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THE COMMODITIZATION OF LABOR

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ABSTRACT

Technical change often simplifies jobs. This increases productivity, but it also makes workers more substitutable—or more "commoditized." Commoditization of labor drives down worker bargaining power: anyone can do the job, implying workers are disposable, which improves the outside option of firms and can lower worker wages. We develop a model that captures both the productivity enhancing and wage depressing effects of commoditizing technical change. Commoditizing technical change involves firms standardizing tasks. This reduces the sensitivity of output to worker quality. Firms benefit because they can more easily fill vacancies for their durable jobs. We show that our model can help explain the divergence between productivity and wages in the service sector, increasing wage markdowns despite falling local concentration, and the decline of the large-firm wage premium.

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1 Introduction

Adam Smith began the *Wealth of Nations* by describing the enormous productivity gains derived from technological change that simplifies the tasks performed by labor (Smith, 1776). Smith referred to this type of technical change as the division of labor. He memorably discussed the example of a pin factory, where the manufacturing of pins was broken into eighteen distinct operations (“one man draws out the wire, another straights it, a third cuts it, a fourth points it, ...”), and by this division the productivity of labor was increased a thousand fold.

The simplification of tasks performed by labor has continued to be a central feature of technological progress ever since, and has spread from manufacturing to other industries. Fast-food restaurants, such as McDonald’s, are one prominent example, with nearly every aspect of meal preparation having been standardized and broken into elementary tasks that can be performed by workers with very minimal skill or training.¹ Other prominent examples include warehouse work and customer service: warehouse workers of the past needed to remember where products were stored, while their modern counterparts follow the real-time directions of handheld devices; customer service workers of the past needed to understand the products they serviced, while their modern counterparts read scripted answers from computer systems that require little specific knowledge.

The economics literature has by-and-large followed Smith in emphasizing the productivity benefits of simplifying technical change. But Karl Marx emphasized a darker side of how the simplification of tasks affects workers: “His labour becomes a labour that anyone can perform. Hence, competitors crowd upon him on all sides” (Marx, 1849). For this and other reasons, Marx argued that division of labor would reduce worker wages. In a similar vein, Braverman (1974) emphasized the adverse effects that “de-skilling”, driven by the scientific management principles advocated by Taylor (1911), had on workers, and Marglin (1974) argued that capitalists seek to shape the workplace to increase control over labor and appropriate surplus from the employment relationship.

We build on these ideas. While the simplification of tasks raises productivity, it also makes workers more replaceable. If firms have market power in the labor market, simplifying technical change improves the outside option of firms, which allows them to increase the wedge be-

¹When one of us (Steinsson) worked at McDonald’s in the 1990s, the only aspect of meal preparation that required any appreciable skill or judgment was putting salt on the hamburger. Evidently, at that time, McDonald’s had not managed to create a practicable device that could distribute a standardized amount of salt on a hamburger with the pressing of a button. This contrast with other aspects of hamburger assembly (ketchup, cheese, onion, pickle, etc.).

tween the wage they offer workers and the marginal product of the workers. Simplifying technical change effectively commoditizes labor, which firms can exploit to increase wage markdowns.

We develop a formal model of technical change that commoditizes labor. In our model, the labor market is imperfectly competitive due to search and matching frictions. Search is directed as in [Moen \(1997\)](#) and firms post wages (promised values). Importantly, we assume that jobs are durable and job creation is inelastic. This implies that vacant jobs are valuable. Each job consists of a continuum of tasks, all performed by labor. However, the output of each of these tasks is determined either by worker know-how (the quality of the worker) or by the firm's technology. When a task is standardized, worker know-how no longer matters. Rather, the firm's technology determines output of the task. In other words, any worker can do the task.

The fraction of tasks that are standardized determines how sensitive the output of the job is to worker know-how. As standardization increases, the output of the job is less and less dependent on worker quality and more and more dependent on the quality of the firm's technology. As this happens, firms become less and less picky about which workers they hire (i.e., reservation worker quality falls). As a consequence, the workers become more replaceable, disposable, or commoditized.

Standardization thus improves the outside option of high quality firms. They can easily fill a vacancy since they are relatively indifferent as to which workers they hire. Their productivity increases, but the share of firm-level output that accrues to labor falls and the wages they pay also fall. This implies that their wage markdowns increase.

At the aggregate level, standardization tends to lower the labor share if firms are heterogeneous. If all firms are identical (and equally standardized), an increase in standardization improves the outside option of firms, but it also improves the outside option of workers. The fact that firms are not picky about workers makes it easy for firms to find workers, but it also makes it easy for workers to find firms. With homogeneous firms, we derive a neutrality result where these two forces cancel out exactly, leaving the labor share unchanged. With heterogeneous firms, however, we show that the aggregate labor share is lower when firms' outside options covary positively with their vacancy filling rates. Since the firms with higher outside options are the ones with a lower labor share, their increased ability to fill vacancies reallocates workers from high to low labor share firms. This results in a fall in the aggregate labor share.

We quantitatively calibrate our model and show that an increase in standardization by "megafirms" generates an increase in output per worker and firm value but at the same time a

fall in wages. The model yields a substantial fall in the large-firm wage premium in line with recent data. A slight extension of the baseline model also implies that hiring costs fall substantially. We present novel evidence that hiring costs are much lower at megafirms than other firms, and particularly so in low-wage service sectors. This suggests that low-wage service-sector megafirms have adopted production technologies that have allowed them to “commoditize” workers.

Commoditization is distinct from automation. Automation is technical change where machines replace workers in certain tasks. In contrast, workers are needed to perform all tasks in our commoditization model. Standardization does not replace workers, rather it makes task output insensitive to the skill of the worker (any worker can do the task). Automation can reduce wages by destroying jobs ([Acemoglu and Restrepo, 2018](#)). Commoditization, however, can reduce wages by making workers more interchangeable, allowing firms to increase wage markdowns. Commoditization does not arise in the neoclassical (competitive labor market) frameworks developed for automation by [Acemoglu and Restrepo \(2018\)](#) or for polarization by [Goos et al. \(2014\)](#) and [Autor and Dorn \(2013\)](#). It is necessary to consider an imperfectly competitive labor market setting to analyze commoditization. We view automation and commoditization as complementary vectors of technical change.

Commoditization has perhaps been most salient in certain parts of the service sector in recent decades. [Gautié, Jaehrling and Perez \(2020\)](#) write in their study of retail sector logistics:

Before [the introduction of pick-by-voice], you had to be an expert in your trade, now you just have to know how to use the tool ... you are plugged in when you start, unplugged at the end of the day ... The resulting deskilling is evidenced by the reduction in the estimated time of training to become fully operational, e.g., from two/three weeks to only two/three days.

—*Neo-Taylorism in the Digital Age (2020)*

[Guendelsberger \(2019\)](#) writes in her autobiographical account of a year spent working at fast-food restaurants, call-centers, retail distribution centers:

As more and more skill is stripped out of a job, the cost of turnover falls; eventually, training an ever-churning influx of new unskilled workers becomes less expensive than incentivizing people to stay by improving the experience of work or paying more.

—*On the Clock (2019)*

[Ehrenreich \(2001\)](#) emphasizes the replaceability of workers in low-wage service sectors, from the perspective of their employers:

Most of the big hotels run ads almost continually, if only to build a supply of applicants to replace the current workers as they drift away or are fired, so finding a job is just a matter of being in the right place at the right time and flexible enough to take whatever is being offered that day.

—*Nickel and Dimed (2001)*

Similarly, [Lazear and McCue \(2018\)](#) document remarkably high levels of churn in low wage service sector jobs.

A burgeoning recent literature has explored theories of monopsony power in labor markets ([Azar and Marinescu, 2024](#); [Kline, 2025](#); [Caldwell, Dube and Naidu, 2026](#)). The core of these models is the mapping between the distribution of workers’ outside options and wages. The outside option of workers is determined by how differentiated potential employers are from the perspective of workers. Empirical work has focused on estimating the slope and curvature of firm-level labor supply curves, which encapsulate this information.

Our model differs from this literature by emphasizing the outside option of firms (as opposed to workers) as a source of labor market power. In general, market power can arise from differentiation on either the buy side or the sell side of a market (or both). The literature on market power in product markets has long emphasized differentiation on the sell side of the market. This focus goes back to Hotelling’s famous model of ice cream sellers choosing where to locate on a beach ([Hotelling, 1929](#)), but carries through to more modern models of product markups ([McFadden, 1974](#); [Dixit and Stiglitz, 1977](#); [Berry, Levinsohn and Pakes, 2004](#)).

The recent literature on monopsony in labor markets has, however, flipped the “location” of differentiation from the supply-side of the market (differentiated workers) to the demand-side of the market (differentiated firms). In our model, supply-side differentiation plays a key role for markdowns in the labor market. Important antecedents to our work in terms of emphasizing supply-side heterogeneity as a source of variation in wage markdowns include [Manning \(2011\)](#), [Kline et al. \(2019\)](#), and [Bloesch, Larsen and Taska \(2022\)](#).²

²[Manning \(2011\)](#) discusses both demand-side and supply-side differentiation as potential sources of markdowns. [Kline et al. \(2019\)](#) present a model with a notion of replaceability of workers. However, their model has different implications than ours: more replaceability (lower training costs in their model) imply lower markups. [Bloesch, Larsen and Taska \(2022\)](#) present evidence on differing degrees of replaceability (hold-up power) of workers of different occupations.

In contrast to existing monopsony models, our model can explain the collapse of the large-firm wage premium over the past few decades (Even and Macpherson, 2012; Bloom et al., 2018; Stansbury and Summers, 2020; Haltiwanger et al., 2024)—a phenomenon that appears most prominently in the service sector (where the large firm wage premium has *completely* disappeared) and among workers without a college degree. In existing monopsony models, large firms must pay higher and higher wages to attract more workers. In our model, however, firms can invest in more standardization, which allows them to grow without raising wages because they become less picky about which workers they hire. A related phenomenon is that large firms need not pay more to recruit workers, a finding that Dube, Freeman and Reich (2010) point out is puzzling from the standpoint of existing monopsony models.³

Our model builds on earlier work emphasizing the importance of growing information and communications technologies (ICT) and intangibles in driving service sector productivity growth. Hsieh and Rossi-Hansberg (2023) argue that an “industrial revolution in services” has been underway in recent decades with firms in the service sector scaling production on the basis of investments in technologies that allow them to replicate production cheaply in a large number of locations. They point to the growing role of intangible investments, especially in the service sector, as driving this process (Haskel and Westlake, 2017; Crouzet and Eberly, 2018). Such technologies help explain the dramatic growth of superstar firms that Autor et al. (2020) show has contributed to the declining labor share.⁴

Rossi-Hansberg, Sarte and Trachter (2021) emphasize that while the growth of megafirms has raised concentration at the national level, local markets have actually become less concentrated as megafirms such as Walmart enter local markets across the country. Berger, Herkenhoff and Mongey (2022) document similar trends and develop a sophisticated quantitative labor market monopsony model calibrated to this evidence and show it implies a 4 percentage point *increase* in the aggregate labor share. In other words, conventional labor market monopsony models predict *falling* rather than rising markdowns. In contrast, our model generates a direct link between increasing national labor market concentration and the markdown through changes in (firm-level) technologies.

Our theory of commoditization is particularly relevant to low-wage service sector industries, which differ from manufacturing in their combination of stagnant wages but growing employ-

³Bloesch, Larsen and Yding (2026) present evidence that recruiting costs are an important source of monopsony power in the short run, but that firm-specific labor supply curves are perfectly elastic in the long run.

⁴Autor et al. (2020) present a model in which the decline of the labor share arises from increasing markups arising from the growth of superstar firms. However, the decline in the labor share *relative* to the intermediate input share suggests that the core explanation may lie in labor market, as opposed to product market, competition.

ment. [Haltiwanger, Hyatt and Spletzer \(2024\)](#) show that the “falling bottom” of wages in low-wage services such as retail and fast-food account for a disproportionate share of earnings inequality growth from 1996 to 2018.⁵ [Hortaçsu and Syverson \(2015\)](#) emphasize the divergence between strong labor productivity growth and weak wage growth in the retail sector. These findings build on previous work documenting the importance of ICT for inventory management and logistics driving productivity growth in retail ([Foster, Haltiwanger and Krizan, 2006](#)). Ethnographic accounts of low wage service sector jobs emphasize the “commoditizing” effects of these technologies ([Gautié et al., 2020](#); [Guendelsberger, 2019](#); [Ehrenreich, 2001](#)), echoing the incredibly high rates of turnover documented by [Lazear and McCue \(2018\)](#).

Our model relies on search frictions as a source of labor market imperfections. The bulk of the search literature assumes that jobs do not exist independently of existing worker-firm matches and that there is free entry in vacancy creation. We deviate from these assumptions, which allows the firm’s outside option to play an important role in our model. If jobs simply disappear when a worker and firm separate, the notion that a worker can be “disposable” cannot be formalized since the job has no value without the worker. [Mercan and Schoefer \(2020\)](#) and [Elsby et al. \(2025\)](#) present evidence that a large fraction of hiring is replacement hiring. [Coles and Kelishomi \(2018\)](#) show that deviating from the free entry assumption helps search models match business cycle fluctuations. [Shimer and Smith \(2000\)](#) and [Hornstein, Krusell and Violante \(2007\)](#) are early papers to assume durable jobs in the search literature.

Our model builds on a number of theoretical developments in the search literature. We build on search models emphasizing the role of selection on idiosyncratic match quality ([Martellini and Menzio, 2020, 2021](#); [Borovičková and Shimer, 2024](#)). We also build on earlier work emphasizing how recruiting technologies affect the large-firm wage premia: [Coles and Mortensen \(2016\)](#) and [Gouin-Bonenfant \(2022\)](#) show that a constant-returns-to-scale recruiting technology allows firms to become large without raising wages. [Gouin-Bonenfant \(2022\)](#) presents a monopsony model that generates a declining labor share associated with the rise of superstar firms. We contrast its predictions with our model for the large-firm wage premium in section 3. [Leduc and Liu \(2024\)](#) consider a model where the threat of automation weakens the bargaining power of workers in booms and thus amplifies business cycles. Finally, [Acemoglu and Restrepo \(2026\)](#) consider the effects of automation in a model in which some workers earn rents. They show that automation targets high-rent jobs amplifying wage losses.

⁵This differs fundamentally from the falling employment that drives wage stagnation in Autor and Dorn’s canonical analysis of the consequences of routine-biased technical change for the manufacturing sector.

A note on language. We use the term commoditization rather than commodification. To commoditize is to make a good or service indistinguishable from other offerings, while to commodify is to turn something into a product that can be bought and sold in a marketplace. Our paper is about the former as opposed to the latter.

2 A Simple Model of Commoditization of Labor

Consider a setting in which time is continuous and the horizon is infinite. We focus on the steady state of our model and drop the time index for notational simplicity. There are a measure m of firms and a unit measure of workers. Workers are ex-ante homogenous, while firms are ex-ante heterogenous. All agents are risk-neutral with discount rate $\rho > 0$.

2.1 Production

Firms differ in the quality $z \in [0, \infty)$ of their technology and the degree to which their technology is standardized $s \in (0, 1]$. We index firms by $x \equiv (z, s)$. Let m_x denote the measure of firms of type x . Each firm of type x consists of a measure k_x of jobs. Importantly, these jobs are durable. When a worker separates from a job, the job becomes vacant and needs to be refilled. We think of the firm as having incurred a fixed cost at an earlier point to create the job. For example, the firm may have bought a machine that needs to be operated or built an outlet that needs to be staffed. We assume for simplicity that the number of firms and the number of jobs are fixed. We show in Appendix D that all of our results in section 3 go through with endogenous entry of firms subject to a fixed cost and endogenous choice of k_x subject to an increasing and convex cost.

Each job consists of a continuum of tasks $\tau \in [0, 1]$. The output of the job is a Cobb-Douglas aggregate of the output of each task

$$A = \exp \left(\int_0^1 \ln y(\tau) d\tau \right), \quad (1)$$

where $y(\tau)$ is the output of task τ .

Whenever a worker matches with a firm, they learn their idiosyncratic aptitude to perform the tasks required for the specific job the firm is hiring for. This idiosyncratic match quality ω is drawn from a distribution $G(\omega)$. It is fixed for the duration of the match. We assume that the

match quality distribution $G(\omega)$ is given by a Pareto distribution:

$$G(\omega) = 1 - (\omega/\underline{\omega})^{-\beta}, \quad (2)$$

where $\underline{\omega}$ is the location parameter and β is the shape parameter. We assume that $\beta > 1 - \underline{s}$, where $\underline{s}$ is the minimum degree of standardization s among all firms.⁶

All tasks are performed by workers in our model. However, the degree to which a worker's know-how (ω) is important depends on how standardized the firm's technology is. A fraction s of the tasks a worker performs have been standardized. The output of these tasks does not depend on the worker's know-how. They are simple enough that all workers can perform them equally well. The output of the standardized tasks is determined by the quality of the firm's technology z . In contrast, the remaining $1 - s$ tasks are not standardized. For these tasks, worker know-how matters: the output of these tasks is determined by ω .⁷ Formally, task-level output is given by

$$y(\tau) = \begin{cases} z & \text{if } \tau \leq s \\ \omega & \text{if } \tau > s. \end{cases} \quad (3)$$

Combining (1) and (3), we have

$$A_x(\omega) = \exp \left(\int_0^s \ln z d\tau + \int_s^1 \ln \omega d\tau \right).$$

which simplifies to

$$A_x(\omega) = z^s \omega^{1-s}. \quad (4)$$

In other words, the output of a job is a Cobb-Douglas function of the quality of the firm's technology z and the worker's match quality ω with the weight on the quality of the firm's technology being determined by the level of standardization of the firm's technology s .

When $s = 1$, output is determined solely by the quality of the firm's technology and the match quality of the worker (i.e., worker know-how) is irrelevant. This is the full-standardization extreme. Conversely, when $s \rightarrow 0$, output is determined solely by the worker's match quality. This is the no-standardization extreme. For intermediate values of standardization, output is partly

⁶This assumption ensures that the expected output at any firm is finite (see equation (28)).

⁷This setup is similar to that in Bassi et al. (2025).

determined by worker know-how and partly by the quality of the firm's technology. As firm's standardize more tasks (raise s), the specific skills of the worker becomes irrelevant. Workers become more indistinguishable, more replaceable, more commoditized from the firm's perspective.

2.2 Search

The economy is subject to search frictions. Search is directed and competitive as in [Moen \(1997\)](#).⁸ For simplicity, we assume that only unemployed workers search. Without loss of generality, we index each submarket by the expected promised value to the worker in excess of the value of being unemployed: $W \equiv \mathcal{W} - U$, where $\mathcal{W}$ is the worker's expected promised value and U is the value of being unemployed. In each period, unemployed workers choose which submarket to search in, and firms choose which submarket to post a vacancy in for each vacant job they have.

By posting a vacancy in submarket W , firms commit to deliver the promised value W (in excess of the value of unemployment) to the worker in expectation conditional on a meeting. There are many ways in which firms can deliver the promised value W to the worker. While the exact details of how firms deliver the promised value are irrelevant for allocations, they matter for the wage. We restrict attention to a relatively simple type of contract: a constant wage over the course of the match that varies by ω .

The number of meetings between unemployed workers and vacant jobs in each submarket is given by the constant-returns-to-scale matching function $\mathcal{M}(u, v)$, where u is the mass of unemployed workers and v is the mass of vacant jobs in that submarket. We assume that the matching function takes the Cobb-Douglas form:

$$\mathcal{M}(u, v) = \kappa u^\eta v^{1-\eta}, \quad (5)$$

where $\eta \in (0, 1)$ is the elasticity of the matching function with respect to the mass of unemployed workers and κ governs the overall efficiency of matching.

Due to the constant-returns-to-scale property of the matching function, the meeting rate of unemployed workers and vacant jobs can be written as a function of market tightness $\theta \equiv v/u$. Define the meeting rate for unemployed workers in a submarket with market tightness θ as $\lambda^U(\theta)$ and the meeting rate for vacant jobs in a submarket with market tightness θ as $\lambda^F(\theta)$. With match-

⁸In Appendix E, we present a version of our model with random search and Nash bargaining.

ing function (5), we have

$$\lambda^U(\theta) = \kappa\theta^{1-\eta} \quad \text{and} \quad \lambda^F(\theta) = \kappa\theta^{-\eta}. \quad (6)$$

When an unemployed worker and a firm meet, they learn the idiosyncratic match quality ω for their prospective match. They then decide whether to form a match or not. All matches separate exogenously at rate δ .

2.3 Value Functions

For the sake of notational simplicity, we assume that the flow value of unemployment and of vacant jobs are both zero. Unemployed workers choose to search for a job in the submarket that offers them the highest value. Their value function is given by

$$\rho U = \max_W \lambda^U(\theta(W))W, \quad (7)$$

where the value of searching in submarket W is the product of the probability of meeting a firm in that submarket $\lambda^U(\theta(W))$ and the expected value of such a meeting W (which takes into account the fact that not all meetings result in matches).

Among all active submarkets, workers must be indifferent about which submarket they choose to search in. This implies that $\lambda^U(\theta(W))W$ must be equal to ρU for all active submarkets (all W with $\theta(W) < \infty$). Recall that $\lambda^U(\theta(W)) = \kappa\theta(W)^{1-\eta}$ (equation (6)). We then have that $\theta(W)$ is given by

$$\theta(W) = KW^{-\frac{1}{1-\eta}}, \quad (8)$$

where $K \equiv \left(\frac{\rho U}{\kappa}\right)^{\frac{1}{1-\eta}}$. The inverse relationship between $\theta(W)$ and W in equation (8) is a key mechanism for generating an upward-sloping labor supply curve in submarket W in our model. Submarkets with high promised value W attract more unemployed workers for each vacancy that is posted. This results in a low equilibrium level of market tightness $\theta(W) = v(W)/u(W)$ in that submarket. In other words, tightness in a submarket is inversely related to the promised value W in that submarket.

As we discussed above, firms commit to deliver expected value W to workers conditional on a meeting. Let $W_x(\omega)$ denote the value workers receive conditional on a match with a particular

match quality ω . This value $W_x(\omega)$ is not uniquely pinned down in equilibrium. It can take a variety of values as long as

$$\int \mathbb{I}_x(\omega) W_x(\omega) dG(\omega) = W \quad (9)$$

and $W_x(\omega) \geq 0$ hold, where $\mathbb{I}_x(\omega)$ is an indicator function that is one if the match is formed. The constraint $W_x(\omega) \geq 0$ ensures that workers do not have an incentive to quit to become unemployed and search for a new job. Given $W_x(\omega)$, the wage $w(W_x(\omega))$ is determined by

$$\rho W_x(\omega) = w(W_x(\omega)) - \delta W_x(\omega) - \rho U. \quad (10)$$

For the results we derive below, it does not matter how we pin down the split of $\{W_x(\omega)\}$ across different match qualities ω so long as they satisfy equation (9) and $W_x(\omega) \geq 0$, since our analysis concerns the average wage at the firm level throughout.

For each vacant job, firms choose in which submarket to post a vacancy to maximize the expected value of the vacancy. The value function for a vacant job is then given by

$$\rho V_x = \max_W \lambda^F(\theta(W)) \Pi_x(W), \quad (11)$$

where $\Pi_x(W)$ is the value of meeting a worker in submarket W net of the value of a vacancy. This net value is given by

$$\Pi_x(W) = \max_{\{\mathbb{I}_x(\omega), W_x(\omega)\}} \int \mathbb{I}_x(\omega) \{J_x(\omega, W_x(\omega)) - V_x\} dG(\omega) \quad (12)$$

subject to equation (9), where $J_x(\omega, W_x(\omega))$ is the value that accrues to a firm from forming a match with a worker with match quality ω and promised value $W_x(\omega)$. Here, we impose that the match formation decision does not depend on the promised value $W_x(\omega)$ given the match quality ω . Workers and firms form matches whenever the surplus from the match is positive. Whether this is the case is not affected by $W_x(\omega)$ as we discuss below.

The value function $J_x(\omega, W_x(\omega))$ solves the following Hamilton-Jacobi-Bellman (HJB) equation:

$$\rho J_x(\omega, W_x(\omega)) = A_x(\omega) - w(W_x(\omega)) + \delta(V_x - J_x(\omega, W_x(\omega))), \quad (13)$$

where $w(W_x(\omega))$ is defined in equation (10).

2.4 Match Formation and Promised Value (Wage) Setting

Define match surplus as

$$S_x(\omega) \equiv J_x(\omega, W_x(\omega)) + W_x(\omega) - V_x. \quad (14)$$

Combining equations (10), (13), and (14) yields

$$(\rho + \delta)S_x(\omega) = A_x(\omega) - \rho U - \rho V_x. \quad (15)$$

Notice that match surplus is independent of $W_x(\omega)$ conditional on ω . Intuitively, $W_x(\omega)$ simply splits the match surplus between the worker and the firm. This relies on workers and firms being risk neutral.

Combining equations (9), (12), and (14) shows that the match formation decision solves

$$\Pi_x(W) = \max_{\{\mathbb{I}_x(\omega)\}} \int \mathbb{I}_x(\omega) S_x(\omega) dG(\omega) - W. \quad (16)$$

This implies that firms and workers will form a match whenever $S_x(\omega) > 0$. Since $S_x(\omega)$ is strictly increasing in match quality ω , the match formation decision is a threshold rule in match quality ω :

$$\mathbb{I}_x(\omega) = \begin{cases} 1 & \text{if } \omega > \omega_x^R \\ 0 & \text{otherwise,} \end{cases} \quad (17)$$

where ω_x^R is the reservation match quality, above which the match is formed. Since our mechanism relies on the endogenous determination of hiring standards, throughout, we assume that parameters are such that the reservation match quality is interior: $\omega_x^R > \underline{\omega}$ for all x .⁹ Equation (15) then implies that the reservation match quality ω_x^R satisfies

$$A_x(\omega_x^R) = \rho U + \rho V_x. \quad (18)$$

⁹We can consider values of $\underline{\omega}$ arbitrarily close to zero by assuming that the efficiency of the matching function goes to infinity as $\underline{\omega} \rightarrow 0$ but let the efficiency of the matching function $\kappa \rightarrow \infty$, so that the matching rates remain constant as in Oberfield (2018).

We are now ready to come back to the optimal promised value (wage) setting problem for vacant jobs. We can use (8), (15), and (16) to rewrite (11) as

$$\rho V_x = \max_{W_x} \kappa K^{-\eta} W_x^{\frac{\eta}{1-\eta}} \left\{ \int_{\omega_x^R}^{\infty} \frac{1}{\rho + \delta} [A_x(\omega) - \rho U - \rho V_x] dG(\omega) - W_x \right\} \quad (19)$$

The first-order condition for the maximization problem on the right-hand side of equation (19) is

$$W_x = \eta \int_{\omega_x^R}^{\infty} \frac{1}{\rho + \delta} [A_x(\omega) - \rho U - \rho V_x] dG(\omega). \quad (20)$$

This condition states that workers obtain a fraction $\eta \in (0, 1)$ of the expected match surplus, a standard property of the directed search model.

2.5 Connection with Existing Monopsony Paradigm

The firm's problem in equation (19) is very similar to a standard monopsony problem that has been extensively studied in the labor economics literature. The firm faces an upward-sloping labor supply curve— $\kappa K^{-\eta} W^{\frac{\eta}{1-\eta}}$ —with an elasticity governed by η . It faces a trade-off in that offering a higher W attracts more workers and makes it easier to fill its vacancy, but also implies paying workers more once they are hired. As in the standard monopsony problem, the worker's outside option matters. This is the ρU term in equation (19). Differently from the standard monopsony problem, however, the firm's outside option also plays an important role. This is the ρV_x term in equation (19). Since ρV_x appears on both the left-hand side and the right-hand side of equation (19), the firm's outside option is endogenously determined as a fixed point of this equation.

To better understand the connection between our model and the existing monopsony paradigm, it is useful to rewrite equation (20) in terms of the wage the worker receives as opposed to their promised utility. Note that equations (9), (10), and (17) imply that the worker's value function satisfies

$$(\rho + \delta)W_x = (1 - G(\omega_x^R)) \{\bar{w}_x - \rho U\}, \quad (21)$$

where $\bar{w}_x \equiv \mathbb{E}[w_x(\omega) | \omega \geq \omega_x^R]$ is the average wage of workers at firm x .

The expected hire per vacancy is $\lambda^F(\theta) \times (1 - G(\omega_x^R))$. Using equation (8), this becomes $\kappa K^{-\eta} W_x^{\frac{\eta}{1-\eta}} \times (1 - G(\omega_x^R))$. Using equation (21) to substitute for W_x into this expression we can

then define the labor supply function as a function of expected wage payments conditional on forming a match:

$$\ell(\bar{w}_x, \omega_x^R) \equiv \frac{1}{(\rho + \delta)^{\frac{\eta}{1-\eta}}} \kappa K^{-\eta} (\bar{w}_x - \rho U)^{\frac{\eta}{1-\eta}} (1 - G(\omega_x^R))^{\frac{1}{1-\eta}}. \quad (22)$$

Using this definition, notice that the elasticity of labor supply faced by a vacancy in our model is

$$\epsilon_x^\ell(\bar{w}_x) \equiv \frac{\frac{\partial \ell(\bar{w}_x, \omega_x^R)}{\partial \bar{w}_x} \bar{w}_x}{\ell(\bar{w}_x, \omega_x^R)} = \frac{\eta}{1 - \eta} \frac{\bar{w}_x}{(\bar{w}_x - \rho U)}. \quad (23)$$

We can then combine this with equations (20) and (21) to get

$$\frac{\bar{A}_x - \rho V_x - \bar{w}_x}{\bar{w}_x} = \frac{1}{\epsilon_x^\ell(\bar{w}_x)}, \quad (24)$$

where $\bar{A}_x \equiv \mathbb{E}[A_x(\omega) | \omega \geq \omega_x^R]$ is the expected marginal product of labor of firm x . Equation (24) is very similar to the standard Lerner formula for a monopsonist, which equates the wage markdown to the inverse of labor supply elasticity. The only difference is that the firm's outside option ρV_x enters the formula in our model. Loosely speaking, for any given labor supply elasticity and marginal product of labor, a higher outside option of firms lowers wages.¹⁰

2.6 Equilibrium

We can now solve for the equilibrium of our model. We begin by solving for the reservation match quality ω_x^R of firm x . The following lemma characterizes the solution.

Lemma 1. *The reservation match quality ω_x^R at firm x is the unique solution to the following equation:*

$$z^s(\omega_x^R)^{1-s} = \rho U + \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1 - \eta) \left\{ \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} z^s(\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^\beta \right] \right\}^{\frac{1}{1-\eta}}. \quad (25)$$

The proof of this lemma (as well other lemmas and propositions in the paper) is in Appendix B. Equation (25) equates the flow output of a match evaluated at the reservation match quality ω_x^R on the left-hand side with the opportunity costs of workers and firms on the right-hand side. The

¹⁰A subtle point is that the labor supply elasticity $\frac{\partial \ell(\bar{w}_x, \omega_x^R)}{\partial \bar{w}_x} \bar{w}_x$ may not necessarily correspond to what has been empirically measured. The typical empirical estimates use firm-level shocks to measure $d\ell/dw$. This is a total derivative and does not hold the reservation match quality fixed. By contrast, what enters into the wage markdown formula is the partial derivative, $\partial \ell / \partial w$, which holds the reservation match quality fixed. Likewise, the wage markdown formula holds the number of vacancies fixed, while many empirically measured labor supply elasticities do not hold the number of vacancies fixed. See also [Caldwell et al. \(2026\)](#) for a related discussion.

left-hand side is increasing in ω_x^R because, as firms increase their reservation match quality ω_x^R , the flow output of a match increases. The right-hand side is decreasing in ω_x^R because, as firms increase hiring standards, it takes more time to fill vacancies, reducing the value of a vacancy. At the optimum, these two forces must be balanced, which is given by the unique intersection.

Having solved for ω_x^R , we can solve for the rest of the equilibrium objects as follows (see Appendix A for derivations). The expected surplus conditional on meeting for firm x is given by

$$S_x \equiv \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^\beta \right], \quad (26)$$

and the expected promised value of workers at firm x is

$$W_x = \eta S_x. \quad (27)$$

Average output per worker at firm x , $\bar{A}_x \equiv \mathbb{E}[A_x(\omega) | \omega \geq \omega_x^R]$, is given by

$$\bar{A}_x = \frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s}. \quad (28)$$

The value of unemployment is

$$\rho U = \kappa \left(\frac{1}{u} \int (W_x)^{\frac{1}{1-\eta}} v_x dm_x \right)^{1-\eta}. \quad (29)$$

Interestingly, the above expression shows that workers effectively view different firms x as imperfect substitutes with constant elasticity of substitution (CES) equal to η over the promised utility W_x . This draws a parallel to the non-search-based monopsony paradigm (see e.g., Kline (2025) for a survey). There, workers view different firms as imperfect substitutes due to their idiosyncratic tastes, which are often assumed to take the CES form. Our directed search model, provides a search-based microfoundation for why workers view different firms as imperfect substitutes.

The vacancy filling rate at firm x , q_x , is the product of the vacancy meeting rate $\lambda^F(\theta(W_x))$ and the matching probability $(1 - G(\omega_x^R))$. Using equation (8) and the definition of K we have that

$$q_x = \kappa \left(\frac{\kappa W_x}{\rho U} \right)^{\frac{\eta}{1-\eta}} (1 - G(\omega_x^R)). \quad (30)$$

The steady state number of employment size and vacancies at firm x are then given by

$$n_x = \frac{q_x}{q_x + \delta} k_x, \quad \text{and} \quad v_x = k_x - n_x \quad (31)$$

The steady state unemployment satisfies

$$u = 1 - \int n_x dm_x. \quad (32)$$

Finally, the average wage at firm x , $\bar{w}_x \equiv \mathbb{E}[w_x(\omega) | \omega \geq \omega_x^R]$, is given by

$$\bar{w}_x = \rho U + \eta \frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s}. \quad (33)$$

We can solve equations (29) - (33) for $\{U, q_x, v_x, n_x, u, \bar{w}_x\}$ as a function of exogenous variables and parameters. This fully characterizes the equilibrium of our economy.

3 Implications of Standardization

How does increased standardization affect firm output, worker wages, and the labor share of income? We first consider changes to a single firm's degree of standardization holding the technology of other firms fixed. We then consider changes to the entire distribution of firm standardization.

3.1 Cross-Sectional Implications

Consider first a setting where we vary the degree of standardization of a single firm holding fixed the degree of standardization of all other firms. For analytical tractability, we focus on "superstar" firms, i.e., firms with high z . The following lemma provides a closed-form characterization of the reservation match quality for such superstar firms:

Lemma 2. *Consider firms with sufficiently high z that $\rho U/z^s \rightarrow 0$. Reservation match quality converges to*

$$\omega_x^R \rightarrow \left\{ B \frac{1-s}{\beta+s-1} z^{s\eta} \right\}^{\frac{1}{\beta-(1-s)\eta}}, \quad (34)$$

as $\rho U/z^s \rightarrow 0$, where $B \equiv \kappa^{1-\eta} K^{-\eta(1-\eta)} \eta^\eta (1-\eta)^{1-\eta} \frac{1}{\rho+\delta} \omega^\beta > 0$.

We can use this lemma to derive a number of sharp predictions on firm outcomes. First, we have the following proposition regarding the reservation match quality:

Proposition 1. *Consider firms with sufficiently high z that $\rho U / z^s \rightarrow 0$. There exists an s^* such that for $s \geq s^*$ the reservation match quality, ω_x^R , is strictly decreasing in s .*

This proposition is the backbone of our analysis. As the degree of standardization s of a firm's technology increases, the output from a job relies more heavily on the quality of the firm's technology z and less on the know-how of the worker it hires (the worker's idiosyncratic match quality ω). This results in high- z firms becoming less picky about the workers they seek to hire, implying that the reservation match quality falls. In other words, these firms lower their hiring standards. In the limit as $s \rightarrow 1$, it doesn't matter at all who is hired, so firms are willing to hire anyone.

The left panel of Figure 1 provides a numerical illustration of Proposition 1 using the baseline calibration of our model described in section 4.1. We plot how the reservation match quality of firms falls as s increases over a wide range of s for two values of z . When s is close to one, the reservation match quality converges to zero (i.e., firms are willing to hire anyone).¹¹

Next we consider the effect of increased standardization on firm output, wages, and the share of the firm's output that accrues to labor:

Proposition 2. *Consider firms with a sufficiently high z that $\rho U / z^s \rightarrow 0$. There exists an s^* such that for $s \geq s^*$:*

1. *Average output per worker, $\bar{A}_x$, is strictly increasing in s .*
2. *The average wage, $\bar{w}_x$, is strictly decreasing in s .*
3. *The firm-level labor share, $\bar{w}_x / \bar{A}_x$, is strictly decreasing in s .*

The middle and right panels of Figure 1 illustrate this proposition numerically. The middle panel shows that output per worker rises with s when s is sufficiently high. The point at which output per worker begins to rise in s is lower the higher z is. In other words, a higher z lowers the threshold at which higher s results in higher output per worker. Intuitively, since higher s increases the weight on z in the production function, raising s is more beneficial for high- z firms.

¹¹For sufficiently low s , reservation match quality, ω_x^R , can rise in s . The reason for this is that raising s has two effects on the potential value of waiting for a better worker which push in opposite directions. First, the weight on the quality of the worker falls. This is the force discussed above. It dominates when s is sufficiently large. But there is a second force: the ω^{1-s} term in the production function is multiplied by z^s and z^s increases when s increases (for high- z firms). This means that having a better worker can matter more since it is multiplying a larger z^s . This force leads firms to want to wait more (raise hiring standards) when s increases. It can dominate for sufficiently low s .

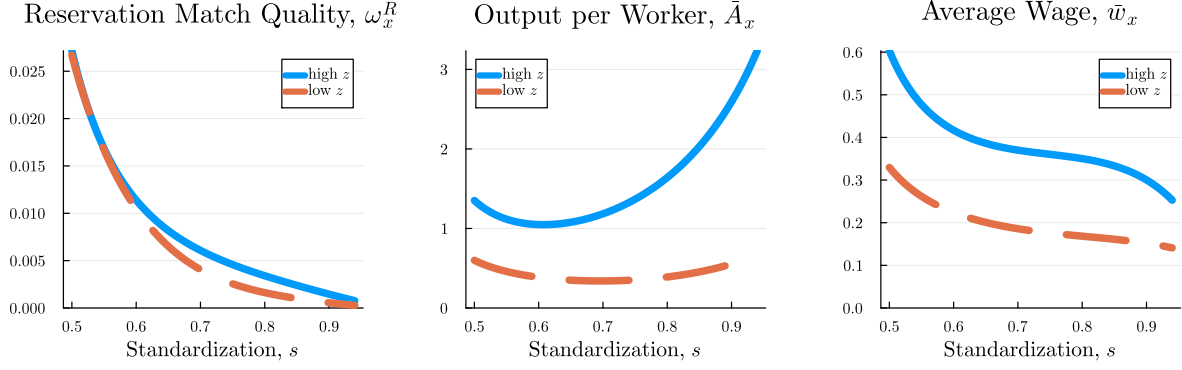


Figure 1: Numerical Illustration for Reservation Wage, Output, and Average Wage

Note: The figure provides a numerical illustration of Propositions 1 and 2. We use our baseline calibration described in Section 4.1 except for z and s . “High z ” refers to firms with $z = 5.0$, while “low z ” refers to firms with $z = 1.0$. The figure plots reservation match quality, output per worker, and the average wage at the firm level for firms with different levels of standardization.

The right panel of Figure 1 shows that—despite output per worker increasing in s —the average wage the firm pays decreases in s . The reason why wages can decrease despite output per worker increasing is that the firm’s outside option improves. This results in a larger markdown of wages below the marginal revenue product of the worker (see equation (24)). Intuitively, high- z firms with high s have a lower reservation match quality ω_x^R (since they care less about worker match quality). This means that they can more easily fill vacancies and have less incentive to post high wages. Finally, since wages fall and output per worker rises with s , the firm-level labor share decreases.

To drive home the role that the firm’s outside option plays in our results, we consider an extension of our model in Appendix F where we drive the value of the firm’s outside option to zero by making unfilled vacancies imperfectly durable. In this limit, the key results of Proposition 2 flip: output per worker falls as s increases, and the labor share rises as s increases. As s increases, the average match quality worsens. This reduces output per worker. It also reduces wages, but it makes the worker’s labor supply curve more elastic (since workers are getting close to their outside option) which erodes the firm’s monopsony power.

In Appendix E, we present random search version of our model with wages determined by Nash bargaining. This version of the model yields a complementary intuition for why wages fall with increased standardization: an increase in s improves the firm’s bargaining position because firms have an easier time finding an alternative worker. This raises the value of the firm’s outside option, which reduces match surplus and lowers wages. We present analogous results to all results in this subsection in Appendix E.

While standardization lowers wages, it still enables high- z firms to grow in size by increasing their vacancy-filling rate.

Proposition 3. *Consider firms with a sufficiently high z that $\rho U/z^s \rightarrow 0$. There exists an s^* such that for $s \geq s^*$:*

1. *The vacancy-filling rate, q_x , is strictly increasing in s .*
2. *The expected surplus, S_x , is strictly increasing in s .*
3. *The expected value of a vacancy, V_x , is strictly increasing in s .*
4. *The expected promised value, W_x , is strictly increasing in s .*

Figure 2 illustrates this proposition numerically. In the top-left panel, we see that, even though the firms with high s pay lower wages, they fill vacancies faster. This occurs because firms with high s lower their hiring standards (lower ω_x^R). A higher vacancy filling rate implies that even if all firms have the same number of jobs to fill (i.e., $k_x = k$ for all x), more standardized firms will be larger.

Perhaps more surprisingly, the expected promised value, W_x , increases with standardization s . Recall that the expected promised value is a share of expected surplus $W_x = \eta S_x$. For high- z firms, expected surplus rises when standardization s increases. This then implies that the expected promised value increases. Intuitively, high- z firms want to attract more applicants when s is high since these applicants are more valuable.

The fact that the expected promised value W_x and the average wage $\bar{w}_x$ move in opposite directions when s increases for a high- z firm implies that standardization is a double-edged sword for workers. Workers are better off in the sense of having access to higher W_x jobs. However, these jobs are high value not because they pay high wages (actually, they pay low wages). They are high value because the job-finding rate is high. Standardization makes finding a job easier, but the jobs are “bad jobs” ex post in that they pay low wages. The high job-finding rate of highly standardized jobs may be viewed as a non-wage job amenity that helps explain why wages are low as in [Lamadon et al. \(2025\)](#).

We now contrast the implications of increased standardization s of high- z firms with the implications of increasing their z . The following proposition shows that increasing z and increasing s have opposite effects on firm wages.

Proposition 4. *In our economy, we have that:*

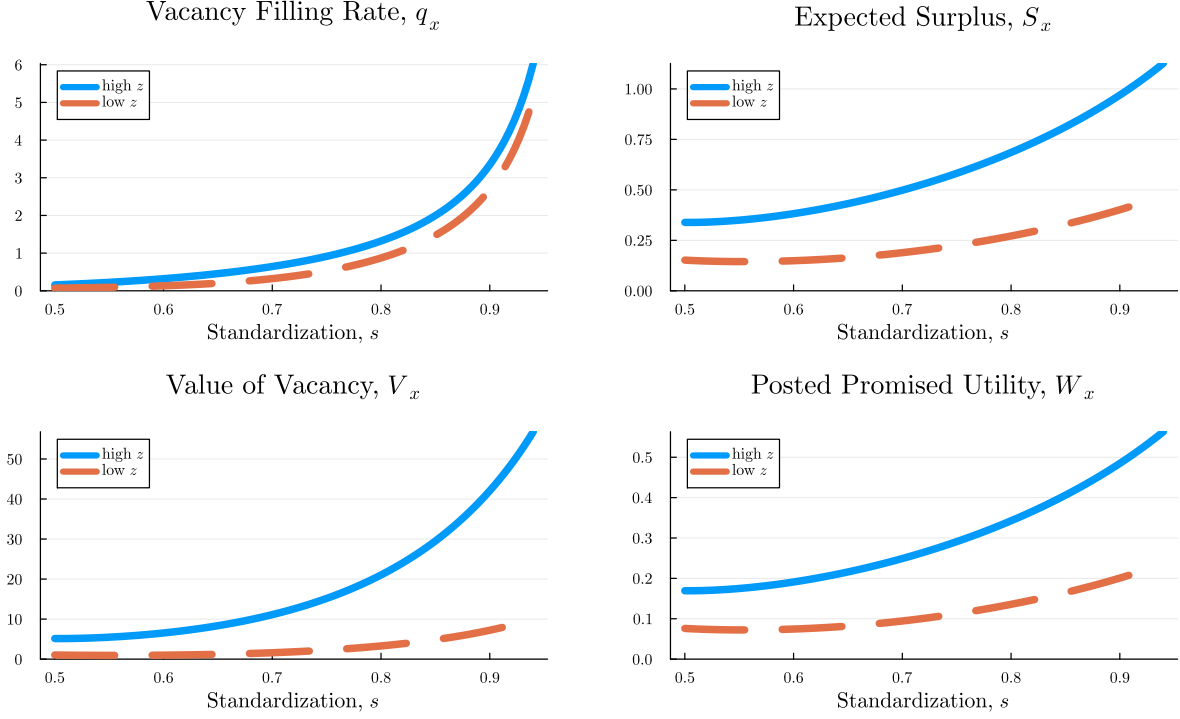


Figure 2: Numerical Illustration for Vacancy-Filling Rate, Surplus, and Value of Vacancy

Note: The figure provides a numerical illustration of Proposition 3. We use our baseline calibration described in Section 4.1 except for z and s . “High z ” refers to firms with $z = 5.0$, while “low z ” refers to firms with $z = 1.0$. The figure plots the vacancy-filling rate, the expected match surplus, and the value of a vacancy for firms with different degrees of standardization.

1. The average wage paid by a firm is strictly increasing in z .
2. Output per worker is strictly increasing in z .
3. The vacancy-filling rate is strictly increasing in z .
4. The labor share is strictly decreasing in z .

Several of these implications are similar to what occurs when s increases: a higher z increases output per worker and the vacancy-filling rate, while decreasing the labor share. These implications echo findings in the model developed by Gouin-Bonenfant (2022). Importantly and differently from an increase in s , an increase in z increases the firm’s wage. This wage increase is the mechanism through which the firm increases its vacancy-filling rate and grows. This is a ubiquitous feature of standard monopsony models. As z increases, firms have an incentive to fill their vacancies faster, which induces them to post higher wages. Our model, in contrast, allows firms to grow without raising wages by adopting a technology that standardizes or “commoditizes” workers.

3.2 Aggregate Implications

So far, we have focused on the cross-sectional implications of standardization. We now study its aggregate implications on the labor share. We do this by considering variation in the entire distribution of $x \equiv (z, s)$.

It is useful, as an intermediate step, to characterize the labor share for arbitrary firm weights ψ_x . The following lemma expresses the labor share in terms of workers' and firms' outside options for arbitrary firm weights.

Lemma 3. *For any nonnegative firm weights ψ_x satisfying $\int \psi_x dm_x = 1$, define $\mathbb{E}_\psi[f_x] \equiv \int f_x \psi_x dm_x$. Define the aggregate labor share with weights ψ_x as $LS^\psi \equiv \mathbb{E}_\psi[\tilde{w}_x] / \mathbb{E}_\psi[\bar{A}_x]$. The weighted labor share satisfies*

$$LS^\psi = \eta + \frac{(1 - \eta)\rho U - \eta\rho \mathbb{E}_\psi[V_x]}{\mathbb{E}_\psi[\bar{A}_x]} \quad (35)$$

$$= \eta + \frac{\eta\rho}{\mathbb{E}_\psi[\bar{A}_x]} (\theta \mathbb{E}_v[V_x] - \mathbb{E}_\psi[V_x]), \quad (36)$$

where $\theta \equiv v/u$ is aggregate market tightness and $\mathbb{E}_v[f_x] \equiv \int f_x (v_x/v) dm_x$ denotes the vacancy-weighted average of f_x .

Equation (35) decomposes the labor share into two terms. The first term is simply η , which corresponds to the fraction of surplus that workers can expect to receive when they meet a firm (equation (27)). The second term shows how deviations in the labor share from η depend on the outside options of workers and firms. When workers have a strong outside option, this raises the labor share, while a strong firm outside option lowers the labor share. In equilibrium, the outside option of workers is tied to the vacancy-weighted average of the outside option of firms. Equation (36) makes this explicit.

Notice that, when $\theta = 1$, the labor share falls below η precisely when $\mathbb{E}_\psi[V_x] < \mathbb{E}_v[V_x]$. In what follows, to simplify the analysis, we assume that the total number of positions in the economy equals the mass of workers: $\int k_x dm_x = 1$. This simplifying assumption implies that, in steady state, $\theta = 1$ in our model.

The analysis in section 3.1 demonstrates that a single high- z firm can grow larger and extract more surplus from its workers by adopting a more standardized technology. But what if all firms standardize their production process? It may be tempting to conclude that this will allow all firms to extract more surplus from workers. The following corollary shows, in a simple case, that this

conjecture is false.

Corollary 1. *If there is no firm heterogeneity and $\theta = 1$, the aggregate labor share is given by*

$$LS^\psi \equiv \bar{w}_x / \bar{A}_x = \eta. \quad (37)$$

Corollary 1 says that the labor share is η for any level of standardization when there is no firm heterogeneity. Intuitively, while standardization increases the firm's outside option, it also increases the worker's outside option if all firms standardize. If the firm loses its current worker, it can easily hire another one. But it is also the case that, if the worker loses their current job, they can easily get another job with another (standardized) firm. Firms can threaten to fire workers, but workers can also threaten to quit given that it is easy to get another job. If McDonald's threatens to replace its workers, they can respond that it's easy to get a job at Burger King. In Corollary 1, these two opposing forces cancel each other out, resulting in the same aggregate labor share regardless of the degree of standardization. Mechanically speaking, this occurs because workers and firms are symmetric in our model when there is no firm heterogeneity and when $\theta = 1$ (which is close to its value in the data during good economic times).

Considering again an economy with heterogeneous firms, notice that, when $\theta = 1$ and $\psi_x = v_x/v$, the second term in equation (36) is zero. This implies that the vacancy-weighted labor share is a useful benchmark when firms are heterogeneous.

Corollary 2. *Assume $\theta = 1$. The vacancy-weighted labor share, defined as $LS^v \equiv \mathbb{E}_v[\bar{w}_x] / \mathbb{E}_v[\bar{A}_x]$, is given by*

$$LS^v = \eta. \quad (38)$$

In other words, even in the presence of heterogeneity, the vacancy-weighted labor share is constant regardless of the level or distribution of standardization in the economy. If firms' employment shares were equal to their vacancy shares, the aggregate labor share would also be η . With these weights, changes in the worker's outside option exactly offset changes in the average firm outside option. Intuitively, vacancies determine the opportunities available to unemployed workers, so the worker's outside option is tied to firms' outside options averaged across vacancies.

In equilibrium, however, the employment shares of firms will not necessarily equal their vacancy shares. This will mean that standardization can affect the labor share in the economy. The following proposition characterizes the conditions under which the employment-weighted labor share is lower than η .

Proposition 5. *Assume $\theta = 1$. The (employment-weighted) aggregate labor share, $LS^n \equiv \mathbb{E}_n[\bar{w}_x]/\mathbb{E}_n[\bar{A}_x]$, is given by*

$$LS^n = \eta - \frac{\eta \rho \text{Cov}_v(V_x, q_x)}{\mathbb{E}_v[q_x \bar{A}_x]}, \quad (39)$$

which is strictly less than η if and only if firms with more valuable outside options fill vacancies faster:

$$LS^n < \eta \iff \text{Cov}_v(q_x, V_x) > 0, \quad (40)$$

where $\text{Cov}_v(V_x, q_x) \equiv \mathbb{E}_v[V_x q_x] - \mathbb{E}_v[V_x] \mathbb{E}_v[q_x]$.

This proposition shows that the aggregate (employment-weighted) labor share is strictly less than the labor share with no heterogeneity, η , if the vacancy filling rate q_x covaries positively with firms' outside options V_x . Recall that the vacancy-weighted labor share equals η . Firms that fill vacancies faster account for a larger share of employment relative to their share of vacancies. If these firms also have stronger outside options, then moving from vacancy weights to employment weights raises the average value of firms' outside options. Employment is then tilted toward firms that have adopted technology to make their workers more replaceable, pushing the aggregate labor share below η . A complementary intuition is that, to the extent that standardized firms are filling their vacancies faster, workers' outside options do not improve much because most of the positions that workers have an easier time getting are already filled.

Proposition 3 provides a mechanism for this positive covariance: among firms with sufficiently high z and s , greater standardization raises both the vacancy-filling rate and the value of a vacancy. Standardization concentrated among high- z firms can therefore generate the positive association between hiring speed and firms' outside options that depresses the aggregate labor share below η . By contrast, uniform standardization leaves the labor share unchanged when firms are identical.

3.3 Endogenous Standardization

Up until this point, we have assumed that the distribution of standardization is exogenously given. We have considered the implications of changes in this exogenously given distribution of standardization, but we have not allowed firms to optimally choose their level of standardization. We now consider an extension of our model where firms can choose the degree of the standardization s endogenously (but z remains exogenously given). We assume that all firms are endowed with a baseline degree of standardization $s = \underline{s}$, and that they can invest to increase the level of s above $\underline{s}$. Firms choose the degree of standardization s to maximize their expected vacancy value subject to a convex cost $\Phi(s)$ per position. In other words, the firms solve the following problem:

$$V_z \equiv \max_{s \in [\underline{s}, 1]} V_x - \Phi(s). \quad (41)$$

We assume that the cost function $\Phi(s)$ is sufficiently convex that the firm's overall problem is concave in s .

The following lemma characterizes the marginal benefit of standardization.

Lemma 4. *Assume $\beta > \eta$. For any s , there exists a threshold $\hat{z}(s)$ such that*

$$\frac{\partial V_x}{\partial s} > 0 \quad \text{if and only if} \quad z > \hat{z}(s). \quad (42)$$

Moreover, the marginal value of standardization $\frac{\partial V_x}{\partial s}$ is strictly increasing in z for firms with $z > \hat{z}(s)$:

$$\frac{\partial^2 V_x}{\partial s \partial z} > 0 \quad \text{for} \quad z > \hat{z}(s). \quad (43)$$

The first part of Lemma 4 states that the marginal benefit of standardization is positive for high- z firms and negative for low- z firms. The second part of Lemma 4 shows that for the firms with positive marginal benefit of standardization, the marginal benefit of standardization is strictly increasing in z .

For low- z firms, the marginal benefit of standardization can be negative because the marginal task can be better performed with the worker's know-how than with firm-specific technology. In contrast, high- z firms benefit more from performing a wider range of tasks with their firm-specific technology. Importantly, this result does not rely on increased standardization generating returns-to-scale (as would occur with a fixed cost of standardization), since the technology we assume is entirely constant returns to scale ($\Phi(s)$ is a per position cost).

Given Lemma 4, we can show that the optimal degree of standardization is increasing in z .

Proposition 6. *Assume $\Phi(s)$ is sufficiently convex so that problem (41) is concave in s .*

1. *There exists a threshold $\hat{z}$ such that, for $z > \hat{z}$, firms invest to increase standardization, $s > \underline{s}$.*
2. *The optimal degree of standardization is strictly increasing in z for firms with $z > \hat{z}$.*

While Proposition 2 and 3 show that high- z firms are the ones that commoditize workers more when standardization s is higher, Proposition 6 shows that these same firms also have the strongest incentive to develop and adopt such technology.

The final question we ask is whether the endogenous choice of standardization is efficient. In Appendix H, we study the problem of a planner that maximizes aggregate consumption subject to the same search frictions as the decentralized equilibrium. The following proposition holds.

Proposition 7. *The equilibrium with endogenous standardization is efficient.*

As in Acemoglu and Shimer (1999) and Jerez (2017), directed search and wage posting jointly ensure that firms' ex-ante investment is efficient in the sense of maximizing aggregate consumption.

4 A Quantification of the Effects of Standardization

To better assess the ability of our model to help explain prominent changes in the labor market over the past few decades, we next propose a quantitative calibration of the model. We first propose a baseline calibration designed to match the size distribution of firms and the large-firm wage premium in 1980. We then consider a shock to standardization that induces large firms to increase their degree of standardization and consider the implications of this shock on various labor-market outcomes.

4.1 Calibration

One period in the model is a year. We set the discount rate to be 5% and the separation rate to 25%. In the baseline economy, we assume that all firms have the same degree of standardization, i.e., $s = \underline{s}$ for all firms, and we normalize $\underline{s} = 0.5$. Since $s = 0.5$ for all firms in the baseline economy, we index firms by z rather than by $x \equiv (z, s)$. We set the matching elasticity parameter to $\eta = 0.5$, a standard parameterization in the literature (Petrongolo and Pissarides, 2001).

Table 1: Summary of Calibration

Parameter	Description	Value	Source/Target
A. EXTERNALLY SET PARAMETERS			
ρ	Discount rate	0.05	5% Interest rate
δ	Separation rate	0.25	Monthly 2% separation prob.
η	Matching function elasticity	0.5	Petrongolo and Pissarides (2001)
$\underline{z}$	Productivity Pareto scale	1.0	Normalization
$\underline{s}$	Baseline standardization	0.5	Normalization
$\kappa(\underline{\omega})^\beta$	Composite scale parameter	1.0	Normalization
B. INTERNALLY CALIBRATED PARAMETERS			
α	Productivity distribution Pareto shape	9.7	Firm size & wage in 1980s
ι	Distribution of positions across firms	8.6	Firm size & wage in 1980s
β	Match quality Pareto shape	0.67	Firm size & wage in 1980s
$\bar{k}$	Overall number of positions	0.14	Market tightness 1
C. PARAMETERS FOR COUNTERFACTUAL			
ϕ	Standardization cost	5.7	Changes in emp. share

Note: The table reports the calibrated parameters for the model. See the text for further discussion.

We assume that the distribution of z across firms is a Pareto distribution with shape parameter α and scale parameter $\underline{z}$. Since $\underline{z}$ only matters for the scale of the economy, we normalize it to $\underline{z} = 1$. The composite parameter $\kappa(\underline{\omega})^\beta$ —involving both the Pareto scale parameter for match quality $\underline{\omega}$ and the matching efficiency parameter κ —can be normalized without loss of generality. We set $\kappa(\underline{\omega})^\beta = 1$. We set the total mass of firms m to a value that yields an average firm size of 20, roughly matching its empirical counterpart in 1980.

We assume that in the baseline economy the number of positions firms have is a function of the quality of their technology z . We parameterize this relationship as being iso-elastic in z :

$$k_z = \bar{k}(z)^\iota, \quad (44)$$

where $\bar{k}$ and $\iota > 0$ are parameters. We set $\bar{k}$ so that the aggregate market tightness is 1.

The parameters that remain are (ι, α, β) . We choose these to match: (i) the firm-size distribution in 1980, and (ii) the wage premium as a function of firm size estimated in [Bloom et al. \(2018\)](#) for the sample period 1980–1986. For the firm-size distribution, we use employment shares from the Business Dynamics Statistics for the following firm-size bins: 1–4, 5–9, 10–19, 20–99, 100–499, 500–



Figure 3: Model Fit

Note: Panel (a) shows the employment share by firm size bins in the model and in the data. The data is from the Business Dynamics Statistics 1980. Panel (b) shows the firm wage premium by firm size bins in the model and in the data. The data is from Bloom et al. (2018) Figure 2A using firm fixed effect estimates based on AKM model.

999, 1000–2499, 2500–4999, 5000–9999, and 10000 or more employees. For the wage premium, we use the relative log-wage across firm-size categories from Bloom et al. (2018), specifically: 1–10, 10–50, 50–250, 250–1000, 1000–2500, 2500–10000, 10000–15000, and 15000 or more employees. We use the firm fixed effect estimates by Bloom et al. (2018) based on the AKM model (Abowd, Kramarz and Margolis, 1999) (Figure 2A in Bloom et al. (2018)). We minimize the squared error between the model and the data for these two moments. (See Appendix C.2 for details.)

Figure 3 shows the fit of the model to these two sets of statistics. The model can successfully replicate the fat-tailed firm-size distribution as well as the sizable firm-size wage premium that we observe in the 1980s. Table 1 summarizes our calibration.

4.2 The Impact of New Standardization Technology

The past few decades have seen a sharp rise in the employment share of “megafirms” (firms with 10,000+ employees). This has been particularly the case in the service sector with the rise of firms such as Walmart and Amazon. At the same time, the large-firm wage premium has fallen substantially (Bloom et al., 2018). Here we consider whether an increase in standardization among large firms can explain these facts.

Starting from the baseline calibration discussed above, we allow firms to invest to increase their standardization, as in Section 3.3. Specifically, we assume that prior to 1980 additional standardization was not technologically feasible, but that after 1980 it became feasible (e.g. due to

innovations in ICT) subject to the following cost function:

$$\Phi(s) = \phi \left(\frac{1}{1-s} - \frac{1}{1-\underline{s}} \right) \quad (45)$$

where $\phi > 0$ is a parameter. This functional form satisfies $\lim_{s \rightarrow 1} \Phi'(s) = \infty$, ensuring that the optimum is bounded above by $s = 1$. Firms choose the standardization level s that maximizes the expected value of their vacant positions, as in equation (41). We calibrate the parameter ϕ to best fit the changes in the employment share of megafirms (with 10,000+ employees) from 1980 to 2023. This increase was 4.3 percentage points.

Figure 4 presents results from this experiment. We present changes in firm-level outcomes for firms broken into two categories by size: megafirms (with 10,000+ employees) and other firms. The top-left panel shows that megafirms increase their level of standardization (s) from 0.5 to about 0.63, while smaller firms do not increase standardization appreciably.¹² The middle panel in the top row reports our calibration target: the employment share by size category. The employment share of megafirms increased by 4.3 percentage points. We match this by construction. The top-right panel shows that increased standardization reduces relative wages at megafirms by about 8%, while relative wages at other firms increase slightly. In sharp contrast, increased standardization increases output per worker very substantially at megafirms or by more than 25%. The combination of the decline in wages and increase in the output per worker imply that megafirms substantially increase wage markdowns when they adopt a higher level of standardization. The bottom-right panel shows that the value of megafirms increases substantially due to higher output per worker, lower wages, and greater employment.

A slight extension of our baseline model allows us to also think about how hiring costs are affected by increased standardization. We can think of our baseline model as the limit of a model where firms must pay an interview cost $\chi > 0$ to reveal match quality. In this model, the expected hiring cost per hire is

$$\chi \frac{1}{1 - G(\omega_x^R)} = \chi (\omega_x^R / \underline{\omega})^\beta. \quad (46)$$

Our model corresponds to the limit of this model where $\chi \rightarrow 0$. The middle panel of the bottom

¹²Standardization is a powerful force for generating increases in market share by dominant firms in our model. If too many firms standardize, then the resulting increase in concentration is larger than what we see in the data. This is why we end up with a calibration where only the megafirms standardize—otherwise standardization has too strong an effect on the firm size distribution.

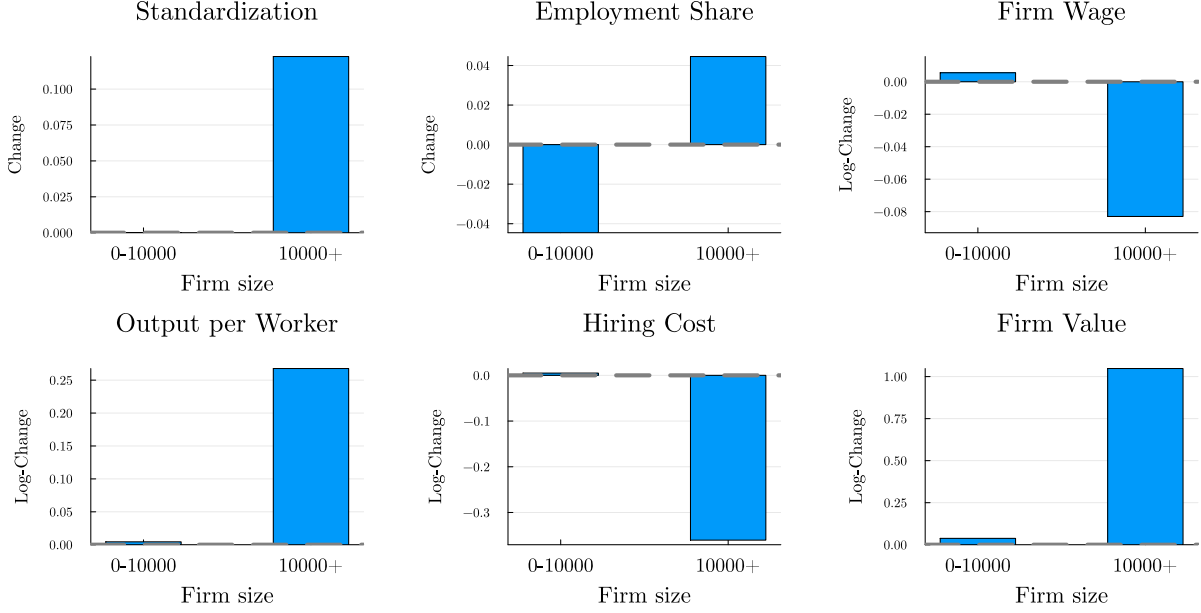


Figure 4: Changes in the Firm-Level Outcomes by Firm Size

Note: The figure shows the change in firm-level outcomes broken down by two firm-size categories: 10,000 or more employees and less than 10,000 employees. All outcomes are weighted by firm size. Firm wages refer to the log wage relative to the wage of firms with 0-10 employees. The hiring cost is computed using equation (46).

row of Figure 4 presents the effect of increased standardization on hiring costs when $\chi > 0$ (but arbitrarily small). Hiring costs at megafirms decline by nearly 40%. This is driven by the decrease in reservation match quality at these firms as they adopt a more standardized technology and care less about worker quality.

Figure 5 compares our model's predictions about wages by firm size to the data. The left panel presents estimates of wages by firm size for the 1980s and 2010s from Bloom et al. (2018). We see that the large-firm wage premium has decreased substantially over the past few decades. In the 1980s megafirms paid almost 60% higher wages than small firms, while in the 2010s this premium has fallen to only about 20%. The right panel presents the model counterpart from our model before and after the availability of increased standardization. The model generates a substantial drop in the wage premium for megafirms, from a premium of more than 50% to about 30%. We conclude that commoditization of labor can help explain the recent fall in the large-firm wage premium, particularly for megafirms.

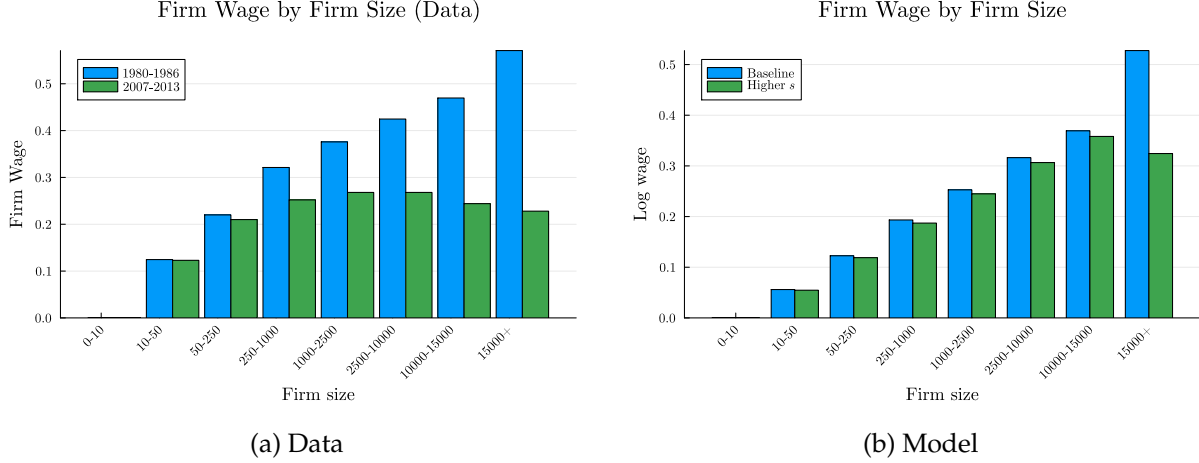


Figure 5: Firm Wage-Size Premium

Note: The figure reports wages by firm size in the data and in our model. For each firm-size bin, wages are reported relative to wages paid at firms with 1-10 employees. The left panel reports empirical estimates from Figures 2A and 2C in Bloom et al. (2018). These estimates are average of firm fixed effects from an AKM model. The right panel reports results from our model. The “baseline” corresponds to our baseline calibration. The “Higher s ” corresponds to the equilibrium when firms can invest in additional standardization.

4.3 Comparison with Existing Explanations for the Rise of Superstar Firms

Existing work has argued that the rise of low labor share superstar firms is due to increasing dispersion in firm productivity without the standardization mechanism we emphasize (see, e.g., Autor et al., 2020; Gouin-Bonenfant, 2022). This model, however, predicts that the large-firm wage premium should have risen from the first to the second time period we consider. To see why, assume that the productivity of firm z is given by z^λ . Then $\lambda = 1$ corresponds to our baseline model and an increase in λ increases the dispersion of productivity. (Increasing λ is equivalent to decreasing the Pareto shape parameter α in our model.) We can then choose λ to match the 4.3 percentage point increase in the employment share of megafirms from 1980 to 2023. This is an analogous exercise to the one we did with increased standardization above.

Figure 6 presents the implied change in wage premia of firms by size. We see that increasing λ (increasing the dispersion of z) results in a substantial increase in the large-firm wage premium in the model. This contrasts sharply with the actual evolution of the large-firm wage premium as we saw in the left panel of Figure 5. If it is higher dispersion in z that allows firms to grow, they must pay increasingly high wage premia to attract workers. If, however, it is standardization that allows large firms to grow, they can grow without paying higher wages. This distinguishes our standardization explanation from other explanations of the rise of superstar firms.

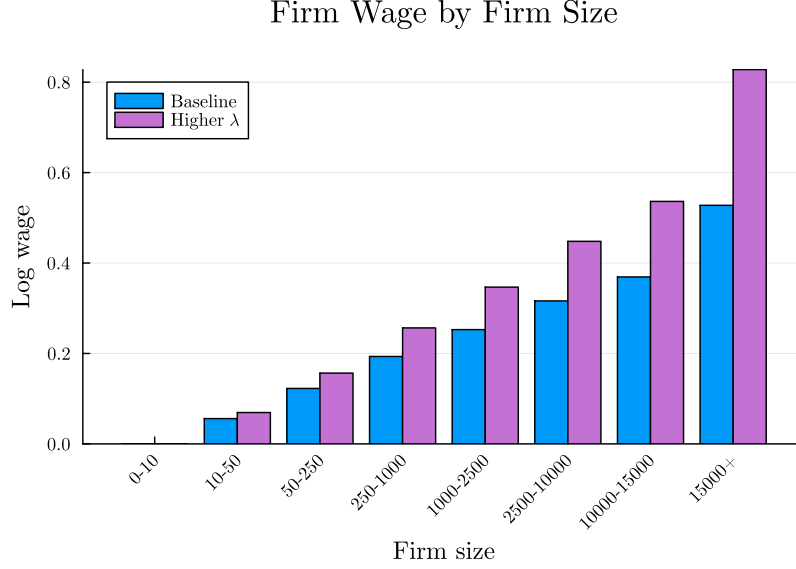


Figure 6: Firm Wage-Size Premium with Increasing Productivity of Superstar Firms

Note: The “Baseline” corresponds to the baseline calibration. The “Higher λ ” corresponds to an equilibrium with greater dispersion of z .

4.4 Endogenous Number of Positions

So far, we have treated the number of positions k_x as an exogenous parameter. In this section, we relax this assumption and allow k_x to respond when firms adopt a more standardized technology. We assume that the number of positions k_z is given by

$$k_z = \bar{k}(z)^t \times (V_z / \bar{V}_z)^\chi, \quad (47)$$

where $\bar{V}_z$ is the baseline value of a vacancy, V_z is the value of a vacancy in the endogenous standardization equilibrium, and $\chi \geq 0$ is a parameter that determines the elasticity of k_z with respect to the value of a vacancy. Our baseline model is a special case with $\chi = 0$. This functional form closely follows [Coles and Kelishomi \(2018\)](#).

Figure 7 presents results analogous to Figure 4 for three cases. The “Baseline” case corresponds to the baseline model with $\chi = 0$. The middle case $\chi = 0.265$ is the benchmark calibration in [Coles and Kelishomi \(2018\)](#), while $\chi = 0.5$ allows for an even larger response of the number of positions to increased standardization. We find that allowing for $\chi > 0$ slightly amplifies the impact of our standardization technology, but only modestly so.

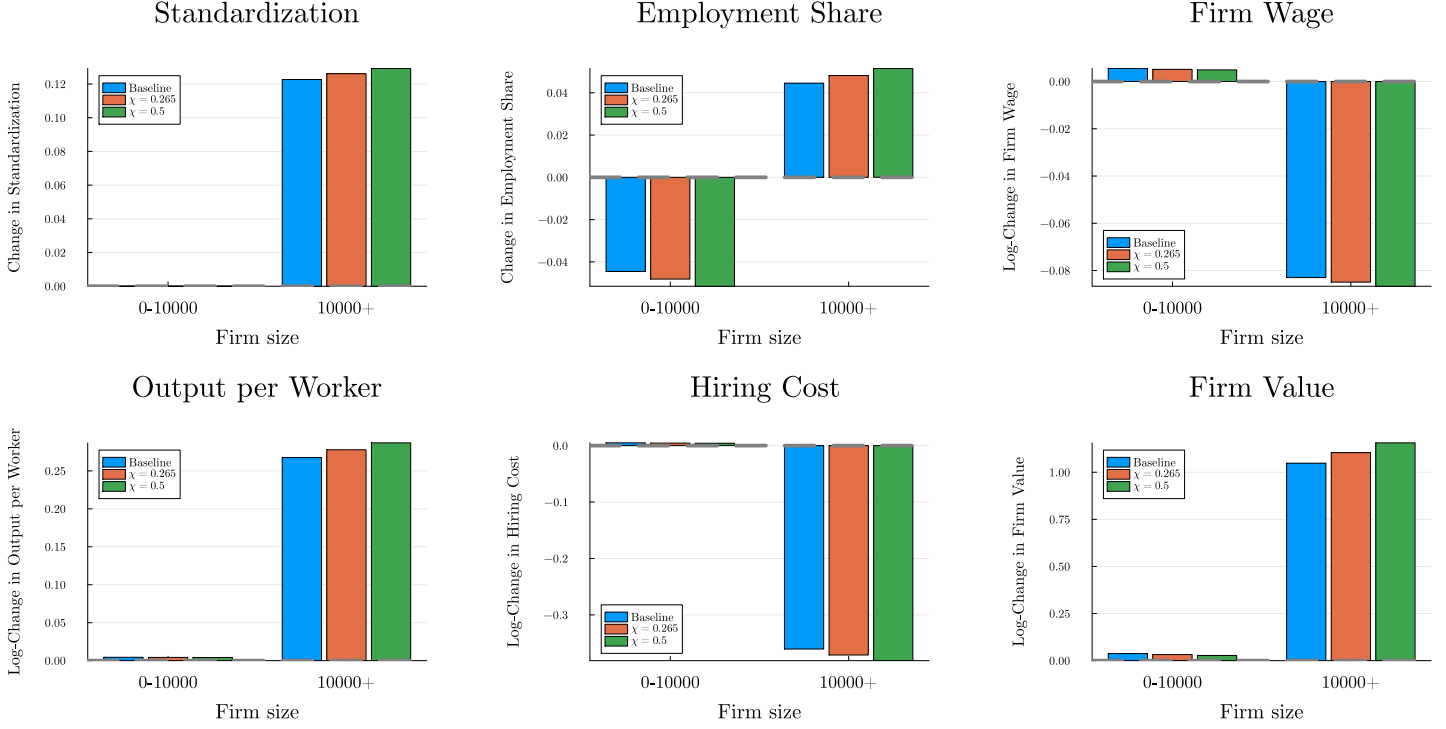


Figure 7: Endogenous Response of the Number of Positions

Note: The figure is a counterpart of Figure 4. The “Baseline” corresponds to the model with $\chi = 0$, and we consider two alternative values for χ : 0.265 and 0.5.

4.5 Evidence on Cost-Per-Hire

Labor economists have long been interested in knowing how much it costs a firm to hire an additional worker. Manning (2011) surveys work on hiring costs but also emphasizes the “paucity and diversity” of the estimates. Existing work is often quite anecdotal, and often considers labor markets that are quite different from the U.S. labor market. The most relevant prior work for our purposes is Dube, Freeman and Reich (2010) who carry out a novel analysis of the relationship between the cost-of-hire and establishment size. They argue that their findings pose an important puzzle for the monopsony literature because low wage jobs appear to have low hiring costs (a finding that is echoed elsewhere in the literature Manning cites).¹³ They focus on hiring costs by establishment size, as opposed to firm size, however.¹⁴

We present new evidence on cost per hire from a survey conducted by the Society for Human Resource Management (SHRM). The SHRM describes itself as the world’s largest HR professional

¹³The model in Manning (2003) implies that low-wage firms can compensate for offering a low wage by incurring greater recruiting costs to meet a certain employment goal.

¹⁴This is important for our purposes since commoditization technologies will generally be adopted at the firm, as opposed to establishment, level, and large “superstar” firms typically consist of many smaller establishments.

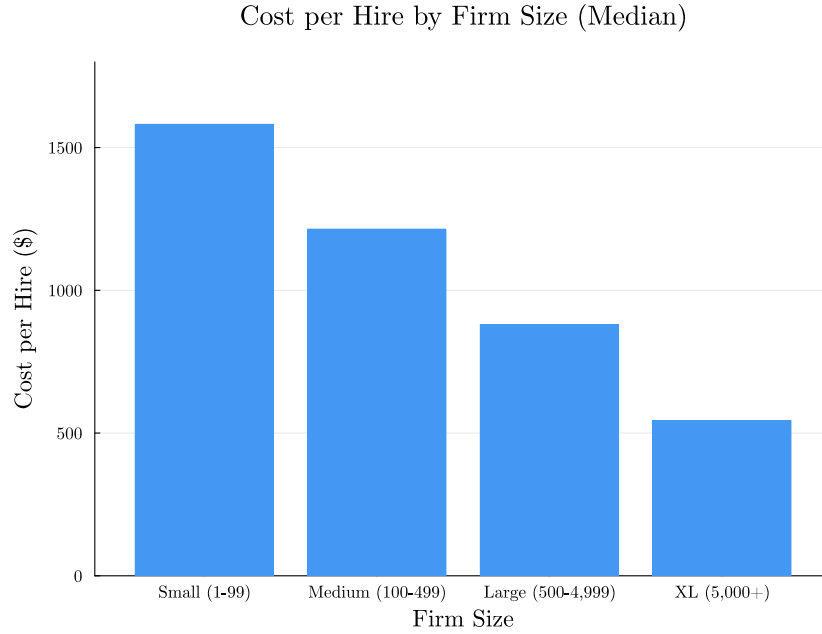


Figure 8: Cost per Hire by Firm Size

Note: Median cost per hire within firm-size bins in data from the SHRM’s HR Benchmarking Reports. We take a mean of these statistics across the 2022 and 2025 surveys.

association. In recent years, the SHRM has twice conducted an HR Benchmarking Report for its paying members which reports, among other things, summary statistics on hiring costs.¹⁵ These surveys were conducted in 2022 and 2025. A key advantage of the SHRM data is that it presents hiring costs stratified by firm size. These data allow us to benchmark our model’s prediction that megafirms have lower hiring costs (since they have lower hiring standards) to cross-sectional statistics on hiring costs by firm size.

We focus on the median cost per hire within firm-size bins and separately within industry in the SHRM surveys. We take an average of these statistics across the two surveys (2022 and 2025), but the main qualitative patterns we emphasize hold in each survey individually. The survey is drawn as a “convenience sample” of SHRM members. As a consequence, it cannot be assumed to be representative of the population of firms as a whole. Below, we discuss an alternative approach that we use to benchmark our industry-level results from the SHRM survey to a more representative sample of firms.

Figure 8 presents the median cost per hire by firm size from the SHRM surveys. Cost per hire

¹⁵SHRM defines non-executive cost per hire as “the costs involved with a new hire. These costs may include the sum of third-party agency fees, advertising agency fees, job fair costs, online job board fees, employee referral costs, travel costs of applicants and staff, relocation costs, recruiter pay and benefits, and talent acquisition system costs divided by the number of hires.”

Table 2: Cost per Hire by Industry

Industry	Hiring cost (\$)
Accommodation and food services	105
Leisure and hospitality	132
Construction	218
Retail trade	250
Arts, entertainment, and recreation	276
Trade, transportation, and utilities	593
Real estate and rental and leasing	879
Mining and logging	981
Transportation, warehousing, and utilities	1089
Health care and social assistance	1097
Private education and health services	1287

Note: The table reports estimates of cost per hire by industry based on the ratio of HR costs from the Occupational Employment Survey (OES) and total hires from JOLTS.

is monotonically declining in firm size. For very large firms with more than 5000 employees, cost per hire is only roughly one third as high as for small (1-99 employee) firms. The overall pattern lines up quite well with the results for hiring costs in our model reported in Figure 4. Our model implies that megafirms optimally choose to adopt a technology with more standardization and lower hiring standards which results in a lower cost per hire.

Barbara Ehrenreich’s *Nickel and Dimed* and Emily Guendelsberger’s *On the Clock* present striking narrative accounts of work in low-wage service sector jobs. These accounts accord well with the exceptionally high turnover rates in these industries reported by Lazear and McCue (2018). The SHRM surveys report cost per hire only at the level of fairly aggregated industries. To analyze the cost per hire for more disaggregated industry categories, we consider a second methodology for estimating the cost per hire. We estimate the ratio of two objects: Total HR costs (in the numerator) and Total Hires (in the denominator) where the former is estimated from the Occupational Employment Statistics (OES) data and the latter is estimated from JOLTS. Appendix G provides the details.

Table 2 presents our cost per hire estimates by industry for the eleven industries we estimate to have the lowest cost per hire. Many of these industries are low-wage service sector industries, and there is considerable overlap with the set of industries that Haltiwanger, Hyatt and Spletzer (2024) emphasize as having low and falling industry wage effects. In Appendix G we merge our estimates of cost per hire based on the OES-JOLTS data with the SHRM survey-based estimates.

This analysis shows that the cross-industry results from this methodology are broadly similar to those from the SHRM surveys. Low-wage services such as “Accommodation and Food Services,” Retail, and Wholesale trade have low cost per hire according to both measures. Moreover, both sources suggest that these industries have a cost per hire that is multiple times lower than the cost per hire in manufacturing.

5 Conclusion

We develop a new model of an old idea. Technical change that simplifies tasks makes workers more replaceable—or more commoditized. While such commoditizing technical change can raise output per worker (as Adam Smith emphasized) it can also lower workers’ bargaining power (as Karl Marx emphasized). Even though labor is in high demand (and not being replaced by capital), the growing irrelevance of the “special skill” of the worker yields “bad jobs” that pay less. Workers are able to find new jobs more easily, but the rewards from any new job in a commoditized firm are decidedly lower.

Recent years have seen an explosion of empirical and theoretical research on monopsony power. Recent surveys of this literature emphasize the worker’s outside option as the core determinant of wage markdowns. We emphasize instead the outside option of the firm—which has played a minimal role in this literature. Our directed search model yields a standard Lerner formula for wage markdowns in which improvements in the firm’s outside option—that arise from commoditizing technologies—also increase markdowns. These results rely on the assumption that jobs are durable and entry is costly. They do not arise in a more standard setting with free entry and in which positions simply “disappear” when a worker and firm separate.

Commoditizing technical change helps explain the combination of rising labor productivity and falling wages in retail, the collapsing large-firm wage premium, the skyrocketing value of intangibles, and low labor share of superstar firms. It can also help explain why wage markdowns appear to be rising in sectors such as retail, even in the face of declining local labor market concentration, in contrast to standard monopsony models.

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A Derivations in Section 2

Using equations (2), (4), (15), and (18), the expected surplus from a match is given by

$$\begin{aligned}\int_{\omega_x^R}^{\infty} S_x(\omega) dG(\omega) &= \frac{1}{\rho + \delta} \int_{\omega_x^R}^{\infty} (A_x(\omega) - \rho U - \rho V_x) dG(\omega) \\ &= \frac{1}{\rho + \delta} \int_{\omega_x^R}^{\infty} (A_x(\omega) - A_x(\omega_x^R)) dG(\omega) \\ &= \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^{\beta} \right].\end{aligned}$$

Our simplifying assumption that $\theta = 1$ at the aggregate level requires that

$$\int \frac{1}{\theta(W_x)} v_x dm_x = u.$$

Using the fact that $\theta(W_x) = KW_x^{-\frac{1}{1-\eta}}$ and solving for K yields

$$K = \frac{1}{u} \int (W_x)^{\frac{1}{1-\eta}} v_x dm_x. \quad (48)$$

Using the fact that $K = (\rho U / \kappa)^{\frac{1}{1-\eta}}$ then yields

$$\rho U = \kappa \left(\frac{1}{u} \int (W_x)^{\frac{1}{1-\eta}} v_x dm_x \right)^{1-\eta}.$$

By taking the conditional expectation of both sides of (10), the average wage at firm x is given by

$$\begin{aligned}\bar{w}_x &\equiv \mathbb{E}[w_x(\omega) | \omega \geq \omega_x^R] \\ &= (\rho + \delta) \mathbb{E}[W_x(\omega) | \omega \geq \omega_x^R] + \rho U \\ &= (\rho + \delta) W_x \frac{1}{1 - G(\omega_x^R)} + \rho U \\ &= \eta \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} + \rho U.\end{aligned}$$

The average output per worker at firm x is given by

$$\begin{aligned}\bar{A}_x &\equiv \mathbb{E}[A_x(\omega) | \omega \geq \omega_x^R] \\ &= \frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s}.\end{aligned}$$

B Proofs

B.1 Proof of Lemma 1

Substituting equation (20) into equation (19) we have

$$\rho V_x = \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \int_{\omega_x^R}^{\infty} \frac{1}{\rho + \delta} [A_x(\omega) - \rho U - \rho V_x] dG(\omega) \right\}^{\frac{1}{1-\eta}}. \quad (49)$$

Note that

$$\begin{aligned} \int_{\omega_x^R}^{\infty} A_x(\omega) dG(\omega) &= \mathbb{E}[A_x(\omega) | \omega \geq \omega_x^R] (1 - G(\omega_x^R)) \\ &= \frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} (\omega_x^R / \underline{\omega})^{-\beta} \end{aligned} \quad (50)$$

Furthermore, recall from equations (4) and (18) that the reservation match quality satisfies

$$A_x(\omega_x^R) = z^s (\omega_x^R)^{1-s} = \rho U + \rho V_x. \quad (51)$$

Substituting equations (50) and (51) into equation (49), we have

$$z^s (\omega_x^R)^{1-s} - \rho U = \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^{\beta} \right] \right\}^{\frac{1}{1-\eta}}. \quad (52)$$

Note that, as we vary ω_x^R from 0 to ∞ , the left-hand side is strictly increasing ranging from $-\rho U$ to ∞ , and the right-hand side is strictly decreasing in ranging from ∞ to 0 (since $\beta > 1 - s$). Therefore, there is unique solution ω_x^R that satisfies this equation, provided that $\underline{\omega}$ is sufficiently small.

B.2 Proof of Lemma 2

Dividing both sides of (25) by z^s , we have

$$(\omega_x^R)^{1-s} - \rho U / z^s = \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} (\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^{\beta} \right] \right\}^{\frac{1}{1-\eta}} z^{\frac{s\eta}{1-\eta}}. \quad (53)$$

In the limit as $\rho U/z^s \rightarrow 0$, we have

$$(\omega_x^R)^{1-s} = \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} (\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^\beta \right] \right\}^{\frac{1}{1-\eta}} z^{\frac{s\eta}{1-\eta}}. \quad (54)$$

Solving for ω_x^R yields

$$\omega_x^R = \left\{ B \frac{1-s}{\beta + s - 1} z^{s\eta} \right\}^{\frac{1}{\beta - (1-s)\eta}}, \quad (55)$$

where

$$B \equiv \kappa^{1-\eta} K^{-\eta(1-\eta)} \eta^\eta (1-\eta)^{1-\eta} \frac{1}{\rho + \delta} \underline{\omega}^\beta > 0. \quad (56)$$

B.3 Proof of Proposition 1

When $\rho U/z^s \rightarrow 0$, the reservation match quality ω_x^R is given by

$$\omega_x^R = \left\{ B \frac{1-s}{\beta + s - 1} z^{s\eta} \right\}^{\frac{1}{\beta - (1-s)\eta}}.$$

Taking the log derivative, holding z , U , and K fixed,

$$\begin{aligned} \frac{d \ln \omega_x^R}{ds} &= \frac{1}{\beta - (1-s)\eta} \left\{ -\frac{1}{1-s} - \frac{1}{\beta + s - 1} + \eta \log z \right\} \\ &\quad - \frac{\eta}{(\beta - (1-s)\eta)^2} \log \left\{ B \frac{1-s}{\beta + s - 1} z^{s\eta} \right\}. \end{aligned} \quad (57)$$

As $s \uparrow 1$, the negative term proportional to $1/(1-s)$ dominates the logarithmic term, since $(1-s) \log(1-s) \rightarrow 0$. Thus the derivative tends to $-\infty$, and ω_x^R is strictly decreasing in s for s sufficiently close to 1.

B.4 Proof of Proposition 2

The output per worker at firm x is given by

$$\bar{A}_x = \frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s}. \quad (58)$$

Under $\rho U / z^s \rightarrow 0$ and using (34), we have

$$\bar{A}_x = \frac{\beta}{\beta + s - 1} z^s \left\{ B \frac{1-s}{\beta + s - 1} z^{s\eta} \right\}^{\frac{1-s}{\beta - (1-s)\eta}}. \quad (59)$$

Log-differentiating this with respect to s , we obtain

$$\begin{aligned} \frac{d \ln \bar{A}_x}{ds} = & -\frac{1}{\beta + s - 1} + \log z + \frac{1}{\beta - (1-s)\eta} \left\{ -1 - \frac{1-s}{\beta + s - 1} + (1-s)\eta \log z \right\} \\ & - \frac{\beta}{(\beta - (1-s)\eta)^2} \log \left\{ B \frac{1-s}{\beta + s - 1} z^{s\eta} \right\}. \end{aligned} \quad (60)$$

As $s \uparrow 1$, the term $-\beta \log(1-s)/(\beta - (1-s)\eta)^2$ tends to $+\infty$, while the remaining terms stay bounded. Therefore, $\bar{A}_x$ is strictly increasing in s for s sufficiently close to 1.

Now consider wages. The average wage at firm x is given by

$$\bar{w}_x = \eta \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} + \rho U. \quad (61)$$

Since ρU does not depend on s at the individual firm level, it is sufficient to show that the wage premium over ρU is decreasing in s . Using the expression for $\bar{A}_x$, we have

$$\bar{w}_x - \rho U = \frac{\eta(1-s)}{\beta} \bar{A}_x. \quad (62)$$

Taking the log derivative gives

$$\frac{d \ln(\bar{w}_x - \rho U)}{ds} = -\frac{1}{1-s} + \frac{d \ln \bar{A}_x}{ds}. \quad (63)$$

Using (60), we can collect the unbounded terms as $s \uparrow 1$:

$$\frac{d \ln(\bar{w}_x - \rho U)}{ds} = -\frac{1}{1-s} - \frac{\beta}{(\beta - (1-s)\eta)^2} \log(1-s) + O(1). \quad (64)$$

Since $(1-s) \log(1-s) \rightarrow 0$, the first term dominates, yielding

$$\lim_{s \uparrow 1} \frac{d \ln(\bar{w}_x - \rho U)}{ds} = -\infty. \quad (65)$$

Since $\bar{w}_x - \rho U > 0$ and U is fixed, the average wage is strictly decreasing in s for sufficiently large s .

Given $\bar{A}_x$ increases and $\bar{w}_x$ decreases, the firm-level labor share, $\bar{w}_x / \bar{A}_x$, decreases.

B.5 Proof of Proposition 3

The vacancy filling rate is given by

$$q_x \equiv \kappa K^{-\eta} \times (W_x)^{\frac{\eta}{1-\eta}} \times (1 - G(\omega_x^R)). \quad (66)$$

Note that

$$\begin{aligned} W_x &= \eta \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^\beta \right] \\ &= \eta \left[\frac{z^s (\omega_x^R)^{1-s} - \rho U}{\kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta)} \right]^{1-\eta}. \end{aligned}$$

As we have shown in the proof of Proposition 2, $\bar{A}_x$ is increasing in s for sufficiently high s and z . Since $z^s (\omega_x^R)^{1-s} = (\beta + s - 1) \bar{A}_x / \beta$, cutoff output is also increasing in s . The identity $\rho V_x = z^s (\omega_x^R)^{1-s} - \rho U$ and the expression above then imply that V_x and W_x are strictly increasing in s . Since $S_x = W_x / \eta$, expected surplus increases as well. Finally, Proposition 1 implies that $1 - G(\omega_x^R)$ increases in s . Together with the increase in W_x , this implies that q_x is strictly increasing in s .

B.6 Proof of Proposition 4

The firm wage is given by

$$\bar{w}_x = \eta \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} + \rho U \quad (67)$$

Therefore, it is sufficient to show that $z^s (\omega_x^R)^{1-s}$ is increasing in z . Recall that ω_x^R solves

$$z^s (\omega_x^R)^{1-s} - \rho U = C [z^s (\omega_x^R)^{1-s-\beta}]^{\frac{1}{1-\eta}}, \quad (68)$$

where

$$C \equiv \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left[\frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} \underline{\omega}^\beta \right]^{\frac{1}{1-\eta}} > 0. \quad (69)$$

Define cutoff output as $t_x \equiv z^s(\omega_x^R)^{1-s}$. Substituting $\omega_x^R = (t_x/z^s)^{1/(1-s)}$ into the preceding equation gives

$$t_x - \rho U = Cz^{\frac{s\beta}{(1-s)(1-\eta)}} t_x^{-\frac{\beta+s-1}{(1-s)(1-\eta)}}. \quad (70)$$

At fixed s , U , and K , the left-hand side is strictly increasing in t_x , while the right-hand side is strictly decreasing in t_x and strictly increasing in z . Therefore, t_x is strictly increasing in z . This shows that the firm wage is strictly increasing in z .

Since the output per worker is given by

$$\bar{A}_x = \frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s}, \quad (71)$$

the output per worker also increases with z . The labor share is given by

$$\frac{\bar{w}_x}{\bar{A}_x} = \frac{\eta \frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} + \rho U}{\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s}} \quad (72)$$

$$= \frac{\eta \frac{1-s}{\beta+s-1} + \rho U \frac{1}{z^s (\omega_x^R)^{1-s}}}{\frac{\beta}{\beta+s-1}}, \quad (73)$$

which decreases with z .

Now consider the vacancy filling rate, which is given by

$$q_x = \kappa K^{-\eta} (W_x)^{\frac{\eta}{1-\eta}} (1 - G(\omega_x^R)) \quad (74)$$

$$= \kappa K^{-\eta} \left(\eta \frac{1}{\rho + \delta} \frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^\beta \right] \right)^{\frac{\eta}{1-\eta}} \underline{\omega}^\beta (\omega_x^R)^{-\beta}. \quad (75)$$

Therefore, whether the vacancy filling rate increases with z depends on whether $(z^s (\omega_x^R)^{1-s})^{\frac{\eta}{1-\eta}} (\omega_x^R)^{-\beta \frac{1}{1-\eta}}$ increases with z . We rewrite the equation that determines ω_x^R in (25) as

$$1 - \rho U \frac{1}{z^s (\omega_x^R)^{1-s}} = B (z^s (\omega_x^R)^{1-s})^{\frac{\eta}{1-\eta}} (\omega_x^R)^{-\beta \frac{1}{1-\eta}}, \quad (76)$$

where

$$B \equiv \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1 - \eta) \left[\frac{1}{\rho + \delta} \frac{1-s}{\beta+s-1} \underline{\omega}^\beta \right]^{\frac{1}{1-\eta}} > 0. \quad (77)$$

We have shown that t_x is strictly increasing in z , so the left-hand side of (76), $1 - \rho U/t_x$, is strictly increasing in z . Since B is independent of z , the product on the right-hand side also increases in z . In turn, this implies that the vacancy filling rate increases with z .

B.7 Proof of Lemma 3

Combining equations (33), (28), and (18) gives

$$\bar{w}_x = \eta \bar{A}_x + (1 - \eta) \rho U - \eta \rho V_x. \quad (78)$$

Taking averages under any nonnegative weights ψ_x that integrate to one and dividing by $\mathbb{E}_\psi[\bar{A}_x]$ yields

$$LS^\psi = \eta + \frac{(1 - \eta) \rho U - \eta \rho \mathbb{E}_\psi[V_x]}{\mathbb{E}_\psi[\bar{A}_x]}, \quad (79)$$

which proves (35).

To obtain the vacancy-weighted representation, market clearing across submarkets requires $\int v_x / \theta(W_x) dm_x = u$. Substituting $\theta(W_x) = KW_x^{-1/(1-\eta)}$ gives

$$K = \frac{1}{u} \int W_x^{\frac{1}{1-\eta}} v_x dm_x. \quad (80)$$

The worker's indifference condition and the firm's vacancy-value equation, together with $W_x = \eta S_x$, imply

$$\rho U = \kappa K^{1-\eta}, \quad (81)$$

$$\rho V_x = \kappa K^{-\eta} \frac{1-\eta}{\eta} W_x^{\frac{1}{1-\eta}}. \quad (82)$$

Integrating the second equation over vacancies and using the definition of K yields

$$\begin{aligned} \eta \rho \int V_x v_x dm_x &= (1 - \eta) \kappa K^{-\eta} \int W_x^{\frac{1}{1-\eta}} v_x dm_x \\ &= (1 - \eta) \kappa K^{1-\eta} u = (1 - \eta) \rho U u. \end{aligned} \quad (83)$$

Dividing by ρu and recalling $\theta = v/u$, we obtain

$$(1 - \eta)U = \eta\theta \mathbb{E}_v[V_x]. \quad (84)$$

Substituting this identity into (35) proves (36) for any aggregate market tightness θ .

B.8 Proof of Proposition 5

In steady state, equation (31) implies $n_x = q_x v_x / \delta$. Therefore,

$$\frac{n_x}{n} = \frac{q_x}{\mathbb{E}_v[q_x]} \frac{v_x}{v}, \quad \mathbb{E}_n[f_x] = \frac{\mathbb{E}_v[q_x f_x]}{\mathbb{E}_v[q_x]}. \quad (85)$$

It follows that the difference between employment-weighted and vacancy-weighted average outside options is

$$\begin{aligned} \mathbb{E}_n[V_x] - \mathbb{E}_v[V_x] &= \frac{\mathbb{E}_v[q_x V_x] - \mathbb{E}_v[q_x] \mathbb{E}_v[V_x]}{\mathbb{E}_v[q_x]} \\ &= \frac{\text{Cov}_v(V_x, q_x)}{\mathbb{E}_v[q_x]}. \end{aligned} \quad (86)$$

Applying Lemma 3 with $\theta = 1$ and employment weights gives

$$\begin{aligned} LS^n &= \eta + \frac{\eta\rho}{\mathbb{E}_n[\bar{A}_x]} (\mathbb{E}_v[V_x] - \mathbb{E}_n[V_x]) \\ &= \eta - \frac{\eta\rho \text{Cov}_v(V_x, q_x)}{\mathbb{E}_v[q_x] \mathbb{E}_n[\bar{A}_x]} \\ &= \eta - \frac{\eta\rho \text{Cov}_v(V_x, q_x)}{\mathbb{E}_v[q_x \bar{A}_x]}. \end{aligned} \quad (87)$$

This proves (39). Since $\eta\rho > 0$ and $\mathbb{E}_v[q_x \bar{A}_x] > 0$, we conclude that

$$LS^n < \eta \iff \text{Cov}_v(V_x, q_x) > 0. \quad (88)$$

B.9 Proof of Lemma 4

Under the assumption that the problem (41) is concave in s , it suffices to show that the marginal benefit of standardization is positive for productive firms and negative for unproductive firms:

$$\frac{d}{ds} V_{zs} > 0 \quad \text{if and only if} \quad z > \hat{z}, \quad (89)$$

Given $s \equiv (z, s)$, the vacancy value V_x solves

$$\rho V_x = \max_{\omega_x^R} \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \int_{\omega_x^R}^{\infty} \frac{1}{\rho + \delta} [A_x(\omega) - \rho U - \rho V_x] dG(\omega) \right\}^{\frac{1}{1-\eta}}. \quad (90)$$

Since G is Pareto, we have

$$\rho V_x = \max_{\omega_x^R} \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \frac{1}{\rho + \delta} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} - \rho U - \rho V_x \right] (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}}. \quad (91)$$

Differentiating both sides with respect to s and applying the envelope theorem at the optimal cutoff, we have

$$\begin{aligned} \rho \frac{dV_x}{ds} &= \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho + \delta} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} - \rho U - \rho V_x \right] (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}-1} \\ &\quad \times \frac{1}{\rho + \delta} (\omega_x^R / \underline{\omega})^{-\beta} \left\{ \frac{\partial}{\partial s} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right] - \rho \frac{dV_x}{ds} \right\} \\ &= \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho + \delta} \left[\frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right] (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}-1} \\ &\quad \times \frac{1}{\rho + \delta} (\omega_x^R / \underline{\omega})^{-\beta} \left\{ \frac{\partial}{\partial s} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right] - \rho \frac{dV_x}{ds} \right\}. \end{aligned} \quad (92)$$

The partial derivative of expected output holds ω_x^R fixed; the terms involving $d\omega_x^R/ds$ cancel by the envelope theorem. We can solve for $\frac{dV_x}{ds}$ as

$$\rho \frac{dV_x}{ds} = \frac{\kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho + \delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta}-1} \frac{\partial}{\partial s} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right]}{1 + \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho + \delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta}-1}}. \quad (93)$$

We now prove the first part and the second part of Lemma 4 separately.

B.9.1 Proof of the first part of Lemma 4

We first prove the following intermediate result.

Lemma 5. For sufficiently large z , z/ω_x^R is strictly increasing in z , and $z/\omega_x^R \rightarrow \infty$ as $z \rightarrow \infty$.

Proof. Recall that ω_x^R solves the following equation:

$$z^s (\omega_x^R)^{1-s} - \rho U = B [z^s (\omega_x^R)^{1-s-\beta}]^{\frac{1}{1-\eta}}, \quad (94)$$

where

$$B \equiv \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left[\frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} \omega^\beta \right]^{\frac{1}{1-\eta}} > 0. \quad (95)$$

Let

$$y \equiv \frac{z}{\omega_x^R}. \quad (96)$$

Then we can rewrite (25) as

$$zy^{s-1} - \rho U = Bz^{\frac{1-\beta}{1-\eta}} y^{\frac{\beta+s-1}{1-\eta}}, \quad (97)$$

or

$$F(z, y) \equiv zy^{s-1} - \rho U - Bz^{\frac{1-\beta}{1-\eta}} y^{\frac{\beta+s-1}{1-\eta}} = 0. \quad (98)$$

Observe that

$$\partial_y F(z, y) = z(s-1)y^{s-2} - B \frac{\beta + s - 1}{1-\eta} z^{\frac{1-\beta}{1-\eta}} y^{\frac{\beta+s-1}{1-\eta}-1} \quad (99)$$

$$< 0, \quad (100)$$

because $s-1 < 0$ and $\beta > 1-s$, and

$$\partial_z F(z, y) = y^{s-1} - B \frac{1-\beta}{1-\eta} z^{\frac{1-\beta}{1-\eta}-1} y^{\frac{\beta+s-1}{1-\eta}}. \quad (101)$$

We discuss the two cases separately. The first case is $\beta \geq 1$. In this case, it is clear that $\partial_z F(z, y) > 0$.

The second case is $\beta < 1$. In this case, we rewrite (101) as

$$\partial_z F(z, y) = y^{s-1} - B \frac{1-\beta}{1-\eta} z^{\frac{1-\beta}{1-\eta}-1} y^{\frac{\beta+s-1}{1-\eta}} \quad (102)$$

$$= y^{s-1} - \frac{1-\beta}{1-\eta} \frac{1}{z} (zy^{s-1} - \rho U) \quad (103)$$

$$= y^{s-1} \frac{\beta - \eta}{1-\eta} + \frac{1-\beta}{1-\eta} \frac{\rho U}{z}, \quad (104)$$

where the second line uses (97). This expression is strictly positive as long as $\beta > \eta$. Combining the two cases, we have that $\partial_z F(z, y) > 0$ if $\beta > \eta$.

Applying the implicit function theorem, we have

$$\frac{dy}{dz} = -\frac{F_z}{F_y} > 0 \quad (105)$$

under the condition that $\beta > \eta$. This shows $y \equiv z/\omega_x^R$ is strictly increasing in z . Moreover, from (97),

$$\lim_{z \rightarrow \infty} y = \lim_{z \rightarrow \infty} B^{-\frac{1-\eta}{\beta-\eta(1-s)}} z^{\frac{\beta-\eta}{\beta-\eta(1-s)}} = \infty. \quad (106)$$

□

Equation (93) implies that

$$\text{sign}\left(\frac{dV_x}{ds}\right) = \text{sign}\left(\frac{\partial}{\partial s} \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]\right) \quad (107)$$

The partial derivative holding ω_x^R fixed is

$$\frac{\partial}{\partial s} \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right] = \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right] \left(-\frac{1}{\beta+s-1} + \ln z - \ln \omega_x^R \right). \quad (108)$$

Therefore, whether $\frac{dV_x}{ds}$ is positive or negative depends on the sign of $-\frac{1}{\beta+s-1} + \ln z - \ln \omega_x^R$. We now see how the sign of this term varies with z . As shown earlier, the sign of $\frac{dV_x}{ds}$ is determined by the sign of $-\frac{1}{\beta+s-1} + \ln z - \ln \omega_x^R = -\frac{1}{\beta+s-1} + \ln y$, where $y \equiv z/\omega_x^R$. Then, Lemma 5 implies that y is strictly increasing in z and grows without a bound as $z \rightarrow \infty$. Since y is strictly increasing in z , we have that there exists a unique $\hat{z}(s)$ such that

$$\frac{dV_x}{ds} > 0 \quad \text{if and only if} \quad z > \hat{z}(s). \quad (109)$$

B.9.2 Proof of the second part of Lemma 4

We now prove the second part of Lemma 4. Recall that

$$\rho \frac{dV_x}{ds} = \frac{\kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho+\delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta}-1}}{1 + \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho+\delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta}-1}} \quad (110)$$

$$\times \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right] \left(-\frac{1}{\beta+s-1} + \ln z - \ln \omega_x^R \right). \quad (111)$$

We rewrite this expression as

$$\rho \frac{dV_x}{ds} = \frac{\mathcal{C}_{z,s}}{1 + \mathcal{C}_{z,s}} \mathcal{D}_{z,s} \mathcal{E}_{z,s}, \quad (112)$$

where

$$\mathcal{C}_{z,s} \equiv \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho + \delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta} - 1} \quad (113)$$

$$\mathcal{D}_{z,s} \equiv \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right] \quad (114)$$

$$\mathcal{E}_{z,s} \equiv -\frac{1}{\beta + s - 1} + \ln z - \ln \omega_x^R. \quad (115)$$

Let $t_x \equiv z^s (\omega_x^R)^{1-s}$. Using (25), the first two terms can be written as

$$\mathcal{C}_{z,s} = \frac{\beta + s - 1}{(1 - \eta)(1 - s)} \left(1 - \frac{\rho U}{t_x} \right), \quad (116)$$

$$\mathcal{D}_{z,s} = \frac{\beta}{\beta + s - 1} t_x = \bar{A}_x. \quad (117)$$

The proof of Proposition 4 shows that t_x is strictly increasing in z at fixed s , U , and K . Hence $\mathcal{C}_{z,s}$ and $\mathcal{D}_{z,s}$ are positive and strictly increasing in z . We have already shown that $\mathcal{E}_{z,s}$ is strictly increasing in z . Therefore, $\rho \frac{dV_x}{ds}$ is strictly increasing in z whenever $\mathcal{E}_{z,s} > 0$, which is the case when $z > \hat{z}(s)$.

B.10 Proof of Proposition 6

Given the concavity of the problem (41), the following first order condition is necessary and sufficient for the optimal standardization level:

$$\frac{\partial V_{z,s}}{\partial s} \leq \Phi'(s), \quad (118)$$

with equality whenever $s > \underline{s}$. Given $\Phi'(s) \geq 0$ for all s , firms with $\frac{\partial V_{z,s}}{\partial s} < 0$ will not invest, implying $s = \underline{s}$. For firms with $\frac{\partial V_{z,s}}{\partial s} > 0$, there exists a unique cutoff productivity $\hat{z}$ such that $\frac{\partial V_{z,s}}{\partial s} \Big|_{z=\hat{z}, s=\underline{s}} = \Phi'(\underline{s})$ such that the firms are indifferent between investing and not investing because $\frac{\partial V_{z,s}}{\partial s}$ is strictly increasing in z . For firms with $z > \hat{z}$, the optimal standardization level is strictly

increasing in z by implicit function theorem:

$$\frac{ds}{dz} = -\frac{\frac{\partial^2 V_{z,s}}{\partial s \partial z}}{\frac{\partial^2 V_{z,s}}{\partial s^2} - \Phi''(s)} > 0. \quad (119)$$

B.11 Proof of Proposition 7

The proof is given in Appendix H.

C Details on Quantitative Model

C.1 Computational Algorithms

Algorithms 1 and 2 compute the equilibrium as a fixed point in the value of unemployment. Within each iteration, all firms face the same guess $U^{(k)}$ and the implied $K^{(k)}$. We aggregate only after solving the entire cross section. The trial update $\hat{U}^{(k)}$ is the right-hand side of (29), evaluated at the current allocations, divided by ρ . We allow a relaxation parameter $a \in (0, 1]$ and test convergence using the undamped residual $|\hat{U}^{(k)} - U^{(k)}|$. Reaching the iteration limit without satisfying this test is reported as nonconvergence.

Algorithm 1 The Baseline Equilibrium with Exogenous Standardization

```

Choose  $U^{(0)} > 0$ , tolerance  $\varepsilon_U > 0$ ,  $a \in (0, 1]$ , and iteration limit  $k_{\max}$ 
Set iteration counter  $k \leftarrow 0$ 
while  $k < k_{\max}$  do
  Set  $K^{(k)} \leftarrow (\rho U^{(k)} / \kappa)^{1/(1-\eta)}$ 
  for each  $x \equiv (z, s)$  do
    Solve for  $\omega_x^R$  using Lemma 1 at  $(U^{(k)}, K^{(k)})$ 
    Compute  $S_x$ ,  $W_x$ , and  $q_x$  using (26), (27), and (30)
    Compute  $v_x$  and  $n_x$  using (31)
  end for
  Compute  $u \leftarrow 1 - \int n_x dm_x$  using (32)
  Compute  $\hat{U}^{(k)}$  using (29)
  if  $|\hat{U}^{(k)} - U^{(k)}| \leq \varepsilon_U$  then
    return  $U^{(k)}$  and the current firm allocations and unemployment rate
  end if
  Set  $U^{(k+1)} \leftarrow (1 - a)U^{(k)} + a\hat{U}^{(k)}$  and  $k \leftarrow k + 1$ 
end while
Report nonconvergence

```

Algorithm 1 holds the distribution of technology and the number of positions fixed. For each guess of unemployment value, it computes each firm's cutoff, expected surplus, promised value,

Algorithm 2 The Counterfactual Equilibrium with Endogenous Standardization

Choose $U^{(0)} > 0$, tolerance $\varepsilon_U > 0$, $a \in (0, 1]$, and iteration limit $k_{\max}$
Set iteration counter $k \leftarrow 0$
while $k < k_{\max}$ **do**
 Set $K^{(k)} \leftarrow (\rho U^{(k)} / \kappa)^{1/(1-\eta)}$
 for each z **do**
 for each candidate $s \in [\underline{s}, 1)$, with $x \equiv (z, s)$ **do**
 Solve for ω_x^R using Lemma 1 at $(U^{(k)}, K^{(k)})$
 Compute $V_{z,s} \leftarrow A_{z,s}(\omega_x^R) / \rho - U^{(k)}$ using (18)
 end for
 Choose $s^*(z) \in \arg \max_s \{V_{z,s} - \Phi(s)\}$ and retain its cutoff
 Set $x \leftarrow (z, s^*(z))$ and compute S_x , W_x , and q_x using
 (26), (27), and (30)
 Compute v_x and n_x using (31) with $k_x = k_z$
 end for
 Compute $u \leftarrow 1 - \int n_{z,s^*(z)} dm_z$ using (32)
 Compute $\hat{U}^{(k)}$ using (29), integrating over dm_z
 if $|\hat{U}^{(k)} - U^{(k)}| \leq \varepsilon_U$ **then**
 return $U^{(k)}$, $s^*(z)$, and the current allocations and unemployment rate
 end if
 Set $U^{(k+1)} \leftarrow (1 - a)U^{(k)} + a\hat{U}^{(k)}$ and $k \leftarrow k + 1$
end while
Report nonconvergence

vacancy-filling rate, vacancies, and employment. The unemployment rate is then obtained by subtracting aggregate employment from the unit mass of workers. The returned allocations are those computed at the unemployment value that satisfies the convergence test.

Algorithm 2 additionally chooses standardization to maximize $V_{z,s} - \Phi(s)$ for each productivity type z . Its search domain reflects the quantitative cost function, which diverges as $s \rightarrow 1$. Aggregate quantities use only the chosen technology at each z , weighted by the productivity distribution dm_z . For the exercise with endogenous positions, update k_z using (47) and the net value $V_z = V_{z,s^*(z)} - \Phi(s^*(z))$ before computing vacancies and employment. As usual, trial allocations must imply $u > 0$; an infeasible guess must be revised before evaluating (29).

C.2 Details on the Calibration

We calibrate three parameters (ι, α, β) to match two sets of empirical moments: (i) the firm size distribution in 1980, and (ii) the firm size wage premium over 1980–1986, as reported in Bloom et al. (2018). For the firm size distribution, we use employment shares from the Business Dynamics Statistics across the following firm size bins: 1–4, 5–9, 10–19, 20–99, 100–499, 500–999, 1000–2499,

2500–4999, 5000–9999, and 10000 or more employees. For the wage premium, we use the relative log wage across firm size categories from Bloom et al. (2018), specifically: 1–10, 10–50, 50–250, 250–1000, 1000–2500, 2500–10000, 10000–15000, and 15000 or more employees. We use their firm fixed effect estimates based on AKM model (Abowd et al., 1999) as a baseline (Figure 2A in Bloom et al. (2018)).

We choose $\Theta \equiv (\iota, \alpha, \beta)$ as the solution of the following minimization problem:

$$\min_{\Theta} \left\{ \sum_{i=1}^{N_s} \omega_i^s \times (emp_i(\Theta) - emp_i^{data})^2 + \sum_{i=1}^{N_w} \omega_i^w \times (wage_i(\Theta) - wage_i^{data})^2 \right\}, \quad (120)$$

where $emp_i(\Theta)$ is the employment share of firms in size class i computed from the model given the parameters Θ , emp_i^{data} is its data counterpart from the Business Dynamics Statistics 1980, and ω_i^s is the weighting factor for the size class i , which we assume to be the employment share of the size class i in the data. Similarly, $wage_i(\Theta)$ is the firm wage premium (log wage relative to the smallest size category) of firms in size class i computed from the model given the parameters Θ , $wage_i^{data}$ is its data counterpart from Bloom et al. (2018), and ω_i^w is the weighting factor for the size class i , which we assume to be one.

D Endogenous Job Creation and Entry

In our baseline model, the measure of firms is fixed and the number of positions (jobs) each firm has is also fixed. Here, we generalize the baseline model by considering endogenous job creation and endogenous firm entry.

D.1 Endogenous Job Creation

Suppose that firms can endogenously create vacant jobs subject to a convex cost. The value that a firm x derives from creating a job is V_x . Let k_x^n denote the flow of new jobs and let $c_x^k(k_x^n)$ be the increasing and convex flow cost of creating them. The firm's job creation problem is then

$$\max_{k_x^n} V_x k_x^n - c_x^k(k_x^n). \quad (121)$$

Suppose that each job, whether vacant or filled, is destroyed at rate $\varphi > 0$. Job destruction leaves the firm with no continuation value from that position and returns an employed worker to

unemployment. Vacancies and employment evolve according to

$$\begin{aligned}\partial_t v_x &= k_x^n + \delta n_x - (q_x + \varphi)v_x, \\ \partial_t n_x &= q_x v_x - (\delta + \varphi)n_x.\end{aligned}\tag{122}$$

Adding these equations gives the law of motion for the total number of jobs, $k_x = v_x + n_x$:

$$\partial_t k_x = k_x^n - \varphi k_x.\tag{123}$$

The steady-state stocks are therefore

$$k_x = \frac{k_x^n}{\varphi}, \quad v_x = \frac{\delta + \varphi}{q_x + \delta + \varphi} k_x, \quad n_x = \frac{q_x}{q_x + \delta + \varphi} k_x.\tag{124}$$

With positive job destruction, the vacancy, filled-job, and worker value equations become

$$\begin{aligned}(\rho + \varphi)V_x &= \max_W \lambda^F(\theta(W))\Pi_x(W), \\ (\rho + \delta + \varphi)J_x(\omega, W_x(\omega)) &= A_x(\omega) - w(W_x(\omega)) + \delta V_x, \\ (\rho + \delta + \varphi)W_x(\omega) &= w(W_x(\omega)) - \rho U.\end{aligned}\tag{125}$$

Here, $W_x(\omega)$ is the worker's value in excess of unemployment, as in the baseline model. Using the definition of surplus in (14), these imply

$$\begin{aligned}(\rho + \delta + \varphi)S_x(\omega) &= A_x(\omega) - \rho U - (\rho + \varphi)V_x, \\ A_x(\omega_x^R) &= \rho U + (\rho + \varphi)V_x.\end{aligned}\tag{126}$$

The directed-search condition $W_x = \eta S_x$ continues to hold, with expected surplus computed using these modified value equations.

If we assume

$$c_x^k(k_x^n) = \bar{c}_x^k \frac{(k_x^n)^{1+1/\chi}}{1 + 1/\chi}, \quad \chi > 0,\tag{127}$$

we have

$$k_x = \frac{1}{\varphi(\bar{c}_x^k)^\chi} (V_x)^\chi. \quad (128)$$

To recover the durable-job environment in the main text, take $\varphi \rightarrow 0$ while holding $1/[\varphi(\bar{c}_x^k)^\chi]$ fixed. The value equations and the ratios of vacancies and employment to positions then converge to their baseline counterparts, with an endogenous stock of positions.

For the application with endogenous standardization, let the job-creation cost depend on z but not on s , and use the value of a newly created position net of its standardization cost, $V_z = \max_s \{V_{zs} - \Phi(s)\}$, as defined in (41). Replacing V_x by V_z in the creation problem and setting $1/[\varphi(\bar{c}_z^k)^\chi] = \bar{k}z' / (\bar{V}_z)^\chi$ yields the position-supply relation (47) in the durable-job limit.

D.2 Endogenous Entry of Firms

We next consider a separate extension with endogenous firm entry and a fixed number k_x of positions at each surviving firm. New firms are free to enter subject to a fixed cost c^e . After paying this cost, they draw x from the distribution H and are endowed with k_x vacant positions. Firms exit exogenously at rate $\varkappa > 0$, destroying all of their positions. The position and worker value equations are given by (125) with φ replaced by $\varkappa$.

In this case, firms will enter until

$$\int V_x k_x dH_x = c^e. \quad (129)$$

Let m_0 denote the flow of entrants. The mass of firms evolves according to $\partial_t m = m_0 - \varkappa m$, so stationarity requires

$$m = \frac{m_0}{\varkappa}, \quad dm_x = m dH_x. \quad (130)$$

The free-entry condition and market clearing jointly determine m , and the replacement flow is $m_0 = \varkappa m$.

At positive turnover, firms differ in age because entrants start with all positions vacant. Let v_x and n_x denote vacancies and employment averaged across surviving firms of type x . In steady

state, entry creates $\varkappa k_x$ vacancies per surviving firm, so flow balance requires

$$\varkappa k_x + \delta n_x = (q_x + \varkappa)v_x, \quad q_x v_x = (\delta + \varkappa)n_x. \quad (131)$$

Consequently,

$$v_x = \frac{\delta + \varkappa}{q_x + \delta + \varkappa} k_x, \quad n_x = \frac{q_x}{q_x + \delta + \varkappa} k_x. \quad (132)$$

Taking $\varkappa \rightarrow 0$ with a finite stationary mass of firms makes the entry flow vanish and recovers the baseline value equations and firm-size formulas. Thus the individual-firm equations in the main text apply in the durable limits of these two extensions, with k_x or m determined endogenously. Aggregate results that assume $\theta = 1$ additionally require total positions to equal the mass of workers; endogenous job creation or entry does not impose this restriction automatically.

E An Alternative Model with Random Search and Wage Bargaining

In our baseline model, we assume that search is directed and firms choose what wages (promised values) to post. While these assumptions have the advantage of being closer to the existing monopsony literature, random search with wage bargaining is far more common in the labor search literature. Below, we show that all our insights naturally carry over to an environment with random search and wage bargaining.

Consider an economy with a single labor market where all unemployed workers and vacancies randomly meet. Meeting is governed by a matching function $\mathcal{M}(u, v) = \kappa u^\eta v^{1-\eta}$. Upon a meeting of an unemployed worker and a vacant position, match quality, ω , is revealed and the worker and firm decide whether to form a match or not. Wages are determined by Nash bargaining with worker bargaining power $\gamma \in (0, 1)$. Let

$$\lambda^F \equiv \frac{\mathcal{M}(u, v)}{v}, \quad \lambda^U \equiv \frac{\mathcal{M}(u, v)}{u}, \quad (133)$$

be the meeting rates of vacancies and unemployed workers, respectively, where $v \equiv \int v_x dm_x$ denotes the total mass of vacant positions and u denotes the unemployment rate.

The value function of a vacant job at firm x , V_x , solves

$$\rho V_x = \lambda^F \int \max \{0, J_x(\omega) - V_x\} dG(\omega). \quad (134)$$

The value of a matched job at firm x when performed by a worker with match quality ω is denoted $J_x(\omega)$ and solves

$$\rho J_x(\omega) = A_x(\omega) - w_x(\omega) + \delta(V_x - J_x(\omega)),$$

where $w_x(\omega)$ is the wage. The value of an unemployed worker is given by

$$\rho U = \lambda^U \int \frac{v_x}{v} \int \max \{0, W_x(\omega) - U\} dG(\omega) dm_x. \quad (135)$$

The value of an employed worker, $W_x(\omega)$, solves

$$\rho W_x(\omega) = w_x(\omega) + \delta(U - W_x(\omega)).$$

Define the joint match surplus as $S_x(\omega) \equiv W_x(\omega) + J_x(\omega) - U - V_x$. Using the above equations, we have that

$$(\rho + \delta)S_x(\omega) = A_x(\omega) - \rho U - \rho V_x. \quad (136)$$

The wage is determined by standard Nash bargaining with worker's bargaining power γ . This results in the following surplus splits:

$$W_x(\omega) = U + \gamma S_x(\omega), \quad J_x(\omega) = V_x + (1 - \gamma)S_x(\omega). \quad (137)$$

The wage is then given by

$$w_x(\omega) = \gamma(\rho + \delta)S_x(\omega) + \rho U. \quad (138)$$

The reservation match quality ω_x^R solves

$$S_{zs}(\omega_{zs}^R) = 0, \quad (139)$$

or equivalently

$$A_x(\omega_x^R) = \rho U + \rho V_x. \quad (140)$$

The steady-state unemployment rate is given by

$$u = \frac{\delta}{\delta + \lambda^U \int \frac{v_x}{v} (1 - G(\omega_x^R)) dm_x}. \quad (141)$$

The vacancy-filling rate at firm x is

$$q_x \equiv \lambda^F (1 - G(\omega_x^R)). \quad (142)$$

Vacancies and employment evolve according to

$$\begin{aligned} \partial_t v_x &= \delta n_x - q_x v_x, \\ \partial_t n_x &= q_x v_x - \delta n_x. \end{aligned} \quad (143)$$

Thus $v_x + n_x = k_x$ remains constant, and steady state requires $q_x v_x = \delta n_x$. Solving these two conditions gives

$$v_x = k_x \frac{\delta}{\delta + q_x}, \quad (144)$$

$$n_x = k_x \frac{q_x}{\delta + q_x}. \quad (145)$$

The rest of the model is unchanged from the baseline model.

The following lemma is a counterpart of Lemma 1.

Lemma 6. *The reservation match quality ω_x^R at firm x solves*

$$z^s (\omega_x^R)^{1-s} - \rho U = \lambda^F (1 - \gamma) \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} (\omega_x^R / \underline{\omega})^{-\beta}. \quad (146)$$

Proof. Recall the reservation match quality satisfies

$$z^s (\omega_x^R)^{1-s} - \rho U = \rho V_x. \quad (147)$$

Substituting (137) into (134), we obtain

$$\rho V_x = \lambda^F(1 - \gamma) \int_{\omega_x^R} S_x(\omega) dG(\omega) \quad (148)$$

$$= \lambda^F(1 - \gamma) \frac{1}{\rho + \delta} \int_{\omega_x^R} [A_x(\omega) - \rho U - \rho V_x] dG(\omega) \quad (149)$$

$$= \lambda^F(1 - \gamma) \frac{1}{\rho + \delta} \int_{\omega_x^R} [A_x(\omega) - A_x(\omega_x^R)] dG(\omega) \quad (150)$$

$$= \lambda^F(1 - \gamma) \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} (\omega_x^R / \underline{\omega})^{-\beta}. \quad (151)$$

Substituting (151) into (147), we obtain the desired result. $\square$

The following lemma provides a counterpart of Lemma 2.

Lemma 7. *Suppose z is large enough so that $\rho U / z^s \rightarrow 0$. In such a limit,*

$$\omega_x^R \rightarrow \underline{\omega} \left(\lambda^F(1 - \gamma) \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} \right)^{1/\beta}. \quad (152)$$

Proof. Under the limit, Lemma 6 boils down to

$$1 = \lambda^F(1 - \gamma) \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} (\omega_x^R / \underline{\omega})^{-\beta}. \quad (153)$$

Solving for ω_x^R gives

$$\omega_x^R = \underline{\omega} \left(\lambda^F(1 - \gamma) \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} \right)^{1/\beta}. \quad (154)$$

$\square$

This shows that, asymptotically, the reservation match quality is independent of z . With this result, it is straightforward to show the same set of cross-sectional implications as in our baseline model.

Proposition 8. *Consider firms with sufficiently high z so that $\rho U / z^s \rightarrow 0$. The reservation match quality ω_x^R is strictly decreasing in s .*

1. *The reservation match quality ω_x^R is strictly decreasing in s .*
2. *The vacancy filling rate, and firm size are strictly increasing in s .*
3. *There exists s^* such that for $s > s^*$, the output per worker is strictly increasing in s .*

4. There exists s^* such that for $s > s^*$, average wage and labor share are decreasing in s .

Proof. Log-differentiating (154) at fixed z , U , and meeting rates gives

$$\frac{d \ln \omega_x^R}{ds} = \frac{1}{\beta} \left[-\frac{1}{1-s} - \frac{1}{\beta+s-1} \right] < 0. \quad (155)$$

Thus ω_x^R is decreasing in s . The vacancy filling rate is

$$q_x = \lambda^F (1 - G(\omega_x^R)) \quad (156)$$

$$= \left((1-\gamma) \frac{1}{\rho+\delta} \frac{1-s}{\beta+s-1} \right)^{-1}, \quad (157)$$

which is strictly increasing in s . Since the firm size is increasing in q_x , the firm size is also strictly increasing in s . The output per worker is

$$\bar{A}_x \equiv \frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s}. \quad (158)$$

Imposing the limit of (154), we have

$$\bar{A}_x \equiv \frac{\beta}{\beta+s-1} z^s \left(\underline{\omega} \left(\lambda^F (1-\gamma) \frac{1}{\rho+\delta} \frac{1-s}{\beta+s-1} \right)^{1/\beta} \right)^{1-s}. \quad (159)$$

The log derivative is

$$\frac{d \ln \bar{A}_x}{ds} = -\frac{1}{\beta+s-1} + (\ln z - \ln \omega_x^R) + (1-s) \frac{d \ln \omega_x^R}{ds} \quad (160)$$

$$= -\frac{1}{\beta+s-1} + \ln z - \ln \underline{\omega} - \frac{1}{\beta} \left(\ln \frac{\lambda^F (1-\gamma)}{\rho+\delta} + \ln(1-s) - \ln(\beta+s-1) \right) \quad (161)$$

$$- (1-s) \frac{1}{\beta} \left[\frac{1}{1-s} + \frac{1}{\beta+s-1} \right] \quad (162)$$

$$= -\frac{1}{\beta+s-1} + \ln z - \ln \underline{\omega} - \frac{1}{\beta} \left(\ln \frac{\lambda^F (1-\gamma)}{\rho+\delta} + \ln(1-s) - \ln(\beta+s-1) \right) \quad (163)$$

$$- \frac{1}{\beta} \left(1 + \frac{1-s}{\beta+s-1} \right). \quad (164)$$

For sufficiently large s , the above expression is positive (through term $\ln(1-s)$), implying $\frac{d \ln \bar{A}_x}{ds} >$

0. The average wage at firm x is

$$\bar{w}_x = \rho U + \gamma \frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s}. \quad (165)$$

Taking the log derivative of $\bar{w}_x - \rho U$,

$$\frac{d \ln(\bar{w}_x - \rho U)}{ds} = -\frac{1}{1-s} - \frac{1}{\beta + s - 1} + (\ln z - \ln \omega_x^R) + (1-s) \frac{d \ln \omega_x^R}{ds} \quad (166)$$

$$= -\frac{1}{1-s} - \frac{1}{\beta + s - 1} + \ln z - \ln \underline{\omega} \quad (167)$$

$$- \frac{1}{\beta} \left(\ln \frac{\lambda^F(1-\gamma)}{\rho + \delta} + \ln(1-s) - \ln(\beta + s - 1) \right) - \frac{1}{\beta} \left(1 + \frac{1-s}{\beta + s - 1} \right). \quad (168)$$

As in (65), we can show

$$\lim_{s \rightarrow 1} -\frac{1}{1-s} - \frac{1}{\beta} \ln(1-s) = -\infty. \quad (169)$$

Since this term is the only term that is unbounded as s approaches 1, we have $\frac{d \ln(\bar{w}_x - \rho U)}{ds} < 0$ for s sufficiently close to 1. Since $\bar{A}_x$ increases and $\bar{w}_x$ decreases as s increases, the labor share must decrease as s increases. $\square$

F Imperfectly Durable Vacancies

In our baseline model, jobs are perfectly durable. This along with costly entry implies that firms have a non-zero outside option that varies with their technology $x \equiv (z, s)$. We emphasize how the value of the firm's outside option affects the wage markdown firms choose in equilibrium in our model (equation (24)) and more generally are key to our main results. To drive this point home more clearly, we now consider an extension of the model in which the value of the firm's outside option goes to zero.

To drive the value of the firm's outside option to zero, we assume that vacant positions are destroyed at a Poisson rate $\varkappa \in [0, \infty)$ and take a limit where $\varkappa \rightarrow \infty$. Notice that we are assuming only that vacant positions are destroyed at a rate $\varkappa$, not filled positions. We retain the assumption that matches separate at rate δ . In our model, firms and workers face no interesting decisions after a match has been formed and until an exogenous separation occurs. All the interesting economics occurs at the match formation stage. By driving the destruction rate of vacant positions to infinity, we drive the value of the outside option of firms to zero in the match formation stage without affecting the duration of filled positions.

We assume that firms create new vacant positions at a flow rate v_x^n . Vacancies are filled at

rate q_x , and separations return filled positions to the vacancy stock. The stock-flow equations are therefore

$$\begin{aligned}\partial_t v_x &= v_x^n + \delta n_x - (q_x + \kappa) v_x, \\ \partial_t n_x &= q_x v_x - \delta n_x.\end{aligned}\tag{170}$$

Adding the two equations, the total number of positions $k_x = v_x + n_x$ evolves according to

$$\partial_t k_x = v_x^n - \kappa v_x.\tag{171}$$

In steady state, $q_x v_x = \delta n_x$ and $v_x^n = \kappa v_x$. For $\kappa > 0$, this gives

$$v_x = \frac{v_x^n}{\kappa}, \quad n_x = \frac{q_x v_x}{\delta}, \quad k_x = \left(1 + \frac{q_x}{\delta}\right) v_x.\tag{172}$$

At $\kappa = 0$, a stationary stock requires $v_x^n = 0$, and the total number of positions remains fixed as in the baseline model.

The HJB equation for vacancy (11) is modified as

$$(\rho + \kappa) V_x = \max_W \lambda^F(\theta(W)) \Pi_x(W).\tag{173}$$

Since (8), (15), and (16) remain the same, we can substitute them into (173) to obtain

$$(\rho + \kappa) V_x = \max_{W_x} \kappa K^{-\eta} W_x^{\frac{\eta}{1-\eta}} \left\{ \int_{\omega_x^R}^{\infty} \frac{1}{\rho + \delta} [A_x(\omega) - \rho U - \rho V_x] dG(\omega) - W_x \right\}\tag{174}$$

Following the same steps as in Appendix B.1, we can rewrite the above expression as

$$(\rho + \kappa) V_x = \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1 - \eta) \left\{ \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^\beta \right] \right\}^{\frac{1}{1-\eta}}.\tag{175}$$

Recall that the reservation match quality satisfies

$$A_x(\omega^R) = \rho U + \rho V_x.\tag{176}$$

Solving for V_x in (175) and substituting into (176), we have

$$z^s(\omega_x^R)^{1-s} - \rho U = \frac{\rho}{\rho + \varkappa} \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s(\omega_x^R)^{1-s} \left[(\omega_x^R)^{-\beta} \underline{\omega}^\beta \right] \right\}^{\frac{1}{1-\eta}}. \quad (177)$$

This cutoff equation reduces to Lemma 1 when $\varkappa = 0$. Vacancy and employment stocks follow the flow equations above in place of (31); the remaining search, match-formation, and wage conditions are unchanged.

Recall that the left-hand side of equation (177) is upward sloping in ω_x^R , while the right-hand side is downward sloping in ω_x^R . Notice that $\varkappa$ only shows up on the right-hand side of equation (177) and that it shifts the right-hand side down as a function of ω_x^R . This implies that $\varkappa > 0$ lowers ω_x^R . Intuitively, the value of waiting for a better value of ω is smaller since the vacancy may disappear.

We now study the limit case where vacancies become fully non-durable, i.e., $\varkappa \rightarrow \infty$. In order to make sure this limit is well-defined, we also let $v_x^n \rightarrow \infty$ so that $v_x = v_x^n / \varkappa$ remains constant. This limit case of entirely non-durable vacancies is widely assumed in the literature that builds on Burdett and Mortensen (1998) models. In this case, we obtain sharply different implications from our baseline model.

Proposition 9. *Consider the limit of $\varkappa \rightarrow \infty$ while $v_x^n / \varkappa$ remains constant for all x . Then, the following holds.*

1. *The labor share at firm x is given by*

$$\frac{\bar{w}_x}{\bar{A}_x} = \frac{\beta - (1-\eta)(1-s)}{\beta}, \quad (178)$$

which is strictly increasing in s .

2. *The average output per worker at firm x is given by*

$$\bar{A}_x = \frac{\beta}{\beta - (1-s)} \rho U, \quad (179)$$

which is strictly decreasing in s .

3. *The average wage at firm x is given by*

$$\bar{w}_x = \frac{\beta - (1-\eta)(1-s)}{\beta - (1-s)} \rho U, \quad (180)$$

which is strictly decreasing in s .

Proof. Under the limit of $\varkappa \rightarrow \infty$, equation (177) collapses to

$$z^s (\omega_x^R)^{1-s} = \rho U. \quad (181)$$

Substituting (181) into (28), the average output per worker at firm x is

$$\bar{A}_x = \frac{\beta}{\beta - (1-s)} \rho U. \quad (182)$$

Substituting (181) into (33), the average wage at firm x is

$$\bar{w}_x = \frac{\beta - (1-\eta)(1-s)}{\beta - (1-s)} \rho U. \quad (183)$$

Dividing (183) by (182), we obtain

$$\frac{\bar{w}_x}{\bar{A}_x} = \frac{\beta - (1-\eta)(1-s)}{\beta}. \quad (184)$$

□

In sharp contrast to the result in our baseline model, when vacancies are entirely non-durable ($\varkappa \rightarrow \infty$), the labor share is strictly *increasing* in standardization. This is precisely the opposite of what happens when vacancies are perfectly durable ($\varkappa = 0$). In our baseline model, for high- z firms, the outside option of workers is unimportant relative to the outside option of firms. As s increases, the outside option of high- z firms improves and this increases the wage markdown and decreases the labor share. When $\varkappa \rightarrow \infty$, however, the outside option of firms goes to zero and the equilibrium is shaped by the outside option of workers.

Notice that in the $\varkappa \rightarrow \infty$ limit the average output per worker and the average wage are independent of the firm's quality z —see equations (182) and (183). This is because an increase in z is exactly offset by a drop in average match quality. As s increases, average output per worker and the average wage fall. These variables are determined by the mean of ω^{1-s} in our model (see equation (4)). Recall that ω is distributed Pareto. A larger s results in a thinner tail for ω^{1-s} and therefore a smaller average value for this variable.

Most importantly, as wages get closer to worker's outside option, the firm faces a more elastic labor supply curve, which erodes its monopsony power in the labor market. This is a direct

consequence of the Lerner formula—equation (24)—after imposing $V_x = 0$. With $V_x = 0$, the only reason firm’s wage markdown varies is through a change in the labor supply elasticity, which increases as firm’s output declines. Put differently, workers gain a stronger bargaining position as their outside option becomes more binding.

G Comparing Alternative Cost per Hire Measures

Our aim here is to compare our estimates of the cost per hire from the SHRM HR Benchmarking Report to an alternative methodology based on the ratio of total costs of hiring to the total number of hires. We obtain employment and salaries in human resources (HR) by industry from Occupational Employment Statistics (OES) data and multiply these together to get total HR costs by sector. We then divide this total cost by total hires by industry from JOLTS.

We then merge the OES/JOLTS based measure of cost per hire with our survey measure from the SHRM HR Benchmarking Reports. This requires us to create harmonized industry groupings that can be used to merge the OES/JOLTS data with the industry categories presented by SHRM. The harmonized industry groupings are much broader than the original groupings in either of the two underlying sources. Figure G.1 presents a scatter plot showing the relationship between the estimates from the two sources.

There is undoubtedly measurement error in this estimate of hiring costs since HR workers (in the numerator) may not be the only employees participating in hiring, and also, HR workers may carry out other tasks beyond hiring. Nevertheless, Figure G.1 shows that this alternative measure provides broadly congruent results on the extent of “labor commoditization” by industry.

H Planning Problem

In this appendix, we study the problem of a (constrained) planner who is subject to the same search frictions as the decentralized economy. We consider an economy in which standardization is endogenous, as in Section 3.3.

H.1 The Planner’s Problem with Endogenous Standardization

We consider an economy in which standardization is chosen at entry. In order to ensure that the steady state is well-defined, we assume that firms exit exogenously at rate κ and are replaced by entering firms with the same level of quality z . The economy in the main text is a limiting case of

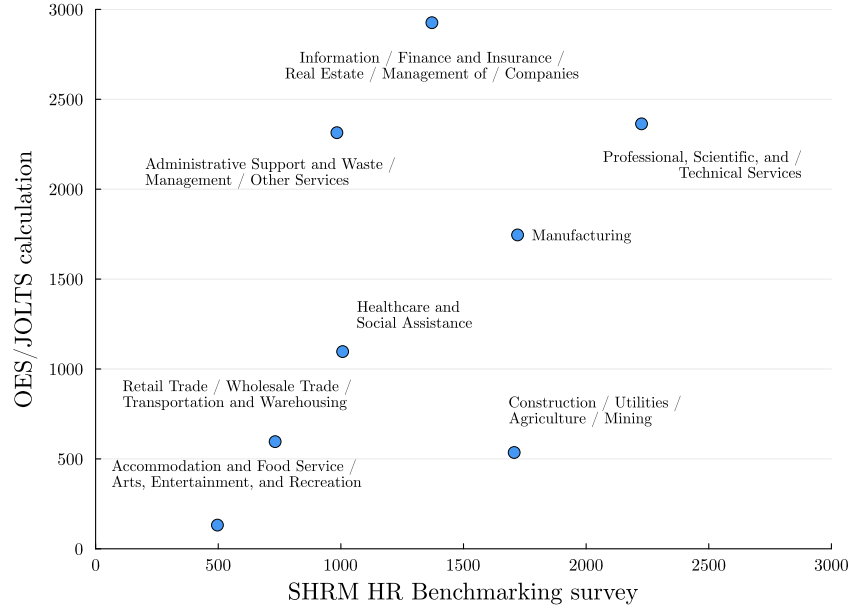


Figure G.1: Comparing Two Measures of Cost per Hire by Industry

Note: This scatter plot has median cost per hire from the SHRM HR Benchmark survey on the horizontal axis and average cost per hire from OES/JOLTS on the vertical axis.

$\varkappa \rightarrow 0$. Upon entry, a firm chooses its degree of standardization $s \in [s, 1]$ once and for all, paying a one-time cost $\Phi(s)$ for each of its k_z jobs. As in the main text, we index firm types and submarkets by $x \equiv (z, s)$. A match of quality ω at a type- x firm produces $A_x(\omega)$.

Let v_{xt} denote the density of vacancies and $\mu_{xt}(\omega)$ the density of filled jobs at type- x firms. Employment at these firms is $n_{xt} \equiv \int_0^\infty \mu_{xt}(\omega) d\omega$. The planner directs u_{xt} unemployed workers to submarket x , accepts meetings according to $\mathbb{I}_{xt}(\omega) \in \{0, 1\}$, and assigns entering firms a technology according to the density σ_{xt} , with $\int_0^1 \sigma_{xt} ds = 1$ for each z and t . The planner's problem is

$$\max_{\{u_{xt}, \mathbb{I}_{xt}(\omega), \sigma_{xt}\}} \int_0^\infty e^{-\rho t} \int \left\{ \int_0^1 \int_0^\infty A_x(\omega) \mu_{xt}(\omega) d\omega ds - \varkappa k_z \int_0^1 \Phi(s) \sigma_{xt} ds \right\} dm_z dt, \quad (185)$$

subject to the law of motion for matches,

$$\partial_t \mu_{xt}(\omega) = \mathcal{M}(u_{xt}, v_{xt}) \mathbb{I}_{xt}(\omega) g(\omega) - (\delta + \varkappa) \mu_{xt}(\omega), \quad (186)$$

the law of motion for vacancies,

$$\partial_t v_{xt} = \varkappa k_z \sigma_{xt} + \delta n_{xt} - \varkappa v_{xt} - \mathcal{M}(u_{xt}, v_{xt}) \int_0^\infty \mathbb{I}_{xt}(\omega) dG(\omega), \quad (187)$$

and the resource constraint that workers are either employed or searching in some submarket,

$$\int \int_0^1 u_{xt} ds dm_z = 1 - \int \int_0^1 n_{xt} ds dm_z. \quad (188)$$

The second term in the planner's problem (185) is the standardization spending of the flow $\varkappa$ of entering firms.¹⁶ In equation (187), vacancies are created by entrants and by separations at surviving firms, and destroyed by firm exit and by match formation. Matches dissolve at a rate $\delta + \varkappa$: after an idiosyncratic separation the job survives as a type- x vacancy, whereas after firm exit it disappears and is replaced by an entrant's vacancy carrying a newly chosen technology.

Let $\Omega_{xt}(\omega)$ and V_{xt} be the current-value costates on equations (186) and (187) and let ρU_t be the multiplier on equation (188). Writing $\mathcal{M}_{xt} \equiv \mathcal{M}(u_{xt}, v_{xt})$ for the meeting rate, the current-value Hamiltonian is

$$\begin{aligned} \mathcal{H}_t = & \int \int_0^1 \left\{ \int_0^\infty \left[A_x(\omega) \mu_{xt}(\omega) + \Omega_{xt}(\omega) (\mathcal{M}_{xt} \mathbb{I}_{xt}(\omega) g(\omega) - (\delta + \varkappa) \mu_{xt}(\omega)) \right] d\omega \right. \\ & + V_{xt} \left[\varkappa k_z \sigma_{xt} + \delta n_{xt} - \varkappa v_{xt} - \mathcal{M}_{xt} \int_0^\infty \mathbb{I}_{xt}(\omega) dG(\omega) \right] \\ & \left. - \varkappa k_z \Phi(s) \sigma_{xt} \right\} ds dm_z \\ & + \rho U_t \left[1 - \int \int_0^1 n_{xt} ds dm_z - \int \int_0^1 u_{xt} ds dm_z \right]. \end{aligned}$$

The filled-job value $\Omega_{xt}(\omega)$ enters the optimality conditions only through its difference from the vacancy value. We therefore define the social surplus of a match and its expectation over accepted meetings,

$$S_{xt}(\omega) \equiv \Omega_{xt}(\omega) - V_{xt}, \quad \bar{S}_{xt} \equiv \int_0^\infty S_{xt}(\omega) \mathbb{I}_{xt}(\omega) dG(\omega). \quad (189)$$

We derive four optimality conditions.

Acceptance rule. The Hamiltonian is linear in $\mathbb{I}_{xt}(\omega)$ with coefficient $\mathcal{M}_{xt} g(\omega) S_{xt}(\omega)$. The planner therefore forms a match if and only if its social surplus is non-negative,

$$\mathbb{I}_{xt}(\omega) = 1 \iff S_{xt}(\omega) \geq 0, \quad (190)$$

¹⁶If $\Phi(s)$ is instead a flow cost paid over the firm's life, it enters the value equations (193)–(194) as a flow and the entry condition becomes $s_{zt}^* \in \arg \max_s V_{(z,s),t}$; the two formulations coincide in steady state up to the replacement $\Phi \mapsto (\rho + \varkappa)\Phi$.

a threshold rule with reservation match quality ω_x^R satisfying $S_{xt}(\omega_x^R) = 0$.

Allocation of searchers. The first-order condition with respect to u_{xt} is $\mathcal{M}_u \bar{S}_{xt} = \rho U_t$. With the Cobb-Douglas matching function (5), $\mathcal{M}_u = \eta \lambda^U(\theta_{xt})$, where $\theta_{xt} \equiv v_{xt}/u_{xt}$ is tightness in submarket x , so

$$\rho U_t = \eta \lambda^U(\theta_{xt}) \bar{S}_{xt} \quad \text{for all active } x. \quad (191)$$

Standardization at entry. The Hamiltonian is linear in σ_{xt} with coefficient $\varkappa k_z [V_{xt} - \Phi(s)]$. The planner therefore assigns all entering firms the technology

$$s_{zt}^* \in \arg \max_{s \in [0,1]} \{V_{(z,s),t} - \Phi(s)\}, \quad (192)$$

and an interior optimum satisfies $\Phi'(s_{zt}^*) = \partial_s V_{(z,s),t}|_{s=s_{zt}^*}$: the marginal cost of standardizing a job equals the marginal effect of standardization on the social value of a vacancy.

Value of a filled job and of a vacancy. The costate equations $\partial_t \Omega_{xt}(\omega) = \rho \Omega_{xt}(\omega) - \partial \mathcal{H}_t / \partial \mu_{xt}(\omega)$ and $\partial_t V_{xt} = \rho V_{xt} - \partial \mathcal{H}_t / \partial v_{xt}$ read, using $\mathcal{M}_v = (1 - \eta) \lambda^F(\theta_{xt})$,

$$\begin{aligned} \partial_t \Omega_{xt}(\omega) &= (\rho + \delta + \varkappa) \Omega_{xt}(\omega) - A_x(\omega) + \rho U_t - \delta V_{xt}, \\ \partial_t V_{xt} &= (\rho + \varkappa) V_{xt} - (1 - \eta) \lambda^F(\theta_{xt}) \bar{S}_{xt}. \end{aligned} \quad (193)$$

Subtracting the second equation from the first, the vacancy value drops out and the surplus satisfies

$$\partial_t S_{xt}(\omega) = (\rho + \delta + \varkappa) S_{xt}(\omega) - A_x(\omega) + \rho U_t + (1 - \eta) \lambda^F(\theta_{xt}) \bar{S}_{xt}. \quad (194)$$

Since $S_{xt}(\omega)$ is strictly increasing in ω , and evaluating equation (194) at ω_x^R in steady state yields the reservation match quality condition

$$A_x(\omega_x^R) = \rho U + (1 - \eta) \lambda^F(\theta_x) \bar{S}_x. \quad (195)$$

Steady state in the limit of $\varkappa \rightarrow 0$. Taking the limit of $\varkappa \rightarrow 0$ and evaluating the above equations in the steady state, we see that all the conditions coincide with those in the decentralized

equilibrium described in the main body of the paper. After imposing these conditions, equations (194), (193), and (191) become

$$(\rho + \delta)S_x(\omega) = A_x(\omega) - \rho U - \rho V_x \quad (196)$$

$$\rho V_x = (1 - \eta) \lambda^F(\theta_x) \bar{S}_x \quad (197)$$

$$\rho U = \eta \lambda^U(\theta_x) \bar{S}_x \quad \text{for all active } x. \quad (198)$$

The acceptance rule is given by equation (190), and the choice of standardization is given by equation (192). Since all these conditions are the same as in the decentralized equilibrium, the steady state equilibrium of the decentralized economy is efficient. This efficiency of ex-ante investment under directed search is in the spirit of [Acemoglu and Shimer \(1999\)](#) and [Jerez \(2017\)](#).