

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.

2.2 Consumers

Consumers have linear preferences over the final good. 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.

2.3 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

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

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 Kimball aggregator features a demand elasticity that is decreasing in $x(\omega) = y(\omega)/Y$, the relative quantity consumed

of the good. The constant elasticity of substitution (CES) technology that implies iso-elastic demand functions are nested by this specification and correspond to the case of $\Upsilon(x) = x^{\frac{\sigma-1}{\sigma}}$.

The production technology (1) implies the following demand function for variety ω[10]

$$p(\omega) = P \times D \times \Upsilon' \left(\frac{y(\omega)}{Y} \right), \tag{2}$$

where D is a demand shifter defined as

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

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 inverse demand elasticity of variety ω. Equation (2) implies that this elasticity is a function of the relative quantity consumed of variety ω, $x(\omega)$, and is given by

$$\epsilon(x) = -\frac{\Upsilon'(x)}{\Upsilon''(x)\, x}. \tag{4}$$

We assume that the demand system satisfies Marshall's second law of demand.

2.4 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

$$y(\omega) = z\ell(\omega). \tag{5}$$

To operate, firms must pay a fixed production cost $f > 0$.

We assume free entry. To enter the market, firms pay a cost f_e to draw their productivity z from a cumulative distribution function $G(z)$. Entry and fixed operation costs are both in units of final goods.

Taking the demand schedule (2) into account, we can write the revenue function of a firm with productivity z and l number of workers as

$$R(\ell; z) = P \times D \times \Upsilon' \left(\frac{z\ell}{Y} \right) z\ell. \tag{6}$$

We assume that the revenue function satisfies two regularity conditions: $R_{\ell,\ell} \leq 0$ and $R_{z,\ell} \geq 0$.

[10] We relegate derivations to Appendix A.

2.5 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 the 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

$$m(V(\theta), S(\theta)) = A \times \frac{V(\theta)S(\theta)}{V(\theta) + S(\theta)}, \tag{7}$$

where $A \in (0, 1]$ is a scale parameter representing the efficiency of the matching function.[11]

We let $q(\theta) \equiv m(V(\theta), S(\theta))/V(\theta)$ denote the vacancy filling rate. Given the matching function (7), the vacancy filling rate in sub-market θ is given by

$$q(\theta) = A \times \frac{1}{\theta + 1}, \tag{8}$$

which is decreasing in θ. The job finding rate is given by $\theta q(\theta)$, 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., $\eta(\theta) = -q'(\theta)\theta/q(\theta)$. Given the matching function equation (7), this elasticity is given by

$$\eta(\theta) = \frac{\theta}{\theta + 1}, \tag{9}$$

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

$$W = \theta q(\theta) w(\theta) + (1 - \theta q(\theta)) b_u, \tag{10}$$

where W is the value of search and b_u is the unemployment insurance benefit. We can rewrite equation (10) as

$$w(\theta) = \frac{W - b_u}{\theta q(\theta)} + b_u, \tag{11}$$

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.

[11] The matching function in equation (7) is known as the *Telephone-line* matching function. 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 setup.

2.6 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 (11). 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 $w(\theta)$ versus facing a low probability of filling vacancies $q(\theta)$.

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

$$\begin{aligned} \pi(z) = \max_{\theta,\nu} &\left\{R\left(q(\theta)\nu; z\right) - w(\theta)q(\theta)\nu - P \times C(\nu) - P \times f\right\} \\ \text{s.t. } w(\theta) &= \frac{W - b_u}{\theta q(\theta)} + b_u, \end{aligned} \tag{12}$$

with $C(\nu)$ being the vacancy posting cost in units of final goods.

Let $R_\ell(\cdot; z)$ denote the marginal revenue product of labor for a firm with productivity z. As Appendix D.1 shows, the first-order conditions for problem (12) imply the following two relationships for the number of vacancies and the choice of the sub-market

$$\frac{R_\ell\left(q\left(\theta\right)\nu; z\right)}{w\left(\theta\right)} = \mu^n(\theta), \tag{13}$$

and

$$C'(\nu) = \frac{W - b_u}{\theta}\frac{1 - \eta(\theta)}{\eta(\theta)}. \tag{14}$$

Equation (13) 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

$$\mu^n(\theta) = \frac{1}{\eta(\theta)} - \frac{b_u}{w\left(\theta\right)}\frac{1 - \eta(\theta)}{\eta(\theta)}. \tag{15}$$

Intuitively, firms take advantage of search frictions to exercise monopsony power over workers. Section 3 will discuss markdown properties in detail.

2.7 Properties of the vacancy posting problem

Equation (14) 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 $C'\left(\nu\right) = \lambda c$, equation (14) 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.[12] 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 D.2, characterizes the properties of the vacancy posting problem as a function of firms' productivity.

Proposition 2 *If vacancy posting costs are strictly convex, then more productive firms ($z_1 > z_2$): (i) post more vacancies ($\nu_1 > \nu_2$) and hire more workers ($\ell_1 > \ell_2$), (ii) locate in less tight labor markets ($\theta_1 < \theta_2$); (iii) pay higher wages ($w_1 > w_2$); (iv) have higher markdowns ($\mu_1^n > \mu_2^n$); (v) charge higher markups; and (vi) earn higher profits ($\pi_1 > \pi_2$).*

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.*

2.8 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 $z \geq z^*$ decide to operate. The free entry condition ensures that entry occurs until expected profits are equal to the entry cost

$$\int_{z^*}^{\infty} \pi(z) g(z) dz = P \times f_e. \tag{16}$$

[12] 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.

Labor market clearing. The total number of individuals searching for a job in equilibrium is equal to total population

$$M \int_{z^*}^{\infty} \frac{\ell(z)}{\theta(z) q(\theta(z))} \phi(z) dz = L, \tag{17}$$

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

$$\phi(z) = \frac{g(z)}{1 - G(z^*)}, \quad z \geq z^*. \tag{18}$$

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

$$Y = C + M \times f + M_e \times f_e + M \times \int_{z^*}^{\infty} C(\nu(z)) \phi(z) dz, \tag{19}$$

where $M_e = \frac{M}{1 - G(z^*)}$ is the number of entrants and $C = W - T$ 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

$$T = M b_u \int_{z^*}^{\infty} \left(\frac{1}{\theta(z) q(\theta(z))} - 1 \right) \ell(z) \phi(z) dz. \tag{20}$$

The equilibrium is a set of total output Y, consumption C, taxes T, the measure of firms M, the measure of entrants M_e, cutoff productivity z^*, and firms' prices, submarkets, 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.

After specifying functional forms in Section 4, we discuss the algorithm that we implement to solve for the equilibrium.

3 Markdown and markup properties

In this section, 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 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; 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.

3.1 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.[13] This channel works within a sub-market.

Formally, plugging equation (11) into equation (15) delivers

$$\mu^n(\theta) = \frac{1}{\eta(\theta)} - \frac{Ab_u\left(1-\eta(\theta)\right)}{W - b_u(1 - A\eta(\theta))}, \tag{21}$$

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

$$\frac{\partial \mu^n(\theta)}{\partial b_u} = -\frac{A\left(1-\eta(\theta)\right)W}{[W - b_u(1 - A\eta(\theta))]^2} < 0. \tag{22}$$

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

$$\frac{\partial \mu^n(\theta)}{\partial A} = -\frac{b_u(1-\eta(\theta))(W-b_u)}{[W - b_u(1 - A\eta(\theta))]^2} < 0. \tag{23}$$

Moreover, the shielding effect of b_u on markdowns is stronger in a less efficient labor market with a lower A. In particular, the appendix shows that

$$\frac{\partial^2 \mu^n(\theta)}{\partial A \partial b_u} > 0. \tag{24}$$

[13] A similar argument regarding workers' outside options applies to other settings, for example, self-employment in Amodio, Medina and Morlacco (2022).

The intuition behind this result is straightforward. In a less efficient labor market, firms have more monopsony power (see equation (23)), and therefore the same increase in unemployment benefits shields workers and reduces markdowns to a larger extent.

3.2 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 (12) with respect to the choice of the sub-market (see Appendix D.1) can be simplified to

$$R_\ell \left(q\left(\theta\right) \nu; z \right) = b_u + \frac{W - b_u}{A\eta\left(\theta\right)^2}. \tag{25}$$

Appendix D.3 shows that θ falls with either b_u or A:

$$\frac{\partial \theta}{\partial b_u} < 0, \ \frac{\partial \theta}{\partial A} < 0. \tag{26}$$

The intuition behind this result is as follows. An increase in b_u or A reduces wages in each sub-market (see equation (11)). 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 D.2).

As discussed above, an increase in unemployment benefits or matching efficiency pushes firms to locate in less tight sub-markets. Using equation (21), we can show that markdowns are smaller in tighter labor markets:

$$\frac{\partial \mu^n(\theta)}{\partial \theta} = \frac{\left(b_u - w(\theta)\right)\left(b_u\left(1-\eta\right) + w(\theta)\right)}{\left[(\theta+1)\eta(\theta)w(\theta)\right]^2} < 0. \tag{27}$$

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, the appendix shows that

$$\frac{\partial^2 \theta}{\partial b_u \partial A} > 0, \tag{28}$$

and

$$\frac{\partial^2 \mu^n(\theta)}{\partial \theta \partial A} > 0. \tag{29}$$

The first result, equation (28), 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 (29), 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.

3.3 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. To elaborate, as equation (25) 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. Our calibrated model in Section 4

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.

3.4 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 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

$$\Upsilon(x) = 1 + (\sigma - 1)\exp\left(\frac{1}{\varepsilon}\right)\varepsilon^{\frac{\sigma}{\varepsilon}-1}\left[\Gamma\left(\frac{\sigma}{\varepsilon}, \frac{1}{\varepsilon}\right) - \Gamma\left(\frac{\sigma}{\varepsilon}, \frac{x^{\frac{\varepsilon}{\sigma}}}{\varepsilon}\right)\right], \tag{30}$$

with $\sigma > 1$ and $\varepsilon \geq 0$ and where $\Gamma(\cdot,\cdot)$ is the upper incomplete gamma function.[14] Under this specification, the demand elasticity takes the following form

$$\epsilon(x) = \sigma x^{-\frac{\varepsilon}{\sigma}}. \tag{31}$$

Setting $\varepsilon = 0$ would reduce the demand system to the CES case.[15] 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 (2) and (30) imply that:

$$\bar{p} = P \times D \times \frac{\sigma - 1}{\sigma}\exp\left(\frac{1}{\varepsilon}\right). \tag{32}$$

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

[15] Notice that a profit-maximizing firm facing the demand equation (2) 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	1.15
Demand elasticity parameter	ε	0.69
Vacancy posting cost (elasticity)	α	1.01
Vacancy posting cost (scale)	λ	14.4
Panel B: Fixed parameters		
Pareto distribution (scale)	z_m	1
Pareto distribution (shape)	κ	2.1
Fixed entry cost	f_e	2
Fixed production cost	f	0
Matching function efficiency	A	0.5
Unemployment benefit	b_u	0.2
Population size	L	0.1

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.

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

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 sales-weighted average and sales-weighted median of 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 moments 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.

Since the extent of labor market frictions is an important object, we investigate

Table 2. Targeted Moments

Moments	**Data**	**Model**
Median markdown	1.36	1.36
Average markdown	1.53	1.53
Sales-weighted median markup	1.2	1.16
Sales-weighted average markup	1.6	1.56

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

if the model can generate an unemployment rate close to that observed in the data. Although this moment is not targeted, the model generates an unemployment rate of around 7%, only slightly higher than the average unemployment rate in the past two decades in the U.S. which is about 6%.

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 the markdowns distribution and welfare.

Figure 1 shows how markdowns change with unemployment insurance benefits b_u and matching efficiency A. Focusing on rows in this figure shows that given A, markdowns do not respond significantly to changes in unemployment benefits, suggesting that the shielding and congestion effects of unemployment benefits on markdowns roughly cancel out. Interestingly, however, columns of Figure 1 show that markdowns overall fall with a rise in matching efficiency, reflecting that the congestion effect dominates the shielding effect. As for markups, Figure E.1 in appendix shows that while markups are mostly insensitive to changes in b_u, they increase in response to rises in matching efficiency A, which is in line with what we discussed in Section 3.

Responses of markdowns and markups to labor market conditions also influence consumers' welfare, measured by real consumption C. An increase in matching efficiency raises both markups and markdowns, thereby constraining firms' production. This in turn reduces consumption, as Figure 2 presents. Since unemployment benefits do not significantly change markups and markdowns, they do not influence welfare either. Moreover, as Figure 2 shows, unemployment falls with an increase in matching efficiency, while it is mostly insensitive to b_u.

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. We show here that in product markets that do not feature strategic

Figure 1. Markdowns

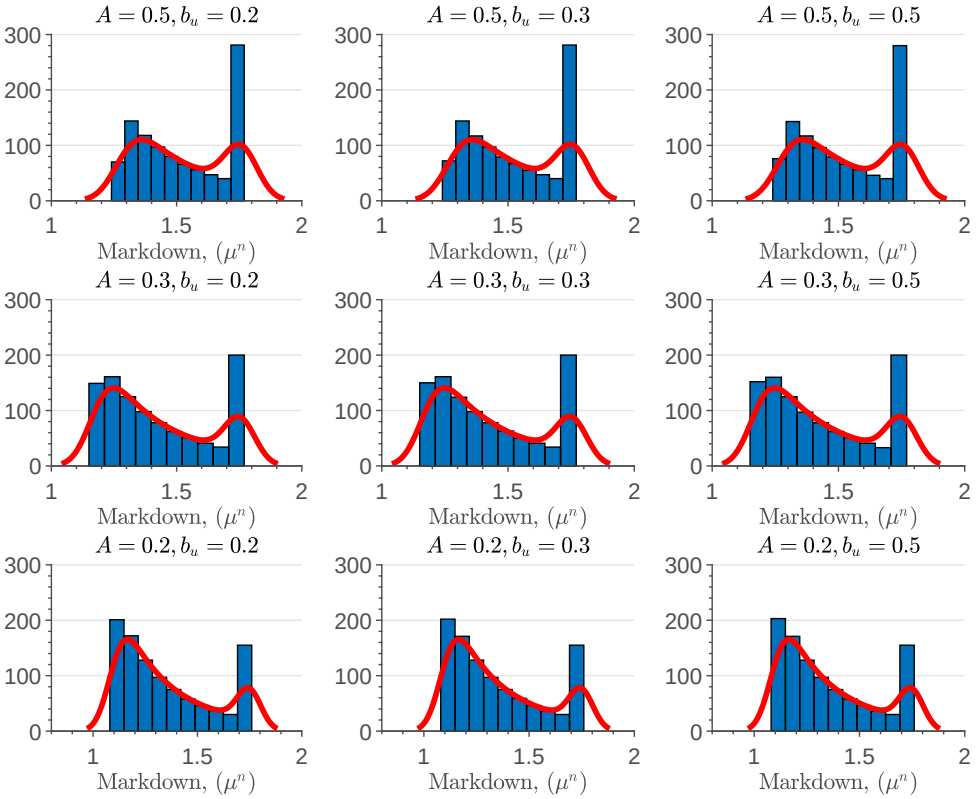
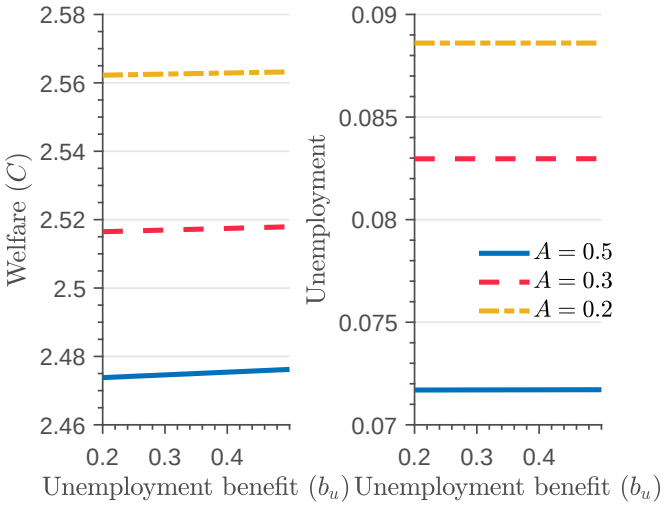


Figure 2. Welfare and Unemployment



complementarity, markdowns fall with an increase in matching efficiency 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 model, leaving

Figure 3. Markdowns (constant markups)

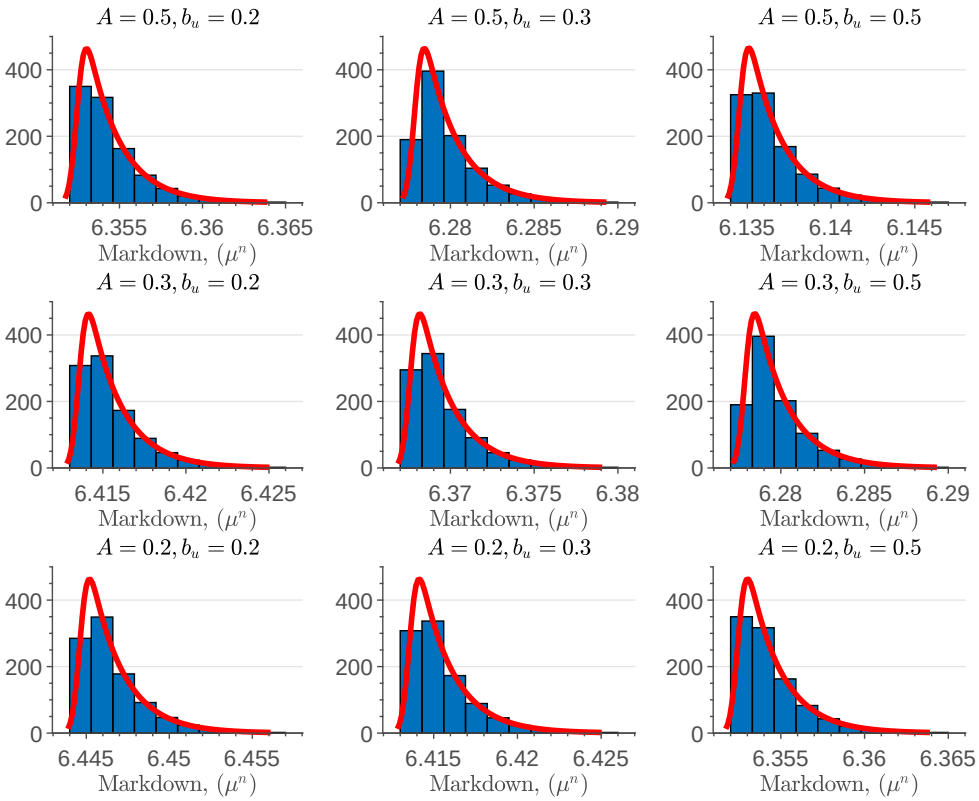
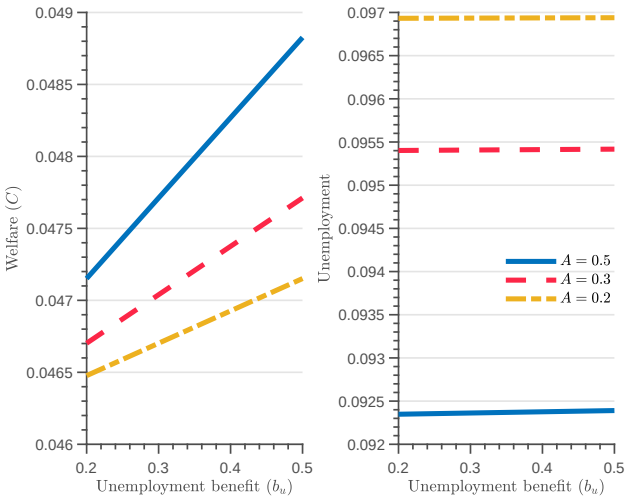
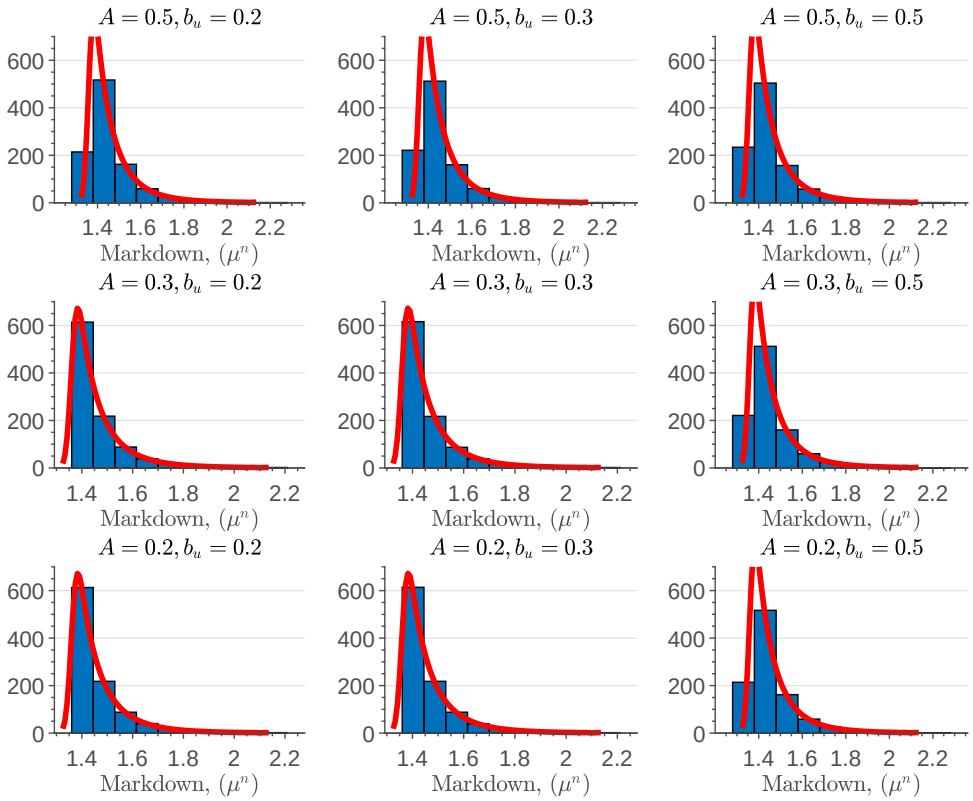


Figure 4. Welfare and Unemployment (constant markups)



all other parameters fixed. In particular, we set $\varepsilon = 0$ but employ other parameters as in Table 1. Figure 3 shows that in this model markdowns fall with matching efficiency. This reduction in markdowns imply that welfare rises with A, as Figure 4 presents.

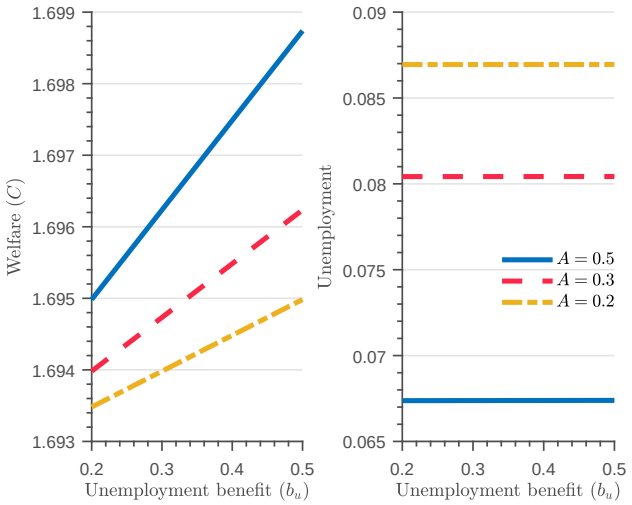
Figure 5. Markdowns (constant markups with re-estimation)



In the exercise above, because we did not re-calibrate the model, the model generates unreasonably high markdowns compared to the data and to our baseline model. To avoid this issue, in the second exercise, we impose constant markups and re-calibrate the model. In particular, we set $\varepsilon = 0$ and re-calibrate the rest of parameters in Panel 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 5 and 6 show that our main results still hold: without strategic complementarities in product markets, markdowns fall and welfare rises with an increase in matching efficiency.

Our results indicate that the congestion effect is stronger under variable markups and dominates the shielding effect under our calibration. The intuition behind this result is as follows. An increase in matching efficiency or unemployment benefits puts upward pressure on wages and downward pressure on markdowns since workers have a better outside option—either due to higher matching efficiency, which makes finding a job easier, or due to higher unemployment benefits. This is the shielding effect of labor market conditions on markdowns. In response to this increase in marginal costs, firms relocate to less tight labor markets to save on vacancy posting costs, which constitutes the congestion effect. In product markets with strategic complementarities and variable

Figure 6. Welfare and Unemployment (constant markups with re-estimation)



markups, firms, especially larger ones, try to maintain their market shares by reducing their vacancy posting costs to a greater extent, leading them to relocate to less tight labor markets compared to firms in a constant-markup environment. This amplifies the congestion effect, causing it to dominate the shielding effect under our calibration.

5 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 Properties of Kimball Demand System

A.1 Deriving the Kimball demand

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

$$\min_{\{y(\omega)\}} \int_0^M p\left(\omega\right) y\left(\omega\right) d\omega \qquad \text{s.t.} \quad 1 = \int_0^M \Upsilon\left(\frac{y\left(\omega\right)}{Y}\right) d\omega.$$

The first-order condition of this problem with respect to good variety ω is given by:

$$p\left(\omega\right) = \frac{\lambda}{Y} \Upsilon'\left(\frac{y\left(\omega\right)}{Y}\right), \tag{33}$$

where λ denotes the Lagrange multiplier. Let the ideal price index be defined as the price P satisfying:

$$PY = \int_0^M p\left(\omega\right) y\left(\omega\right) d\omega,$$

and define the demand shifter D as,

$$D \equiv \left[\int_{\omega\in\Omega} \frac{y\left(\omega\right)}{Y} \Upsilon'\left(\frac{y(\omega)}{Y}\right) d\omega\right]^{-1} \tag{34}$$

Then, $P = \frac{\lambda}{Y}\frac{1}{D}$, and

$$p\left(\omega\right) = P \times D \times \Upsilon'\left(\frac{y(\omega)}{Y}\right). \tag{35}$$

A.2 Elasticity of demand

The elasticity of inverse 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 (2) 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 what determines its demand elasticity is the relative quantity $x(\omega) \equiv y(\omega)/Y$. Therefore, we abuse notation and from now we write the

demand elasticity as in equation (4):

$$\epsilon(x) = -\frac{\Upsilon'(x)}{\Upsilon''(x)\,x}. \tag{36}$$

A.3 Klenow and Willis (2016)'s specification

We now impose the functional form in equation (30). The upper incomplete gamma function is given by,

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

which implies

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

Substituting this information back in equation (36) yields: equation (31):

$$\epsilon(x) = \sigma x^{-\frac{\varepsilon}{\sigma}}. \tag{37}$$

It is straightforward to show that whenever $\varepsilon \to 0$ the demand elasticity converges to $\epsilon(x) \to \sigma$ for all values of x, i.e., the demand elasticity is constant consistent with the CES aggregator.

We can also derive the choked-price $\bar{p}$ defined as the price such that $y(\bar{p}) = 0$:

$$\bar{p} = P \times D \times \frac{\sigma-1}{\sigma}\exp\left(\frac{1}{\varepsilon}\right). \tag{38}$$

A.4 Properties of MRPL

In this section, we show that the marginal revenue product of labor in a closed economy satisfies two properties: (i) it is decreasing in labor ℓ; (ii) it is increasing in productivity z.

(i) We first show that the marginal revenue product of labor 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

$$R_\ell(\ell;z) = PDz\left[1-\frac{1}{\epsilon(x)}\right]\Upsilon'(x), \tag{39}$$

where

$$\Upsilon'(x) = \frac{\sigma - 1}{\sigma} \exp\left(\frac{1}{\varepsilon}\right) e^{-\frac{x^{\frac{\varepsilon}{\sigma}}}{\varepsilon}}, \quad \sigma > 1,\ \varepsilon > 0,$$
$$\epsilon(x) = \sigma x^{-\frac{\varepsilon}{\sigma}}.$$

First, we note that $\Upsilon'(x) > 0$ for all values of x therefore the marginal revenue product of labor 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 those points $R_\ell(\ell; z) > 0$.

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

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

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

(ii) We now show that the marginal revenue product of labor rises with z. Taking the derivative of marginal revenue product of labor in equation (39) with respect to z delivers

$$R_{\ell z}(\ell; z) = D\Upsilon'(x)(1 - \frac{1}{\epsilon(x)}) + D\Upsilon''(x) z \frac{\partial x}{\partial z}(1 - \frac{1}{\epsilon(x)}) + D\Upsilon'(x) \frac{\epsilon'(x)}{\epsilon(x)^2} z \frac{\partial x}{\partial z}. \tag{40}$$

Using the fact that $z\frac{\partial x}{\partial z} = x$, combined with the definition of demand elasticity $\epsilon(x)$, delivers

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

which signs depends on the term inside the bracket.

Let $w \equiv x^{\frac{\varepsilon}{\sigma}}$ and define the function $h(w)$ as:

$$h(w) = -\sigma + \frac{2\sigma + \varepsilon}{\sigma} w - \frac{1}{\sigma} w^2. \tag{41}$$

The function $h(w)$ is a concave parabola that satisfies:

1. Since $x \in [0, \sigma^{\sigma/\varepsilon}]$, its domain is $w \in [0, \sigma]$.
2. The function attains its maximum at $w_{max} = \sigma + \frac{\varepsilon}{2} > \sigma$, and therefore $h(w)$ is increasing in its domain.
3. $h(0) = -\sigma$ and $h(\sigma) = \varepsilon$. Therefore, there exists $w_0 \in [0, \sigma]$ such that $h(w_0) = 0$. The value of w_0 is given by $w_0 = \frac{(2\sigma+\varepsilon) - \sqrt{\varepsilon(4\sigma+\varepsilon)}}{2} > 0$.

It follows then that the marginal revenue product of labor not always increases with z. For all $x \in [w_0, \sigma^{\sigma/\varepsilon}]$, $R_{\ell z}(\ell; z) < 0$.

Remark 1 *The parameters σ and ε not only govern the super-elasticity of demand but they also determine the maximum quantity of relative output that can be sustained in equilibrium.*

B Vacancy posting problem

To characterize the problem of the firm we split the problem into two sub-problems. First, we solve for the choice of sub-market θ and number of vacancies ν for a given level of output y. This problem also characterizes the cost function of the firm. In the second sub-problem, we take the cost functions of the previous step and characterize the optimal level of output chosen by the profit maximizing firm.

B.1 Cost minimization problem

The cost minimization problem is:

$$\begin{aligned} &\min_{\theta,\nu} \left[\frac{W-b_u}{\theta q(\theta)} + b_u\right] \frac{y}{z} + P \times C(\nu) + P \times f \\ &\text{s.t. } \frac{y}{z} = q(\theta)\,\nu, \end{aligned}$$

where we use equation (10) to substitute out wages $w(\theta)$, and the relationship $y/z = \ell$. Taking first-order conditions and operating with these equations yields the following system determining (θ, ν):

$$\begin{aligned} \frac{W-b_u}{\theta}\frac{1-\eta(\theta)}{\eta(\theta)} &= P \times C'(\nu) \\ \frac{y}{z} &= q(\theta)\,\nu, \end{aligned}$$

This equation shows why convex vacancy cost are important to obtain wage dispersion. If vacancy costs were linear, and therefore $C'(\nu) = \lambda$, all firms choose the same sub-market θ and pay the same wage $w(\theta)$. Our wage equation (54) implies then that difference in firm's productivity translate to different levels of employment, but not into differences in wages, marginal revenue product of labor, or markdowns. We summarize this result in the following remark.

Remark 2 *For the equilibrium to feature heterogeneous markdowns is* ***necessary*** *to have convex vacancy costs. However, this condition is not sufficient, we further require positive unemployment insurance or a variable elasticity of the vacancy filling rate.*

Using that $C(\nu) = \lambda\nu^{\alpha}$ and the functional form of the matching function the previous equation simplifies to:

$$\frac{W-b_u}{\theta^2} = P \times \lambda \times \alpha \times \left(\frac{y}{zA}\right)^{\alpha-1} (1+\theta)^{\alpha-1}. \tag{42}$$

It is straightforward to prove that a solution for θ always exists for all $y > 0$. The

number of vacancies a firm posts is then given by:

$$\nu = \frac{y}{zA}(1+\theta). \tag{43}$$

The total cost of the firm is then simply

$$C(y;W,P,z) = \left[\frac{W-b_u}{\theta(y)\,q(\theta(y))} + b_u\right]\frac{y}{z} + P \times C(\nu(y)) + P \times f, \tag{44}$$

with marginal cost given by

$$C_y(y) = \frac{w(\theta(y))}{z}\frac{1}{\mu^n(\theta(y))}, \tag{45}$$

where $\mu^n(y;W,P,z)$ is the markdown charged on wages which equals

$$\frac{1}{\mu^n(y;W,P,z)} \equiv \left[\frac{1}{\eta(\theta)} - \frac{1-\eta(\theta)}{\eta(\theta)}\frac{b_u}{w(\theta)}\right]. \tag{46}$$

B.2 Profit maximization problem

The profit maximization problem is given by:

$$\begin{aligned}\pi &= \max_y py - C(y)\\ \text{s.t.}\quad p &= P \times D \times \Upsilon'\left(\frac{y}{Y}\right),\end{aligned}$$

with first-order conditions given by:

$$\left[1 - \frac{1}{\sigma}\left(\frac{y}{Y}\right)^{\frac{\varepsilon}{\sigma}}\right]\Upsilon'\left(\frac{y}{Y}\right) = \frac{C_y(y)}{P \times D}. \tag{47}$$

While there is no closed form solution for y it is useful re-write equation (47) as follows. Using the Klenow and Willis demand specification we can manipulate equation (47) to get,

$$\left(\frac{\sigma}{\varepsilon} - \frac{\left(\frac{y}{Y}\right)^{\frac{\varepsilon}{\sigma}}}{\varepsilon}\right)\exp\left(\frac{\sigma}{\varepsilon} - \frac{\left(\frac{y}{Y}\right)^{\frac{\varepsilon}{\sigma}}}{\varepsilon}\right) = \Theta \times \frac{C_y(y)}{P \times D},$$

where we define $\Theta \equiv \frac{\sigma}{\varepsilon}e^{\frac{\sigma-1}{\varepsilon}}\frac{\sigma}{\sigma-1}$. The Lambert-W function is defined as the inverse of $f(x) = x\exp(x)$, that is $\mathcal{W}(x\exp(x)) = x$. Using this we can write y/Y as:

$$\frac{y}{Y} = \left[\sigma - \varepsilon\mathcal{W}\left(\Theta \times \frac{C_y(y)}{P \times D}\right)\right]^{\frac{\sigma}{\varepsilon}}. \tag{48}$$

C Computing the closed-economy equilibrium

C.1 Algorithm

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

Step 0: The first step is to find the cut-off productivity above which firms decide to produce, z^*.

1. We guess a value z_0^* and find the optimal choices for a firm with productivity z_0^*.

   (a) We solve first for its optimal size y_0^*. For that guess a value $y_0 \in \left(0, Y_0 \sigma^{\frac{\sigma}{\epsilon}}\right)$ and solve for the sub-market and vacancy choice using equation (42)

$$\frac{W_0 - b_u}{\theta^2} = P \times \lambda \times \alpha \times \left(\frac{y_0}{z_0^* A}\right)^{\alpha-1} (1+\theta)^{\alpha-1},$$
$$v = \frac{y_0}{z_0^*} \frac{1}{q(\theta)}.$$

   Note that the Jacobian for this system is easy to compute and it can speed up computation time.

$$f(\theta) = \frac{W_0 - b_u}{\theta^2} - P \times \lambda \times \alpha \times \left(\frac{y_0}{z_0^* A}\right)^{\alpha-1} (1+\theta)^{\alpha-1},$$
$$f'(\theta) = -2\frac{W_0 - b_u}{\theta^3} - P \times \lambda \times \alpha \times \left(\frac{y_0}{z_0^* A}\right)^{\alpha-1} (\alpha - 1)(1+\theta)^{\alpha-2}.$$

   (b) Construct Lambert-W function

$$t = \mathcal{W}\left(\Theta \times \frac{1}{\mu^n(y)} \frac{w(\theta)/z_0^*}{P \times D_0}\right),$$

   where $w(\theta) = \frac{W - b_u}{\theta q(\theta)} + b_u$ and $\frac{1}{\mu^n(y)} = \left[\frac{1}{\eta(\theta)} - \frac{1-\eta(\theta)}{\eta(\theta)} \frac{b_u}{w(\theta)}\right]$.Since $x \in \left[0, \sigma^{\sigma/\varepsilon}\right]$ we should have $t \in \left[0, \frac{\sigma}{\varepsilon}\right]$. In practise, however, the solution to the equation

$$\Theta \times \frac{1}{\mu^n(y)} \frac{w(\theta)/z_0^*}{P \times D_0} = t \exp(t),$$

   sometimes returns $t \geq \frac{\sigma}{\varepsilon}$.This occurs at negative values of x where the

optimal price is above the choked-price. So in practice we construct,

$$t = \min\left\{\mathcal{W}\left(\Theta \times \frac{1}{\mu^n(y)}\frac{w(\theta)/z_0^*}{P \times D_0}\right), \frac{\sigma}{\varepsilon}\right\}.$$

(c) Plug this into equation (48) to update the value of y:

$$y_1 = Y_0\left[\sigma - \varepsilon \times t\right]^{\frac{\sigma}{\varepsilon}}.$$

If y_1 andy_0 coincide we have found the optimal size of the firm. If not, update the value of y. Once we found a solution y_0^*, we can compute θ_0^* and ν_0^* as well as prices p_0^* and w_0^*. Note that by construction $y_1 \in \left[0, Y_0\sigma^{\frac{\sigma}{\varepsilon}}\right]$.

2. Given firm choices we can compute its profits:

$$\pi_0^* = \left(p_0^* - \frac{w_0^*}{z_0^*}\right)y_0^* - P \times C\left(\nu_0^*\right) - P \times f.$$

If $\pi_0^* = 0$ we have found the productivity cut-off. If not, update the value of z^*.

Step 1: Once we found z_1^* we construct the grid of productivity values $z \geq z_1^*$ and their distribution $\phi_1(z)$ using that:

$$\phi_1(z) = \frac{g(z)}{1 - G(z_1^*)}, \qquad z \geq z_1^*.$$

In Section C.3 we discuss how to discretize the values of z.

Step 2: For each grid value $z \geq z^*$ we compute firm's optimal choices. We follow similar steps as in **Step 0**.

1. (a) Guess a vector of values y_0 where each element correspond to our guess of the production size for the grid values of z.

   (a) Solve for sub-market and vacancy choices using equation (55). Note that the equation that determines the first value of θ in the grid is independent of the rest, hence the Jacobian for this problem is simply:

$$\frac{\partial F_i}{\partial \theta_j} = \text{diag}\left(f_i\left(\theta_i, y_i, z_i\right)\right), \tag{49}$$

   where $f_i(\theta_i, y_i, z_i)$ is the Jacobian we computed in **Step 0**.

   (b) Use equation (48) to update the vector y. The Jacobian for this system is more complex but there is high return in computing it. In Appendix

section C.2 we derive this Jacobian.

2. Once a solution is found use equation (55) to solve for θ. Then, we can construct vacancies ν, employment levels ℓ, firm wages $w(\theta)$ and prices p, markups μ^y and markdowns μ^n, and firms profits π.

Step 3: Construct aggregate variables using numerical integration:[16]

$$\begin{aligned}
D_1 &= \left[M_0 \int_{z_1^*}^{\infty} \Upsilon'\left(x_1(z)\right) x_1(z)\, \phi_1(z)\, dz \right]^{-1} \\
T_1 &= M_0 \times b_u \times \left[\int_{z_0^*}^{\infty} \ell_1 \left(\frac{1}{\theta_1 q(\theta_1)} - 1 \right) \phi_1(z) dz \right], \\
C_1 &= W_0 - T_1 \\
M_1^e &= \frac{M_0}{1 - G\left(z_1^*\right)}.
\end{aligned}$$

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

$$\begin{aligned}
0 &= L - M_0 \int_{z_1^*}^{\infty} \frac{\ell_1(z)}{\theta_1(z)\, q\left(\theta_1(z)\right)} \phi_1(z)\, dz \\
0 &= \frac{P \times f_e}{1 - G\left(z_1^*\right)} - \int_{z_1^*}^{\infty} \pi_1(z)\, \phi_1(z)\, dz, \\
0 &= P \times D_0 - P \times D_1 \\
0 &= Y_0 - \left(C_1 + M_0 \times f + M_1^e \times f_e + M_0 \times \int_{z_1^*}^{\infty} C\left(\nu_1(z)\right) \phi_1(z)\, dz \right),
\end{aligned}$$

Otherwise the code updates (M_0, D_0, Y_0, W_0) and repeats.

C.2 Jacobian for equation (48)

The system is:

$$F(y) = y - Y_0 \left[\sigma - \varepsilon \times \mathcal{W} \left(\Theta \times \frac{1}{\mu^n(\theta)} \frac{w(\theta)/z_0^*}{P \times D_0} \right) \right]^{\frac{\sigma}{\varepsilon}},$$

[16] Note that in equilibrium $D_0 = D_1$, at that point:

$$P_1 = M_0 \int_{z_1^*}^{\infty} p_1(z) \frac{y_1(z)}{Y_0} \phi_1(z)\, dz = D_0 \times \frac{1}{D_1} = 1.$$

So we don't include this equation in our system.

where $w(\theta) = \frac{W-b_u}{\theta q(\theta)} + b_u$ and $\frac{1}{\mu^n(\theta)} = \left[\frac{1}{\eta(\theta)} - \frac{1-\eta(\theta)}{\eta(\theta)}\frac{b_u}{w(\theta)}\right]$ and θ solves:

$$\frac{W_0 - b_u}{\theta^2} = P \times \lambda \times \alpha \times \left(\frac{y}{zA}\right)^{\alpha-1} (1+\theta)^{\alpha-1}.$$

The jacobian is then:

$$J(y) = 1 + \sigma Y_0^{\frac{\varepsilon}{\sigma}} y^{\frac{\sigma-\varepsilon}{\sigma}} \times \frac{d\mathcal{W}\left(\Theta \times \frac{1}{\mu^n(y)}\frac{w(\theta)/z}{P\times D_0}\right)}{dy}.$$

Now note that $\mathcal{W}'(z) = \frac{\mathcal{W}(z)}{z+z\mathcal{W}(z)}$ and $z = \mathcal{W}(z)\exp\mathcal{W}(z)$ hence,

$$J(y) = 1 + \sigma Y_0^{\frac{\varepsilon}{\sigma}} y^{\frac{\sigma-\varepsilon}{\sigma}} \times \frac{\mathcal{W}\left(\Theta \times \frac{1}{\mu^n(\theta)}\frac{w(\theta)/z}{P\times D_0}\right)}{\left[\mathcal{W}\left(\Theta \times \frac{1}{\mu^n(\theta)}\frac{w(\theta)/z}{P\times D_0}\right)+1\right]} \frac{d\left(w(\theta)/\mu^n(\theta)\right)}{dy} \frac{1}{w(\theta)/\mu^n(\theta)},$$

where,

$$\frac{d\left(w(\theta)/\mu^n(\theta)\right)}{dy} = -2\frac{w(\theta)-b_u}{\theta^2}\frac{\partial\theta}{\partial y},$$
$$\frac{\partial\theta}{\partial y} = -\frac{(\alpha-1)\frac{\theta}{y}}{[2+(\alpha-1)\eta(\theta)]}.$$

Putting everything together:

$$J(y) = 1 + \sigma\left(\frac{y}{Y_0}\right)^{-\frac{\varepsilon}{\sigma}} \times \frac{\mathcal{W}\left(\Theta \times \frac{1}{\mu^n(\theta)}\frac{w(\theta)/z}{P\times D_0}\right)}{\mathcal{W}\left(\Theta \times \frac{1}{\mu^n(\theta)}\frac{w(\theta)/z}{P\times D_0}\right)+1} \times \frac{\frac{2}{\theta}\times(\alpha-1)}{2+(\alpha-1)\eta(\theta)} \times \frac{w(\theta)-b_u}{w(\theta)/\mu^n(\theta)}. \tag{50}$$

C.3 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 Proofs

D.1 Profit-maximization problem

This section solves the profit-maximization problem (12). We write first-order-conditions with respect to ν and θ as

$$\{\nu\}: R_\ell\left(q\left(\theta\right)\nu; z\right) q\left(\theta\right) = \frac{W - b_u\left(1 - \theta q(\theta)\right)}{\theta} + C'\left(\nu\right) \tag{51}$$

$$\{\theta\}: R_\ell\left(q\left(\theta\right)\nu; z\right) q'\left(\theta\right) = \frac{b_u(1 + \theta^2 q'(\theta)) - W}{\theta^2}, \tag{52}$$

where $R_\ell(\cdot)$ is the firm's marginal revenue product of labor. Using equation (10) to eliminate W in equation (52) yields

$$R_\ell\left(q\left(\theta\right)\nu; z\right) = \frac{q(\theta)}{\theta q'\left(\theta\right)} b_u \left(1 + \frac{\theta q'\left(\theta\right)}{q(\theta)}\right) - \frac{q\left(\theta\right)}{\theta q'\left(\theta\right)} w\left(\theta\right). \tag{53}$$

Dividing both sides of this equation by $w(\theta)$ and employing the definition of $\eta(\theta)$ delivers

$$\frac{R_\ell\left(q\left(\theta\right)\nu; z\right)}{w\left(\theta\right)} = \frac{1}{\eta(\theta)} - \frac{b_u}{w\left(\theta\right)} \frac{1 - \eta(\theta)}{\eta(\theta)}. \tag{54}$$

To characterize the optimal choice of ν, we solve for $R_\ell(\cdot)$ in equation (52) and substitute it into equation (51) to get

$$\theta = \frac{W - b_u}{C'(\nu)} \frac{1 - \eta(\theta)}{\eta(\theta)}. \tag{55}$$

D.2 Proof of Proposition 2

We first prove that more productive firms operate in less tight labor markets. To achieve this goal, we must take several intermediate steps. Using the definition of $\eta(\theta)$, equation (9), in the optimality condition for ν, equation (14), delivers

$$C'(\nu) = \frac{W - b_u}{\theta^2}. \tag{56}$$

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 (equation (8)), we have that firms that choose to locate in tighter labor markets (higher θ) hire fewer workers as $\ell = q(\theta)\nu$.

Focus now on the first-order condition for θ, equation (52), and simplify terms to

get,

$$R_\ell\left(q\left(\theta\right)\nu;z\right)=b_u-\frac{W-b_u}{q'\left(\theta\right)\theta^2}. \tag{57}$$

Given the previous discussion and that the marginal revenue product of labor falls with ℓ, the left-hand side of this equation is an increasing function of θ.[17] Using the definition of $q(\theta)$ in equation (8) implies that the right-hand side decreases with θ. Hence, if a solution for θ exists, it is unique. We assume that a solution exists and verify this assumption in our calibrated model.

Since the marginal revenue product of labor increases with z, equation (57) implies that θ falls with z. We can therefore conclude that more productive firms operate in less tight labor markets. Since wages are decreasing in θ (equation (11)), 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. Given Marshall's second law of demand, more productive firms therefore charge higher markups.

We now prove that markdowns rise with z. We use the definition of $\eta(\theta)$ from equation (9) in the markdown expression (15) to get

$$\mu^n\left(\theta\right)=\frac{\theta+1}{\theta}-\frac{b_u}{w(\theta)\theta}. \tag{58}$$

Substituting for wages from equation (11) delivers

$$\mu^n\left(\theta\right)=\frac{\frac{(\theta+1)(W-b_u)}{A}\frac{\theta+1}{\theta}+\theta b_u}{\frac{(\theta+1)(W-b_u)}{A}+\theta b_u}, \tag{59}$$

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 profit of a firm with productivity z is given by

$$\pi\left(z\right)=R\left(\ell;z\right)-w\ell-C\left(\nu\right). \tag{60}$$

We use the first-order condition with respect to ν, equation (51), to eliminate the wage bill and get

$$\pi(z)=R\left(\ell;z\right)-R_\ell\left(\ell;z\right)\ell+C'\left(\nu\right)\nu-C\left(\nu\right). \tag{61}$$

Using the definition of demand elasticity and given the production technology (5), we

[17] The marginal revenue product of labor is not always decreasing with the Klenow and Willis specification for the Kimball aggregator. However, it is increasing at a set of values that cannot be sustained as an equilibrium since at those point the marginal revenue product of labor is negative. See Appendix A.4.

can write the marginal revenue product of labor as

$$R_\ell(\ell; z) = \frac{R(\ell; z)}{\ell}\left(1 - \frac{1}{\epsilon\left(\frac{z\ell}{Y}\right)}\right). \tag{62}$$

We can therefore re-write the profit function as

$$\pi(z) = \frac{1}{\epsilon\left(\frac{z\ell}{Y}\right)} R\left(\ell; z\right) + C'\left(\nu\right)\nu - C\left(\nu\right). \tag{63}$$

Since more productive firms generate higher revenues and also produce more output (as proved above), and given Marshall's second law of demand, the first term in equation (63) rises with z. Moreover, since the vacancy cost function is convex, the sum of the second and third terms in this equation also increases with ν and therefore with the productivity level z.

D.3 Properties of the choice of sub-market θ

We first prove that θ falls with either b_u or A. We then show that this response depends on the product market structure.

As discussed in the main text, simplifying the first-order condition for θ, equation (52), delivers

$$R_\ell\left(q\left(\theta\right)\nu; z\right) = b_u + \frac{W - b_u}{A\eta\left(\theta\right)^2}. \tag{64}$$

Given that $A \leq 1$ and $\eta(\theta) < 1$, an increase in b_u reduces the right-hand side of the equations above. Therefore, the left-hand side of this equation must fall too. As Appendix D.2 proved, the 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.

E Additional figures

Figure E.1. Markups

