

The Commoditization of Labor

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May 11, 2026

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 sensitive 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.

JEL Classification: J42, E11

*We would like to thank Sydnee Caldwell, Patrick Kline, Benjamin Schoefer, and participants in seminars we have given for useful comments and discussions. We thank the Smith Richardson Foundation for financial support.

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 straightens 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 the salting of 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 entry is costly. 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 lowers 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 homogenous firms, these two forces cancel out exactly, leaving the labor share unchanged. With heterogeneous firms, however, the aggregate labor share falls when high-quality firms increase standardization.

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 survey 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

Our theory of commoditization of labor helps explain a number of facts about low-wage service sectors over the past few decades. Haltiwanger, Hyatt and Spletzer (2024) show that low wage growth in a narrow set of 4-digit service sectors explains a large fraction of the growth in overall earnings inequality in the economy between 1996 and 2018. Employment in these low-wage service sectors has been growing over this period implying that low wages are not due to disappearing jobs as in manufacturing.

Hortaçsu and Syverson (2015) emphasize a divergence between strong labor productivity growth and weak wage growth in the retail sector. Healthy productivity growth is inconsistent with low wages in retail being due to reallocation of workers from manufacturing as in Autor and Dorn (2013). Productivity growth in retail has been associated with strong investment in new busi-

²Manning (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) presents evidence on differing degrees of replaceability (hold-up power) of workers of different occupations.

ness practices such as inventory management and logistics (Foster, Haltiwanger and Krizan, 2006). To the extent that these investments were commoditizing—as the quotes from Gautié, Jaehrling and Perez (2020), Guendelsberger (2019), and Ehrenreich (2001) above suggest—our model can help explain the combination of healthy productivity growth, low wage growth, and growing employment.

Haltiwanger, Hyatt and Spletzer (2024) also present evidence from worker-firm fixed-effect regressions that increasing wage markdowns have contributed substantially to low wage growth in low-wage service sectors. Models in which monopsony power in the labor market arises from firm heterogeneity (worker outside options) struggle to explain this evidence. Rossi-Hansberg, Sarte and Trachter (2021) emphasize that, while national labor market concentration has been increasing, local labor market concentration has been falling due to the entry of megafirms into many local markets—and this pattern is particularly pronounced in retail trade. As a consequence, conventional labor market monopsony models predict falling markdowns rather than rising markdowns. Berger, Herkenhoff and Mongey (2022) show that their sophisticated quantitative labor market monopsony model implies a 4 percentage point increase in the aggregate labor share when calibrated to recent changes in US labor market concentration. In contrast, our model generates a direct link between increasing national labor market concentration and the markdown.

Autor et al. (2020) emphasize the important role of superstar firms in the recent fall in the labor share of income. They present a model in which an increase in the dispersion of productivity raises the markups of high-productivity firms—and lowers their labor share—through a demand-system channel. Our model also yields predictions for the labor share of superstar firms. However, the mechanism runs through labor market markdowns rather than product market markups.³ Gouin-Bonenfant (2022) presents a monopsony model that generates a declining labor share associated with the rise of superstar firms. But his model implies an increasing large-firm wage premium which is at odds with the data.

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; Haltiwanger et al., 2024)—a phenomenon that appears most prominently in the service sector, where the large firm wage premium has *completely* disappeared. 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

³Our mechanism therefore applies specifically to markdowns on labor, rather than, markups over intermediate inputs, whose share has been relatively stable in recent years.

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.

[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](#)) and show that the growth of superstar firms is due to growth in the number of establishments these firms have. Our model can be viewed as formalizing this narrative with the extra twist that the decrease in marginal cost allowing superstar firms to expand is partly due to commoditization of labor that allows the firms to increase wage markdowns.

In our model, it is search frictions that give rise to imperfect competition. 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. [Bloesch, Larsen and Yding \(2026\)](#) argue 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.

Our model also relates to [Martellini and Menzio \(2020, 2021\)](#) and [Borovičková and Shimer \(2024\)](#) in emphasizing selection on idiosyncratic match quality in the search models. [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. [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.

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 workers 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 Pareto shape parameter. We assume that $\beta > 1 - \underline{s}$, where \underline{s} is the minimum degree of standardization s among all firms.⁴

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 .⁵ 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 how standardized 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 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 becomes more indistinguishable, more replaceable, more commoditized from the firm's perspective.

⁴As we can see from equation (28), this assumption ensures that the expected output at any firm is finite.

⁵This setup is similar to that in Bassi et al. (2025).

2.2 Search

The economy is subject to search frictions. Search is directed and competitive as in Moen (1997).⁶ 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 matching 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

⁶In Appendix E, we present a version of our model with random search and Nash bargaining.

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

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

holds, where $\mathbb{I}_x(\omega)$ is an indicator function that is one if the match is formed. 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 notational simplicity, we assume that all firms choose the same $W_x(\omega)$ that satisfies equation (9).

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

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

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

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

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 .

$$\mathbb{I}_x(\omega) = \begin{cases} 1 & \text{if } \omega > \omega_x^R \\ 0 & \text{otherwise,} \end{cases} \quad (16)$$

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 .⁷ Equation (15) then implies that the reservation match quality ω_x^R satisfies

$$A_x(\omega_x^R) = \rho U + \rho V_x. \quad (17)$$

Combining equations (9), (12), and (14) yields

$$\Pi_x(W) = \max_{\{\mathbb{I}_x(\omega)\}} \int \mathbb{I}_x(\omega) S_x(\omega) dG(\omega) - W. \quad (18)$$

We are now ready to come back to the optimal promised value (wage) setting problem for vacant jobs. We can use (8), (15), and (18) 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)

⁷One simple way to ensure this while keeping matching rates stable is to assume that $\underline{\omega} \rightarrow 0$ but let the efficiency of the matching function go to infinity, $\kappa \rightarrow \infty$, so that the matching rates remain constant, as in Oberfield (2018).

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 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 (16) 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), we can then define the labor supply function as a function of expected wage payments conditional on forming a match:

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

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: for any given labor supply elasticity and marginal product of labor, a higher outside option of firms lowers wages.⁸

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:*

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

The proof of this lemma (as well other lemmas and propositions in the paper) is in Appendix B.

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

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

⁸A subtle point is that the labor supply elasticity $\frac{\partial_w \ell(\bar{w}_x, \omega_x^R) \bar{w}_x}{\ell(\bar{w}_x, \omega_x^R)}$ 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.

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 vacancies and employment size at firm x are then given by

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

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

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

Given these equations, 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 $B \equiv K^{-\eta(1-\eta)} \eta^\eta (1-\eta)^{1-\eta} \frac{1}{\rho+\delta} \underline{\omega}^\beta > 0$.

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.

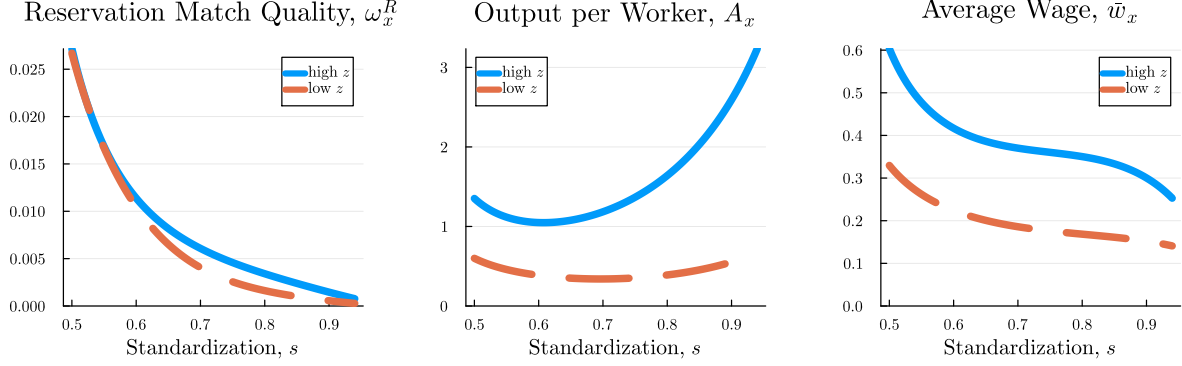


Figure 1: Numerical Illustration for Reservation Wage, Output, and Average Wage

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 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).⁹

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 is z . 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.

⁹For 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 .

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 firm’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

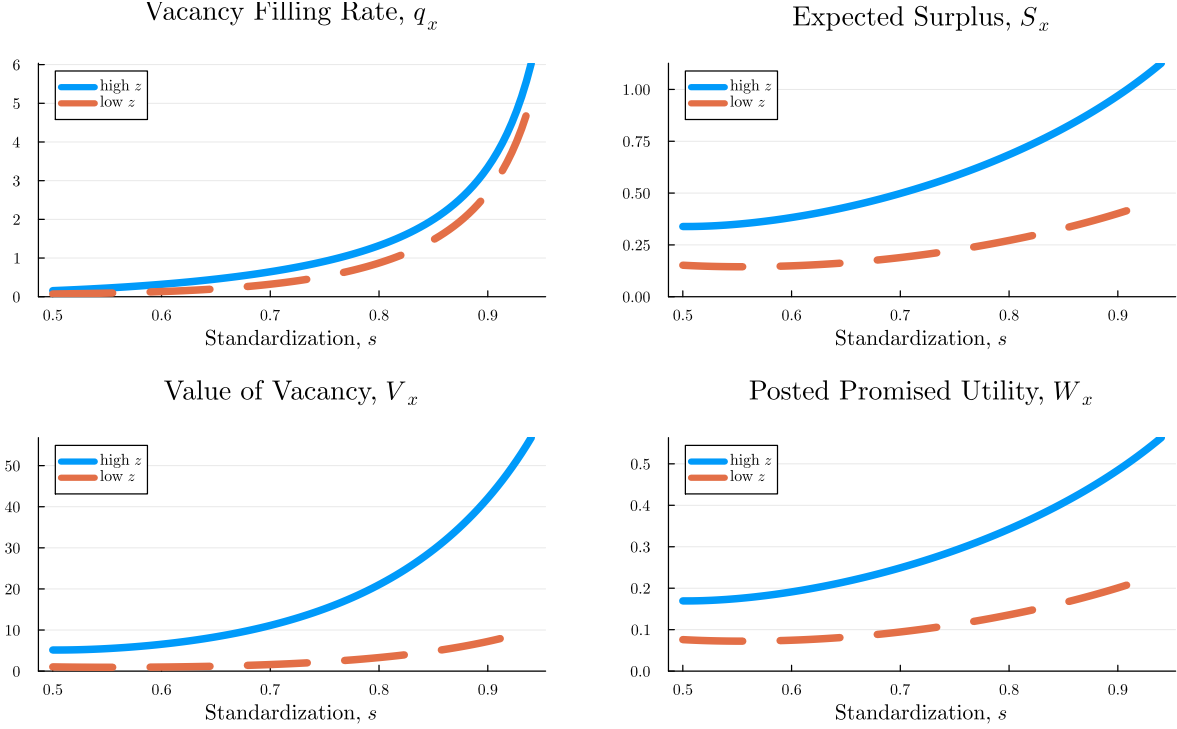


Figure 2: Numerical Illustration for Vacancy-Filling Rate, Surplus, and Value of Vacancy

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.

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 makes it complicated to discuss the effect of standardization on 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.

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:*

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 models 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 more standardized technology.

"These wage increases are key to how the firm increases its vacancy-filling rate—so that it can grow. This is a ubiquitous feature of standard monopsony models. As z increases, the firm has an incentive to fill its vacancies faster, which induces the firm to post higher wages. Our model, in contrast, allows firms to grow without raising wages by adopting a more standardized technology.

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 aggregate labor share where each firm is weighted by an arbitrary weight ψ_x .

Lemma 3. For any weight ψ_x , satisfying $\int \psi_x dm_x = 1$, the labor share where each firm is weighted by ψ_x satisfies

$$\begin{aligned}
 LS^\psi &\equiv \frac{\int \bar{w}_x \psi_x dm_x}{\int \bar{A}_x \psi_x dm_x} \\
 &= \eta + \frac{\eta(1-\eta)\kappa}{\int \bar{A}_x \psi_x dm_x} \left(\theta \int (S_x)^{\frac{1}{1-\eta}} \frac{v_x}{u} dm_x \right)^{-\eta} \left\{ \theta \int (S_x)^{\frac{1}{1-\eta}} \frac{v_x}{v} dm_x - \int (S_x)^{\frac{1}{1-\eta}} \psi_x dm_x \right\}, \quad (35)
 \end{aligned}$$

where $\theta \equiv v/u$ is the aggregate market tightness.

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 summarizes the deviation from a labor share of η . Below, we study how this term varies with the distribution of standardization in the economy. 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 aggregate market tightness, i.e., the ratio of vacancies to unemployed workers, is one in the steady state, $\theta = 1$.

The analysis in the previous section demonstrates that, if a high- z firm is more standardized, this will allow that firm to become larger in size and extract more surplus from workers. But what if all firms standardize their production process? It might be tempting to conclude that this will allow all firms to start extracting more surplus from workers. The following proposition 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

$$LS^\psi \equiv \bar{w}_x / \bar{A}_x = \eta. \quad (36)$$

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 under $\theta = 1$, which is close to its value in the data during good economic times.

If $\psi_x = v_x/v$, the two integrals inside the curly bracket in equation (35) are equal and the whole second term is zero. This implies that the vacancy-weighted labor share is a useful benchmark to consider when there is firm heterogeneity.

Corollary 2. *Assume $\theta = 1$. The vacancy weighted labor share, defined as $LS^v \equiv \int \bar{w}_x \psi_x dm_x / \int \bar{A}_x \psi_x dm_x$ with $\psi_x = v_x/v$, is given by*

$$LS^v = \eta. \quad (37)$$

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. This means that if firms' employment shares were equal to their share of vacancies, the labor share would be η regardless of the distribution of standardization. With this distribution of employment across firms, the outside option of workers and firms changes symmetrically as the distribution of standardization in the economy changes. Intuitively, it is the wages offered by firms weighted by the number of vacancies they post that determines the outside option of the workers in the economy.

In equilibrium, however, the employment shares of firms will not necessarily be equal to 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 $\theta = 1$. Define the employment-weighted labor share as*

$$LS^n \equiv \frac{\int \bar{w}_x \frac{n_x}{n} dm_x}{\int \bar{A}_x \frac{n_x}{n} dm_x}$$

Then,

$$LS^n < \eta \quad \text{if and only if} \quad \text{Cov}_n \left((S_x)^{\frac{1}{1-\eta}}, 1/q_x \right) < 0, \quad (38)$$

where Cov_n is the covariance operator under the probability measure $\frac{n_x}{n} dm_x$: $\text{Cov}_n(A_x, B_x) \equiv \int A_x B_x \frac{n_x}{n} dm_x - \int A_x \frac{n_x}{n} dm_x \int B_x \frac{n_x}{n} dm_x$.

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 (the inverse of q_x covaries negatively) with expected surplus S_x . Intuitively, high-surplus firms are the ones that will tend to have a lower firm-level labor share. (For example, this will be the case if z and s are positively correlated.) If these firms are the ones filling their vacancies faster, employment is more concentrated with these firms than are vacancies. This results in a lower aggregate labor share.

Proposition 3 implies that a positive covariance between the vacancy filling rate and the expected surplus is likely to occur in equilibrium. This proposition says that among high- z firms, higher- s firms have a higher vacancy filling rate and higher surplus. Therefore, while a uniform increase in standardization does not necessarily lower the economy-wide labor share, an increase in standardization that is concentrated among high- z firms will lower the economy-wide labor share.

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:

$$V_z \equiv \max_{s \in [\underline{s}, 1]} V_x - \Phi(s). \quad (39)$$

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*

$$\frac{\partial V_x}{\partial s} > 0 \quad \text{if and only if} \quad z > \hat{z}(s). \quad (40)$$

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

$$\frac{\partial^2 V_x}{\partial s \partial z} > 0 \quad \text{for } z > \hat{z}(s). \quad (41)$$

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 the problem above 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.

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 first 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).

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 :

$$k_z = \bar{k}(z)^\iota, \quad (42)$$

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, 500–999, 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 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.

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 tail	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.

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. One way to interpret this is that prior to 1980 additional standardization was not technologically feasible, but has since become feasible subject to the following cost function:

$$\Phi(s) = \phi \left(\frac{1}{1-s} - \frac{1}{1-\underline{s}} \right) \quad (43)$$

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 (39). We calibrate the parameters ϕ to

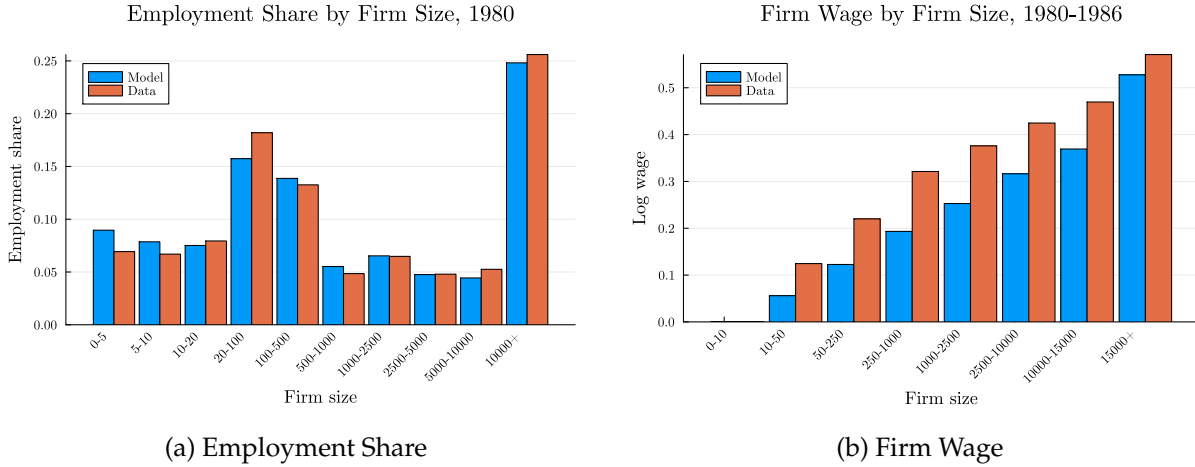


Figure 3: Model Fit

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.

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. 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 wages at megafirms by about 8%, while 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

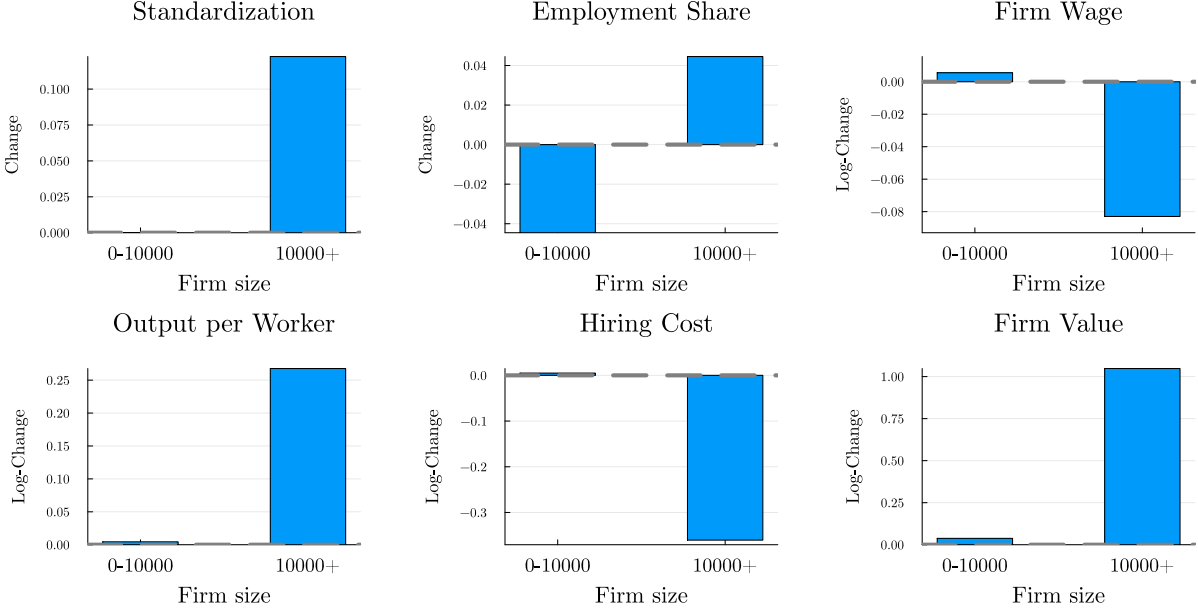


Figure 4: Changes in the Firm-Level Outcomes by Firm Size

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 (44).

hiring cost per hire is

$$\chi \frac{1}{1 - G(\omega_x^R)} = \chi (\omega_x^R / \underline{\omega})^\beta. \quad (44)$$

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

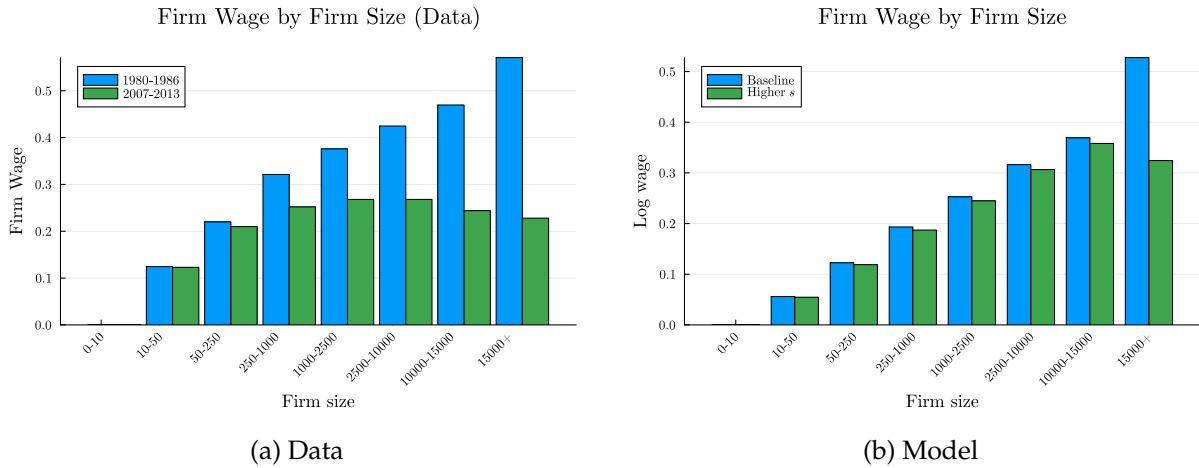


Figure 5: Firm Wage-Size Premium

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.

premium, particularly for megafirms.

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). In our model, this corresponds to increasing dispersion of z holding s fixed. A problem with this explanation is that it predicts that the large-firm wage premium should have risen, when it actually fell.

To see this, 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 dispersion. (Increasing λ is equivalent to decreasing the Pareto shape parameter α in our model.) We 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 what 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 growth without paying higher wages. This distinguishes our

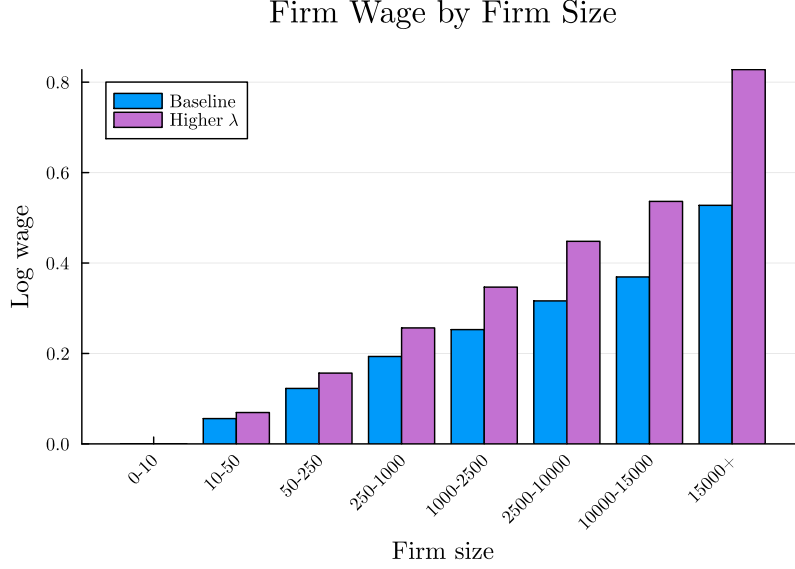


Figure 6: Firm Wage-Size Premium with Increasing Productivity of Superstar Firms

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

standardization explanation from other explanations of the rise of superstar firms.

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

$$k_z = \bar{k}(z)^t \times (V_z / \bar{V}_z)^\chi, \quad (45)$$

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.

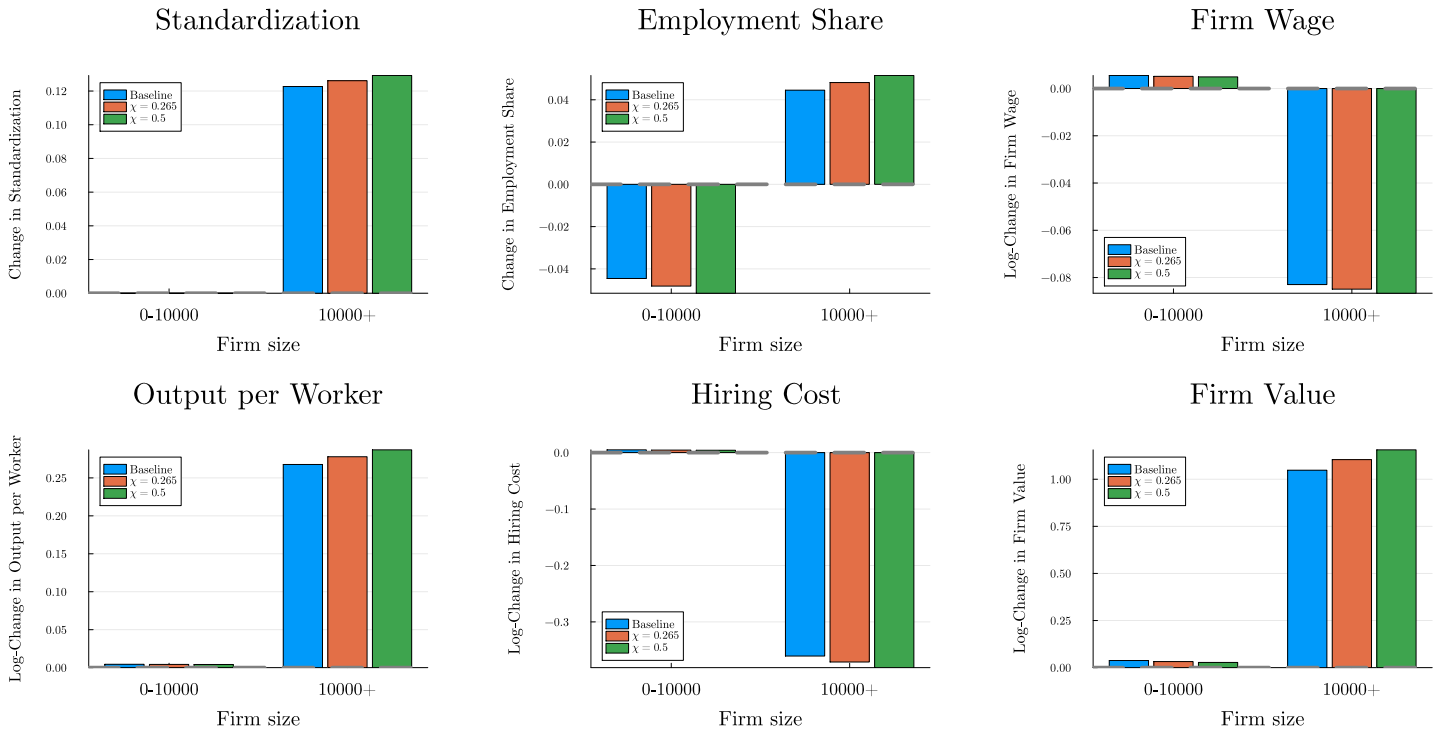


Figure 7: Endogenous Response of the Number of Positions

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 the question of what it costs to hire a 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).¹⁰ They focus on hiring costs by establishment size, as opposed to firm size, however.¹¹

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

¹⁰The 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.

¹¹This 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.

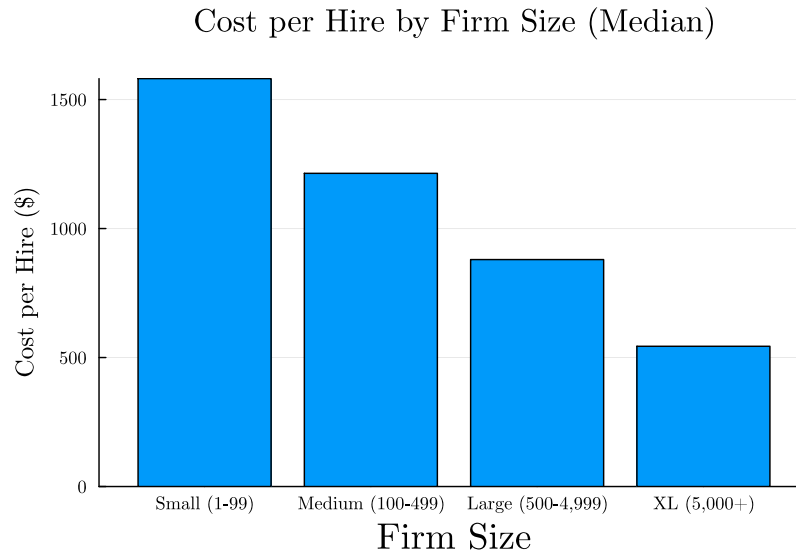


Figure 8: Cost per Hire by Firm Size

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.¹² 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 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

¹²SHRM 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	71
Leisure and hospitality	96
Retail trade	199
Construction	217
Arts, entertainment, and recreation	232
Trade, transportation, and utilities	417
Transportation, warehousing, and utilities	601
Real estate and rental and leasing	690
Health care and social assistance	732
Private education and health services	773
Mining and logging	889

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.

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, and the skyrocketing value of intangibles and low labor share of superstar firms. It can also help explain evidence on why wage markdowns are rising despite declining local labor market concentration in some sectors of the economy.

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A Derivations in Section 2

Using equations (2), (4), (15), and (17), 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

$$K = \frac{1}{u} \int (W_x)^{\frac{1}{1-\eta}} v_x dm_x. \quad (46)$$

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

$$\rho V_x = \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \int_{\omega_x^R}^{\infty} \frac{1}{\rho + \delta} [A_x(\omega) - \rho U - \rho V_x] dG(\omega) \right\}^{\frac{1}{1-\eta}}. \quad (47)$$

Note that

$$\begin{aligned} \int_{\omega_x^R}^{\infty} A_x(\omega) dG(\omega) &= \mathbb{E}[A_x(\omega) | \omega \geq \omega_x^R] (1 - G(\omega_x^R)) \\ &= \frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} (\omega_x^R / \underline{\omega})^{-\beta} \end{aligned} \quad (48)$$

Furthermore, recall that the reservation match quality satisfies

$$A_x(\omega_x^R) = z^s (\omega_x^R)^{1-s} = \rho U + \rho V_x. \quad (49)$$

Substituting (48) and (17) into (47), we have

$$z^s (\omega_x^R)^{1-s} - \rho U = \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} [(\omega_x^R)^{-\beta} \underline{\omega}^{\beta}] \right\}^{\frac{1}{1-\eta}}. \quad (50)$$

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. 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

$$(\omega_x^R)^{1-s} - \rho U / z^s = K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} (\omega_x^R)^{1-s} [(\omega_x^R)^{-\beta} \underline{\omega}^{\beta}] \right\}^{\frac{1}{1-\eta}} z^{\frac{s\eta}{1-\eta}}. \quad (51)$$

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

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

Solving for ω_x^R yields

$$\omega_x^R = \left\{ B \frac{1-s}{\beta+s-1} z^{s\eta} \right\}^{\frac{1}{\beta-(1-s)\eta}}, \quad (53)$$

where

$$B \equiv K^{-\eta(1-\eta)} \eta^\eta (1-\eta)^{1-\eta} \frac{1}{\rho+\delta} \omega^\beta > 0. \quad (54)$$

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,

$$\frac{d \ln \omega_x^R}{ds} = \frac{1}{\beta - (1-s)\eta} \times \left\{ -\frac{1}{1-s} + \frac{1}{\beta+s-1} + \eta \log z \right\} \quad (55)$$

$$+ \frac{\eta}{(\beta - (1-s)\eta)^2} \{ \log B + \log(1-s) - \log(\beta+s-1) + s\eta \log z \} \quad (56)$$

As s approaches 1, $s \uparrow 1$, the above expression grows to minus infinity (through the terms $1/(1-s)$ and $\log(1-s)$). Therefore, 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

$$\bar{A}_x = \frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s}. \quad (57)$$

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

$$\bar{A}_x = \frac{\beta}{\beta+s-1} z^s \left\{ B \frac{1-s}{\beta+s-1} z^{s\eta} \right\}^{\frac{1-s}{\beta-(1-s)\eta}}. \quad (58)$$

Log-differentiating this with respect to s , we obtain

$$\frac{d \ln \bar{A}_x}{ds} = -\frac{1}{\beta + s - 1} + s \log z + \frac{1-s}{\beta - (1-s)\eta} \left\{ -\frac{1}{1-s} + \frac{1}{\beta + s - 1} + \eta \log z \right\} \quad (59)$$

$$+ \frac{-(\beta - (1-s)\eta) + (1-s)\eta}{(\beta - (1-s)\eta)^2} \log \left\{ B \frac{1-s}{\beta + s - 1} z^{s\eta} \right\} \quad (60)$$

$$= -\frac{1}{\beta + s - 1} + s \log z + \frac{1}{\beta - (1-s)\eta} \left\{ -1 + \frac{1-s}{\beta + s - 1} + (1-s)\eta \log z \right\} \quad (61)$$

$$+ \frac{-\beta}{(\beta - (1-s)\eta)^2} \{ \log B + \log(1-s) - \log(\beta + s - 1) + s\eta \log z \}. \quad (62)$$

As s approaches 1, $s \uparrow 1$, the above expression grows to plus infinity (through term $\log(1-s)$). 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

$$\bar{w}_x = \eta \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} + \rho U. \quad (63)$$

Since ρU does not depend on s at the individual firm level, it is sufficient to show that the first term $\eta \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} = \eta(1-s)\bar{A}_x$ is decreasing in s . Taking the log derivative of the above expression,

$$\frac{d \ln \bar{w}_x}{ds} = -\frac{1}{1-s} + \frac{d \ln \bar{A}_x}{ds}. \quad (64)$$

Using (62), we have

$$\frac{d \ln \bar{w}_x}{ds} = -\frac{1}{1-s} - \frac{\beta}{(\beta - (1-s)\eta)^2} \log(1-s) \quad (65)$$

$$- \frac{1}{\beta + s - 1} + s \log z + \frac{1}{\beta - (1-s)\eta} \left\{ -1 + \frac{1-s}{\beta + s - 1} + (1-s)\eta \log z \right\} \quad (66)$$

$$+ \frac{-\beta}{(\beta - (1-s)\eta)^2} \{ \log B + \log(1-s) - \log(\beta + s - 1) + s\eta \log z \} \quad (67)$$

$$= -\frac{1}{1-s} - \frac{\beta}{(\beta - (1-s)\eta)^2} \log(1-s) \quad (68)$$

$$- \frac{1}{\beta + s - 1} + s \log z + \frac{1}{\beta - (1-s)\eta} \left\{ -1 + \frac{1-s}{\beta + s - 1} + (1-s)\eta \log z \right\} \quad (69)$$

$$+ \frac{-\beta}{(\beta - (1-s)\eta)^2} \{ \log B + \log(1-s) - \log(\beta + s - 1) + s\eta \log z \} \quad (70)$$

As s approaches 1, the only term that is unbounded is the following term:

$$\frac{1}{1-s} - \frac{\beta}{(\beta - (1-s)\eta)^2} \log(1-s). \quad (71)$$

We can use L'Hôpital' rule to evaluate the limit as $s \rightarrow 1$:

$$\lim_{s \rightarrow 1} -\frac{1}{1-s} - \frac{\beta}{(\beta - (1-s)\eta)^2} \log(1-s) = \lim_{s \rightarrow 1} -\frac{1}{1-s} \left\{ 1 + \frac{\beta}{(\beta - (1-s)\eta)^2} \log(1-s) \frac{1}{\frac{1}{1-s}} \right\} \quad (72)$$

$$= \lim_{s \rightarrow 1} -\frac{1}{1-s} \left\{ 1 - \frac{\beta}{(\beta - (1-s)\eta)^2} \frac{\frac{1}{1-s}}{\frac{1}{(1-s)^2}} \right\} \quad (73)$$

$$= \lim_{s \rightarrow 1} -\frac{1}{1-s} \left\{ 1 - \frac{\beta(1-s)}{(\beta - (1-s)\eta)^2} \right\} \quad (74)$$

$$= -\infty \quad (75)$$

Therefore sufficiently large s , we have that $\frac{d \ln \bar{w}_x}{ds} < 0$, implying that the average wage is strictly decreasing in 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

$$q_x \equiv \kappa K^{-\eta} \times (W_x)^{\frac{\eta}{1-\eta}} \times (1 - G(\omega_x^R)). \quad (76)$$

Note that

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

As we have shown in the proof of Proposition 2, $\bar{A}_x = \frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s}$ is increasing in s for sufficiently high s and z . This implies $z^s (\omega_x^R)^{1-s}$ is increasing in s . Moreover, $(1 - G(\omega_x^R))$ is decreasing in ω_x^R , and Proposition 1 shows that ω_x^R is decreasing in s . Therefore, the vacancy filling rate, q_x , is increasing in s , provided that s and z are sufficiently large.

B.6 Proof of Proposition 4

The firm wage is given by

$$\bar{w}_x = \eta \frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} + \rho U \quad (77)$$

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

$$z^s (\omega_x^R)^{1-s} - \rho U = C [z^s (\omega_x^R)^{1-s-\beta}]^{\frac{1}{1-\eta}}, \quad (78)$$

where

$$C \equiv K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left[\frac{1}{\rho+\delta} \frac{1-s}{\beta+s-1} \underline{\omega}^\beta \right]^{\frac{1}{1-\eta}} > 0. \quad (79)$$

The left-hand side is strictly increasing in ω_x^R , and the right-hand side is strictly decreasing in ω_x^R . As z increases, both the left-hand side and the right-hand side shift upwards. Consequently, it must be that $z^s (\omega_x^R)^{1-s}$ increases with z . This shows that the firm wage is strictly increasing in z .

Since the output per worker is given by

$$\bar{A}_x = \frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s}, \quad (80)$$

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

$$\frac{\bar{w}_x}{\bar{A}_x} = \frac{\eta \frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} + \rho U}{\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s}} \quad (81)$$

$$= \frac{\eta \frac{1-s}{\beta+s-1} + \rho U \frac{1}{z^s (\omega_x^R)^{1-s}}}{\frac{\beta}{\beta+s-1}}, \quad (82)$$

which decreases with z .

Now consider the vacancy filling rate, which is given by

$$q_x = \kappa K^{-\eta} (W_x)^{\frac{\eta}{1-\eta}} (1 - G(\omega_x^R)) \quad (83)$$

$$= \kappa K^{-\eta} \left(\eta \frac{1}{\rho+\delta} \frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} [(\omega_x^R)^{-\beta} \underline{\omega}^\beta] \right)^{\frac{\eta}{1-\eta}} \underline{\omega}^\beta (\omega_x^R)^{-\beta}. \quad (84)$$

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

$$1 - \rho U \frac{1}{z^s(\omega_x^R)^{1-s}} = B(z^s(\omega_x^R)^{1-s})^{\frac{\eta}{1-\eta}}(\omega_x^R)^{-\beta\frac{1}{1-\eta}}, \quad (85)$$

where

$$B \equiv K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1 - \eta) \left[\frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} \underline{\omega}^\beta \right]^{\frac{1}{1-\eta}} > 0. \quad (86)$$

The left-hand side of (85) is strictly increasing in ω_x^R , and the right-hand side is strictly decreasing in ω_x^R , which uniquely determines ω_x^R . Note that as z increases, both the left-hand side and the right-hand side of (85) increase. This implies that the right-hand side, $(z^s(\omega_x^R)^{1-s})^{\frac{\eta}{1-\eta}}(\omega_x^R)^{-\beta\frac{1}{1-\eta}}$, increases with z . In turn, this implies that the vacancy filling rate increases with z .

B.7 Proof of Lemma 3

Let u denote the steady state unemployment rate, and let v_x denote the number of vacancies for firm x . Our simplifying assumption that $\theta = 1$ at the aggregate level requires that

$$\int \frac{1}{\theta(W_x)} v_x dm_x = u. \quad (87)$$

Substituting $\theta(W) = KW^{-\frac{1}{1-\eta}}$ and solving for K , we have

$$K = \frac{1}{u} \int W_x^{\frac{1}{1-\eta}} v_x dm_x \quad (88)$$

The value of unemployment satisfies

$$\rho U = \kappa \theta(W)^{1-\eta} W \quad (89)$$

$$= \kappa \left(\frac{1}{u} \int (W_y)^{\frac{1}{1-\eta}} v_x dm_y \right)^{1-\eta} \quad (90)$$

$$= \kappa \left(\frac{1}{u} \int (\eta S_y)^{\frac{1}{1-\eta}} v_y dm_y \right)^{1-\eta} \quad (91)$$

$$= \kappa \eta \left(\frac{1}{u} \int (S_y)^{\frac{1}{1-\eta}} v_y dm_y \right)^{1-\eta}, \quad (92)$$

where

$$S_x \equiv \int_{\omega_x^R}^{\infty} S_x(\omega) dG(\omega). \quad (93)$$

The value of a vacancy is

$$\rho V_x = \kappa \theta (W_x)^{-\eta} \{S_x - W_x\} \quad (94)$$

$$= \kappa K^{-\eta} W_x^{\frac{\eta}{1-\eta}} (1-\eta) S_x \quad (95)$$

$$= \kappa \left(\frac{1}{u} \int (\eta S_y)^{\frac{1}{1-\eta}} v_y dm_y \right)^{-\eta} (\eta S_x)^{\frac{\eta}{1-\eta}} (1-\eta) S_x \quad (96)$$

$$= \kappa (1-\eta) \left(\frac{1}{u} \int (S_y)^{\frac{1}{1-\eta}} v_y dm_y \right)^{-\eta} (S_x)^{\frac{1}{1-\eta}}. \quad (97)$$

The average wage at firm x is given by

$$\bar{w}_x = \eta \bar{A}_x + (1-\eta) \rho U - \eta \rho V_x. \quad (98)$$

Let ψ_x be a weight on firm x that satisfies $\int \psi_x dm_x = 1$. For any such weight, we can compute

$$\begin{aligned} \int \bar{w}_x \psi_x dm_x &= \eta \int \bar{A}_x \psi_x dm_x + (1-\eta) \rho U - \eta \rho V_x \\ &= \eta \int \bar{A}_x \psi_x dm_x \\ &\quad + \eta (1-\eta) \kappa \left(\frac{1}{v} \int (S_x)^{\frac{1}{1-\eta}} v_x dm_x \right)^{1-\eta} \\ &\quad - \eta (1-\eta) \kappa \left(\frac{1}{v} \int (S_x)^{\frac{1}{1-\eta}} v_x dm_x \right)^{-\eta} \int (S_x)^{\frac{1}{1-\eta}} \psi_x dm_x \\ &= \eta \int \bar{A}_x \psi_x dm_x \\ &\quad + \eta (1-\eta) \kappa \left(\int (S_x)^{\frac{1}{1-\eta}} \frac{v_x}{u} dm_x \right)^{-\eta} \left\{ \int (S_x)^{\frac{1}{1-\eta}} \frac{v_x}{u} dm_y - \int (S_x)^{\frac{1}{1-\eta}} \psi_x dm_x \right\} \\ &\quad + \eta (1-\eta) \kappa \left(\frac{v}{u} \int (S_x)^{\frac{1}{1-\eta}} \frac{v_x}{v} dm_x \right)^{-\eta} \left\{ \frac{v}{u} \int (S_x)^{\frac{1}{1-\eta}} \frac{v_x}{v} dm_y - \int (S_x)^{\frac{1}{1-\eta}} \psi_x dm_x \right\}, \end{aligned}$$

where $v \equiv \int v_x dm_x$.

B.8 Proof of Proposition 5

From (31), we have

$$v_x = \frac{\delta}{q_x} n_x. \quad (99)$$

Integrating over x ,

$$v = \int v_x dm_x \quad (100)$$

$$= \int \frac{\delta}{q_x} n_x dm_x \quad (101)$$

$$(102)$$

Hence

$$\frac{v_x}{v} = \frac{\frac{1}{q_x} \frac{n_x}{n}}{\int \frac{1}{q_x} \frac{n_x}{n} dm_x} \quad (103)$$

Therefore,

$$\int (S_x)^{\frac{1}{1-\eta}} \left(\frac{v_x}{v} - \frac{n_x}{n} \right) dm_x = \int (S_x)^{\frac{1}{1-\eta}} \frac{n_x}{n} \left(\frac{(1/q_x)}{\int (1/q_x) \frac{n_x}{n} dm_x} - 1 \right) dm_x \quad (104)$$

$$= \frac{1}{\int (1/q_x) \frac{n_x}{n} dm_x} \left[\int (S_x)^{\frac{1}{1-\eta}} (1/q_x) \frac{n_x}{n} dm_x \right. \quad (105)$$

$$\left. - \int (S_x)^{\frac{1}{1-\eta}} \frac{n_x}{n} dm_x \int (1/q_x) \frac{n_x}{n} dm_x \right] \quad (106)$$

$$= \frac{1}{\int (1/q_x) \frac{n_x}{n} dm_x} \text{Cov}_n \left((S_x)^{\frac{1}{1-\eta}}, 1/q_x \right). \quad (107)$$

Evaluating the expression in Lemma 3 with $\psi_x = \frac{n_x}{n}$, we have

$$LS \equiv = \frac{\int \bar{w}_x \frac{n_x}{n} dm_x}{\int \bar{A}_x \frac{n_x}{n} dm_x} \quad (108)$$

$$= \eta + \frac{1}{\int \bar{A}_x \frac{n_x}{n} dm_x} \eta(1-\eta) \kappa \left(\int (S_x)^{\frac{1}{1-\eta}} \frac{v_x}{v} dm_x \right)^{-\eta} \int (S_x)^{\frac{1}{1-\eta}} \left(\frac{v_x}{v} - \frac{n_x}{n} \right) dm_x \quad (109)$$

$$= \eta + \frac{1}{\int \bar{A}_x \frac{n_x}{n} dm_x} \eta(1-\eta) \kappa \left(\int (S_x)^{\frac{1}{1-\eta}} \frac{v_x}{v} dm_x \right)^{-\eta} \frac{1}{\int q_x \frac{n_x}{n} dm_x} \text{Cov}_n \left((S_x)^{\frac{1}{1-\eta}}, 1/q_x \right). \quad (110)$$

The above expression shows that

$$LS < \eta \iff \text{Cov}_n \left((S_x)^{\frac{1}{1-\eta}}, 1/q_x \right) < 0. \quad (111)$$

B.9 Proof of Lemma 4

Under the assumption that the problem (39) is concave in s , it suffices to show that the marginal benefit of standardization is positive for productive firms and negative for unproductive firms:

$$\frac{d}{ds} V_{zs} > 0 \quad \text{if and only if} \quad z > \hat{z}, \quad (112)$$

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

$$\rho V_x = \max_{\omega_x^R} \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \int_{\omega_x^R}^{\infty} \frac{1}{\rho + \delta} [A_x(\omega) - \rho U - \rho V_x] dG(\omega) \right\}^{\frac{1}{1-\eta}}. \quad (113)$$

Since G is Pareto, we have

$$\rho V_x = \max_{\omega_x^R} \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left\{ \frac{1}{\rho + \delta} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} - \rho U - \rho V_x \right] (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}}. \quad (114)$$

Totally differentiating both sides with respect to s , and evaluating it at the optimal value of ω_x^R , we have

$$\begin{aligned} \rho \frac{dV_x}{ds} &= \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho + \delta} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} - \rho U - \rho V_x \right] (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta} - 1} \\ &\quad \times \frac{1}{\rho + \delta} (\omega_x^R / \underline{\omega})^{-\beta} \left\{ \frac{d}{ds} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right] - \rho \frac{dV_x}{ds} \right\} \\ &= \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho + \delta} \left[\frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right] (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta} - 1} \\ &\quad \times \frac{1}{\rho + \delta} (\omega_x^R / \underline{\omega})^{-\beta} \left\{ \frac{d}{ds} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right] - \rho \frac{dV_x}{ds} \right\}. \end{aligned} \quad (115)$$

By the envelope theorem, the terms associated with $\frac{d\omega_x^R}{ds}$ are collectively zero. We can solve for $\frac{dV_x}{ds}$

as

$$\rho \frac{dV_x}{ds} = \frac{\kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho+\delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta}-1}}{1 + \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho+\delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta}-1}} \frac{\partial}{\partial s} \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]. \quad (116)$$

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:

$$z^s (\omega_x^R)^{1-s} - \rho U = B [z^s (\omega_x^R)^{1-s-\beta}]^{\frac{1}{1-\eta}}, \quad (117)$$

where

$$B \equiv K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1-\eta) \left[\frac{1}{\rho+\delta} \frac{1-s}{\beta+s-1} \omega^\beta \right]^{\frac{1}{1-\eta}} > 0. \quad (118)$$

Let

$$y \equiv \frac{z}{\omega_x^R}. \quad (119)$$

Then we can rewrite (25) as

$$zy^{s-1} - \rho U = Bz^{\frac{1-\beta}{1-\eta}} y^{\frac{\beta+s-1}{1-\eta}}, \quad (120)$$

or

$$F(z, y) \equiv zy^{s-1} - \rho U - Bz^{\frac{1-\beta}{1-\eta}} y^{\frac{\beta+s-1}{1-\eta}} = 0. \quad (121)$$

Observe that

$$\partial_y F(z, y) = z(s-1)y^{s-2} - B \frac{\beta + s - 1}{1 - \eta} z^{\frac{1-\beta}{1-\eta}} y^{\frac{\beta+s-1}{1-\eta}-1} \quad (122)$$

$$< 0, \quad (123)$$

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

$$\partial_z F(z, y) = y^{s-1} - B \frac{1 - \beta}{1 - \eta} z^{\frac{1-\beta}{1-\eta}-1} y^{\frac{\beta+s-1}{1-\eta}}. \quad (124)$$

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 (124) as

$$\partial_z F(z, y) = y^{s-1} - B \frac{1 - \beta}{1 - \eta} z^{\frac{1-\beta}{1-\eta}-1} y^{\frac{\beta+s-1}{1-\eta}} \quad (125)$$

$$= y^{s-1} - \frac{1 - \beta}{1 - \eta} \frac{1}{z} (zy^{s-1} - \rho U) \quad (126)$$

$$= y^{s-1} \frac{\beta - \eta}{1 - \eta} + \frac{1 - \beta}{1 - \eta} \frac{\rho U}{z}, \quad (127)$$

where the second line uses (120). 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

$$\frac{dy}{dz} = -\frac{F_z}{F_y} > 0 \quad (128)$$

under the condition that $\beta > \eta$. This shows $y \equiv z/\omega_x^R$ is strictly increasing in z . Moreover, from (120),

$$\lim_{z \rightarrow \infty} y = \lim_{z \rightarrow \infty} B^{-\frac{1-\eta}{\beta-\eta(1-s)}} z^{\frac{\beta-\eta}{\beta-\eta(1-s)}} = \infty. \quad (129)$$

□

Equation (116) implies that

$$\text{sign}\left(\frac{dV_x}{ds}\right) = \text{sign}\left(\frac{\partial}{\partial s} \left[\frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right]\right) \quad (130)$$

We unpack $\frac{d}{ds} \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]$ as follows:

$$\frac{d}{ds} \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right] = \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right] \left(-\frac{1}{\beta+s-1} + \ln z - \ln \omega_x^R \right) \quad (131)$$

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

$$\frac{dV_x}{ds} > 0 \quad \text{if and only if} \quad z > \hat{z}(s). \quad (132)$$

B.9.2 Proof of the second part of Lemma 4

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

$$\rho \frac{dV_x}{ds} = \frac{\kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho+\delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta}-1}}{1 + \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho+\delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta}-1}} \quad (133)$$

$$\times \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right] \left(-\frac{1}{\beta+s-1} + \ln z - \ln \omega_x^R \right). \quad (134)$$

We rewrite this expression as

$$\rho \frac{dV_x}{ds} = \frac{\mathcal{C}_{z,s}}{1 + \mathcal{C}_{z,s}} \mathcal{D}_{z,s} \mathcal{E}_{z,s}, \quad (135)$$

where

$$\mathcal{C}_{z,s} \equiv \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho+\delta} (\omega_x^R / \underline{\omega})^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta}-1} \quad (136)$$

$$\mathcal{D}_{z,s} \equiv \left[\frac{\beta}{\beta+s-1} z^s (\omega_x^R)^{1-s} \right] \quad (137)$$

$$\mathcal{E}_{z,s} \equiv -\frac{1}{\beta+s-1} + \ln z - \ln \omega_x^R. \quad (138)$$

First, we show that $\mathcal{C}_{z,s}$ is strictly increasing in z . To see this, (25) can be equivalently written as

$$1 - \frac{\rho U}{z^s (\omega_x^R)^{1-s}} = \underbrace{\kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} \left\{ \frac{1}{\rho + \delta} (\omega_x^R / \omega)^{-\beta} \right\}^{\frac{1}{1-\eta}} \left[\frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} \right]^{\frac{1}{1-\eta} - 1}}_{=\mathcal{C}_{z,s}}, \quad (139)$$

which determines ω_x^R as a unique solution, since the left-hand side is strictly increasing in ω_x^R and the right-hand side is strictly decreasing in ω_x^R . As z increases, since both the left-hand side and the right-hand side are increasing in z , it must be that $\mathcal{C}_{z,s}$ is strictly increasing in z . For the similar reason, $\mathcal{D}_{z,s}$ is strictly increasing in z . To see this, recall (25):

$$\underbrace{z^s (\omega_x^R)^{1-s}}_{=\mathcal{D}_{z,s}} - \rho U = B [z^s (\omega_x^R)^{1-s-\beta}]^{\frac{1}{1-\eta}}, \quad (140)$$

which determines ω_x^R as a unique solution, since the left-hand side is strictly increasing in ω_x^R and the right-hand side is strictly decreasing in ω_x^R . As z increases, since both the left-hand side and the right-hand side are increasing in z , it must be that $\mathcal{D}_{z,s}$ is 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 as long as $\mathcal{E}_{z,s} > 0$ which is the case when $z > \hat{z}(s)$.

B.10 Proof of Proposition 6

Given the concavity of the problem (39), the following first order condition is necessary and sufficient for the optimal standardization level:

$$\frac{\partial V_{z,s}}{\partial s} \leq \Phi'(s), \quad (141)$$

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:

$$\frac{ds}{dz} = - \frac{\frac{\partial^2 V_{z,s}}{\partial s \partial z}}{\frac{\partial^2 V_{z,s}}{\partial s^2} - \Phi''(s)} > 0. \quad (142)$$

C Details on Quantitative Model

C.1 Computational Algorithms

Algorithm 1 The Baseline Equilibrium with Exogenous Standardization

```
Guess  $U^{(0)}$ 
Fix tolerances  $\varepsilon_U > 0$ 
Set iteration counter  $k \leftarrow 0$ 
while  $\|U^{(k+1)} - U^{(k)}\| > \varepsilon_U$  do
  for each  $x \equiv (z, s)$  do
    Solve for  $\omega_x^R$  using Lemma 1
    Recover  $S_x$  and  $W_x$  as well as  $v_x, n_x$ , and  $u$  using (31) and (32).
    Update  $U$  using (29) and set  $U^{(k+1)} := U$ .
  end for
end while
```

Algorithm 2 The Counterfactual Equilibrium with Endogenous Standardization

```
Guess  $U^{(0)}$ 
Fix tolerances  $\varepsilon_U > 0$ 
Set iteration counter  $k \leftarrow 0$ 
while  $\|U^{(k+1)} - U^{(k)}\| > \varepsilon_U$  do
  for each  $z$  do
    for each  $s$  do
      Solve for  $\omega_x^R$  using Lemma 1
      Recover  $V_x$  using (17)
    end for
    Choose  $s^*(z)$  at  $\arg \max_s V_x - \Phi(s)$ , and set  $x := (z, s^*(z))$ .
    Recover  $S_x$  and  $W_x$  as well as  $v_x, n_x$ , and  $u$  using (31) and (32).
    Update  $U$  using (29) and set  $U^{(k+1)} := U$ .
  end for
end while
```

Algorithm 1 describes the algorithm for computing the baseline equilibrium with exogenous standardization. We start from guessing the value of unemployment U . We then solve for the reservation match quality ω_x^R for each firm x using Lemma 1. We then recover the rest of equilibrium objects such as the surplus S_x , the promised value W_x , the number of vacancies v_x , the number of unemployed workers n_x , and the unemployment rate u using (31) and (32). We then update U using (29) and repeat the process until we find a fixed point in U .

Algorithm 2 describes the algorithm for computing the counterfactual equilibrium with endogenous standardization. The only difference from the baseline equilibrium is that now we solve the optimal standardization level $s^*(z)$ for each firm z .

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:

$$\min_{\Theta} \left\{ \sum_{i=1}^{N_s} weight_i \times (emp_i(\Theta) - emp_i^{data})^2 + \sum_{i=1}^{N_w} weight_i \times (wage_i(\Theta) - wage_i^{data})^2 \right\}, \quad (143)$$

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 $weight_i$ 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 $weight_i$ 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 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 number of jobs firm x creates and let $c_x^k(k_x^n)$ be

an increasing and convex cost of creating jobs. The firm's job creation problem is then

$$\max_{k_x^n} V_x k_x^n - c_x^k(k_x^n). \quad (144)$$

Suppose that each job within a firm is destroyed at a rate φ . The stock-flow equation for the mass of jobs at firm x is the given by

$$\partial_t k_x = k_x^n - \varphi k_x. \quad (145)$$

This implies that the steady state number of positions at firm x is

$$k_x = \frac{k_x^n}{\varphi}. \quad (146)$$

In the baseline model, k_x is allowed to vary arbitrarily with x . This implies that all the theoretical results in Section 3 continue to hold, without further qualification.

If we assume

$$c_x^k(k_x^n) = \bar{c}_x^k \frac{(k_x^n)^{1+1/\chi}}{1+1/\chi}, \quad (147)$$

we have

$$k_x = \frac{1}{\varphi(\bar{c}_x^k)^\chi} (V_x)^\chi, \quad (148)$$

which gives equation (45) by letting $\frac{1}{\varphi(\bar{c}_x^k)^\chi} = \bar{k}z' / (\bar{V}_z)^\chi$.

D.2 Endogenous Entry of Firms

It is straightforward to endogenize firm entry. Suppose new firms are free to enter subject to a fixed cost c^e . After paying the fixed cost, they draw x from a density function dH_x and are endowed with k_x vacant positions. Finally, suppose firms exit exogenously at rate \varkappa .

In this case, firms will enter until

$$\int V_x k_x dH_x = c^e. \quad (149)$$

This equation pins down the mass of entrants m_0 as well as the total mass of firms $m = \frac{m_0}{\varkappa}$. The

measure of each firm x is simply $m_x \equiv mdH_x$.

Since the baseline model abstracts from firm dynamics, it corresponds to the case where $\varkappa \rightarrow 0$. In this case, all firms have their steady state size. Since the baseline model allows m_x to vary arbitrarily with x , all the theoretical results in Section 3 continue to hold, without further qualification.

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

$$\lambda^F \equiv \frac{\mathcal{M}(u, v)}{v}, \quad \lambda^U \equiv \frac{\mathcal{M}(u, v)}{u}, \quad (150)$$

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

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

$$\rho V_x = \lambda^F \int \max \{0, J_x(\omega) - V_x\} dG(\omega). \quad (151)$$

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

$$\rho U = \lambda^U \int \frac{v_x}{v} \int \max \{0, W_x(\omega) - U\} dG(\omega) dm_x. \quad (152)$$

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

$$(\rho + \delta)S_x(\omega) = A_x(\omega) - \rho U - \rho V_x. \quad (153)$$

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

$$W_x(\omega) = U + \gamma S_x(\omega), \quad J_x(\omega) = V_x + (1 - \gamma)S_x(\omega). \quad (154)$$

The wage is then given by

$$w_x(\omega) = \gamma(\rho + \delta)S_x(\omega) + \rho U. \quad (155)$$

The reservation match quality ω_x^R solves

$$S_{zs}(\omega_{zs}^R) = 0, \quad (156)$$

or equivalently

$$A_x(\omega_x^R) = \rho U + \rho V_x. \quad (157)$$

The steady state unemployment rate and distribution of vacancies are given by

$$u = \frac{\delta}{\delta + \lambda^U \int \frac{v_x}{v} (1 - G(\omega_x^R)) dm_x'}, \quad (158)$$

and

$$v_x = k_x \frac{\delta}{\delta + \lambda^F q_x}, \quad (159)$$

where

$$q_x \equiv \lambda^F (1 - G(\omega_x^R)) \quad (160)$$

is the vacancy-filling rate. The steady state size of firm x is

$$n_x = k_x \frac{q_x}{\delta + \lambda^F q_x}. \quad (161)$$

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*

$$z^s (\omega_x^R)^{1-s} - \rho U = \lambda^F (1 - \gamma) \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} (\omega_x^R / \underline{\omega})^{-\beta}. \quad (162)$$

Proof. Recall the reservation match quality satisfies

$$z^s (\omega_x^R)^{1-s} - \rho U = \rho V_x. \quad (163)$$

Substituting (154) into (151), we obtain

$$\rho V_x = \lambda^F (1 - \gamma) \int_{\omega_x^R} S_x(\omega) dG(\omega) \quad (164)$$

$$= \lambda^F (1 - \gamma) \frac{1}{\rho + \delta} \int_{\omega_x^R} [A_x(\omega) - \rho U - \rho V_x] dG(\omega) \quad (165)$$

$$= \lambda^F (1 - \gamma) \frac{1}{\rho + \delta} \int_{\omega_x^R} [A_x(\omega) - A_x(\omega_x^R)] dG(\omega) \quad (166)$$

$$= \lambda^F (1 - \gamma) \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} (\omega_x^R / \underline{\omega})^{-\beta}. \quad (167)$$

Substituting (167) into (163), 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,

$$\omega_x^R \rightarrow \underline{\omega} \left(\lambda^F (1 - \gamma) \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} \right)^{1/\beta}. \quad (168)$$

Proof. Under the limit, Lemma 6 boils down to

$$1 = \lambda^F (1 - \gamma) \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} (\omega_x^R / \underline{\omega})^{-\beta}. \quad (169)$$

Solving for ω_x^R gives

$$\omega_x^R = \underline{\omega} \left(\lambda^F (1 - \gamma) \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} \right)^{1/\beta}. \quad (170)$$

□

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 7. 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. From (170), it is immediate to see ω_x^R is decreasing in s . The vacancy filling rate is

$$q_x = \lambda_F (1 - G(\omega_x^R)) \quad (171)$$

$$= \left((1 - \gamma) \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} \right)^{-1}, \quad (172)$$

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

$$\bar{A}_x \equiv \frac{\beta}{\beta + s - 1} z^s (\omega_x^R)^{1-s}. \quad (173)$$

Imposing the limit of (170), we have

$$\bar{A}_x \equiv \frac{\beta}{\beta + s - 1} z^s \left(\underline{\omega} \left(\lambda^F (1 - \gamma) \frac{1}{\rho + \delta} \frac{1 - s}{\beta + s - 1} \right)^{1/\beta} \right)^{1-s}. \quad (174)$$

The log derivative is

$$\frac{d \ln \bar{A}_x}{ds} = -\frac{1}{\beta + s - 1} + (\ln z - \ln \omega_x^R) + (1 - s) \frac{d \ln \omega_x^R}{ds} \quad (175)$$

$$= -\frac{1}{\beta + s - 1} + \ln z - \ln \underline{\omega} - \frac{1}{\beta} \left(\ln \frac{\lambda^F (1 - \gamma)}{\rho + \delta} + \ln(1 - s) - \ln(\beta + s - 1) \right) \quad (176)$$

$$+ (1 - s) \frac{1}{\beta} \left[\frac{1}{1 - s} - \frac{1}{\beta + s - 1} \right] \quad (177)$$

$$= -\frac{1}{\beta + s - 1} + \ln z - \ln \underline{\omega} - \frac{1}{\beta} \left(\ln \frac{\lambda^F (1 - \gamma)}{\rho + \delta} + \ln(1 - s) - \ln(\beta + s - 1) \right) \quad (178)$$

$$+ \frac{1}{\beta} \left(1 - \frac{1 - s}{\beta + s - 1} \right). \quad (179)$$

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

$$\bar{w}_x = \rho U + \gamma \frac{1 - s}{\beta + s - 1} z^s (\omega_x^R)^{1-s}. \quad (180)$$

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

$$\frac{d \ln(\bar{w}_x - \rho U)}{ds} = -\frac{1}{1 - s} - \frac{1}{\beta + s - 1} + (\ln z - \ln \omega_x^R) + (1 - s) \frac{d \ln \omega_x^R}{ds} \quad (181)$$

$$= -\frac{1}{1 - s} - \frac{1}{\beta + s - 1} + \ln z - \ln \underline{\omega} \quad (182)$$

$$- \frac{1}{\beta} \left(\ln \frac{\lambda^F (1 - \gamma)}{\rho + \delta} + \ln(1 - s) - \ln(\beta + s - 1) \right) + \frac{1}{\beta} \left(1 - \frac{1 - s}{\beta + s - 1} \right). \quad (183)$$

As in (75), we can show

$$\lim_{s \rightarrow 1} -\frac{1}{1 - s} - \frac{1}{\beta} \ln(1 - s) = -\infty. \quad (184)$$

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. □

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 v_x^n new positions every period. The stock-flow equations of the number of positions at firm x is then

$$\partial_t v_x = -\varkappa v_x + v_x^n, \tag{185}$$

which results in the steady state number of vacancies

$$v_x = \frac{v_x^n}{\varkappa}. \tag{186}$$

The stock-flow equation of firm size is

$$\partial_t n_x = -\delta n_x + q_x v_x, \tag{187}$$

where q_x is the vacancy-filling rate. The steady-state firm size is, therefore,

$$n_x = \frac{q_x v_x}{\delta}. \quad (188)$$

The HJB equation for vacancy (11) is modified as

$$(\rho + \varkappa)V_x = \max_W \lambda^F(\theta(W))\Pi_x(W). \quad (189)$$

Since (8), (15), and (18) remain the same, we can substitute them into (189) to obtain

$$(\rho + \varkappa)V_x = \max_{W_x} \kappa K^{-\eta} W_x^{\frac{\eta}{1-\eta}} \left\{ \int_{\omega_x^R}^{\infty} \frac{1}{\rho + \delta} [A_x(\omega) - \rho U - \rho V_x] dG(\omega) - W_x \right\} \quad (190)$$

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

$$(\rho + \varkappa)V_x = \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1 - \eta) \left\{ \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} [(\omega_x^R)^{-\beta} \underline{\omega}^\beta] \right\}^{\frac{1}{1-\eta}}. \quad (191)$$

Recall that the reservation match quality satisfies

$$A_x(\omega^R) = \rho U + \rho V_x. \quad (192)$$

Solving for V_x in (191) and substituting into (192), we have

$$z^s (\omega_x^R)^{1-s} - \rho U = \frac{\rho}{\rho + \varkappa} \kappa K^{-\eta} \eta^{\frac{\eta}{1-\eta}} (1 - \eta) \left\{ \frac{1}{\rho + \delta} \frac{1-s}{\beta + s - 1} z^s (\omega_x^R)^{1-s} [(\omega_x^R)^{-\beta} \underline{\omega}^\beta] \right\}^{\frac{1}{1-\eta}}. \quad (193)$$

This offers a strict generalization of Lemma 1, which can be obtained by setting $\varkappa = 0$. The rest of the equilibrium conditions remain unchanged.

Recall that the left-hand side of equation (193) 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 (193) 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 8. *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*

$$\frac{\bar{w}_x}{\bar{A}_x} = \frac{\beta - (1 - \eta)(1 - s)}{\beta}, \quad (194)$$

which is strictly increasing in s .

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

$$\bar{A}_x = \frac{\beta}{\beta - (1 - s)} \rho U, \quad (195)$$

which is strictly decreasing in s .

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

$$\bar{w}_x = \frac{\beta - (1 - \eta)(1 - s)}{\beta - (1 - s)} \rho U, \quad (196)$$

which is strictly decreasing in s .

Proof. Under the limit of $\varkappa \rightarrow \infty$, equation (193) collapses to

$$z^s (\omega_x^R)^{1-s} = \rho U. \quad (197)$$

Substituting (197) into (28), the average output per worker at firm x is

$$\bar{A}_x = \frac{\beta}{\beta - (1 - s)} \rho U. \quad (198)$$

Substituting (197) into (33), the average wage at firm x is

$$\bar{w}_x = \frac{\beta - (1 - \eta)(1 - s)}{\beta - (1 - s)} \rho U. \quad (199)$$

Dividing (199) by (198), we obtain

$$\frac{\bar{w}_x}{\bar{A}_x} = \frac{\beta - (1 - \eta)(1 - s)}{\beta}. \quad (200)$$

□

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 (198) and (199). 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.

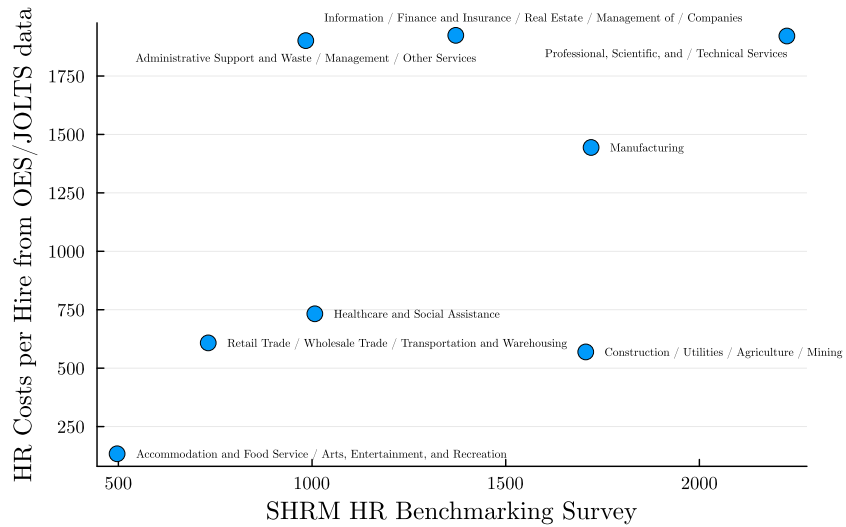


Figure G.1: Comparing Two Measures of Cost per Hire by Industry

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.

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, in Appendix G we show that this alternative measure provides broadly congruent results on the extent of “labor commoditization” by industry.