American Economic Review 2022, 112(1): 169–212
https://doi.org/10.1257/aer.20190790

Imperfect Competition, Compensating Differentials, and Rent Sharing in the US Labor Market†

By Thibaut Lamadon, Magne Mogstad, and Bradley Setzler*

We quantify the importance of imperfect competition in the US labor market by estimating the size of labor market rents earned by American firms and workers. We construct a matched employer-employee panel dataset by combining the universe of US business and worker tax records for the period 2001–2015. Using this panel data, we identify and estimate an equilibrium model of the labor market with two-sided heterogeneity where workers view firms as imperfect substitutes because of heterogeneous preferences over nonwage job characteristics. The model allows us to draw inference about imperfect competition, worker sorting, compensating differentials, and rent sharing. (*JEL* D24, H24, H25, J22, J24, J31, J42)

How pervasive is imperfect competition in the labor market? Arguably, this question is really about the size of rents earned by employers and workers from ongoing employment relationships (Manning 2011). In the textbook model of a competitive labor market, the law of one price holds and there should exist a single market compensation for a given quality of a worker, no matter which employer she works for. If labor markets are imperfectly competitive, however, the employer or worker or both may also earn rents from an employment relationship. If a worker gets rents, the loss of the current job makes the worker worse off—an identical job cannot be found at zero cost. If an employer gets rents, the employer will be worse off if a worker leaves—the marginal product is above the wage and worker replacement is costly.

To draw inference about imperfect competition in the labor market, it therefore seems natural to measure the size of rents earned by employers and workers. However, these rents are not directly observed, and recovering them from data has proven difficult for several reasons. One challenge is that observationally equivalent workers could be paid differentially because of unobserved skill differences, not

*Lamadon: Department of Economics, University of Chicago (email: lamadon@uchicago.edu); Mogstad: Department of Economics, University of Chicago, Statistics Norway, NBER, IFS (email: magne.mogstad@gmail.com); Setzler: Department of Economics, Pennsylvania State University (email: bradley.setzler@gmail.com). Thomas Lemieux was the coeditor for this article. Mogstad and Setzler acknowledge financial support from NSF Grant SES-1851808, the Washington Center for Equitable Growth, and the Norwegian Research Council. The findings and conclusions expressed are solely those of the authors and do not represent the views of the US Treasury, IRS, any agency of the Federal Government, or the NBER. The authors declare that they have no relevant or material financial interests that relate to the research described in this paper. We are grateful to Raj Chetty, Nathan Hendren, Danny Yagan, and Owen Zidar for help and guidance in using the IRS data. We are particularly thankful to Neele Balke for her extensive feedback. We also appreciate the constructive comments and suggestions from three anonymous referees, Stephane Bonhomme, Derek Neal, and discussants and participants at various conferences and seminars.

† Go to https://doi.org/10.1257/aer.20190790 to visit the article page for additional materials and author disclosure statements.

imperfect competition (see, e.g., Abowd, Kramarz, and Margolis 1999; Gibbons et al. 2005). Another challenge is that observed wages may not necessarily reflect the full compensation that individuals receive from working in a given firm. Indeed, both survey data (e.g., Hamermesh 1999, Pierce 2001, Maestas et al. 2018) and experimental studies (e.g., Mas and Pallais 2017, Wiswall and Zafar 2018, Chen et al. 2020) suggest that workers may be willing to sacrifice higher wages for better nonwage job characteristics or amenities when choosing an employer. Thus, firm-specific wage premiums could reflect unfavorable amenities, not imperfect competition.

The primary goal of our paper is to address these challenges and quantify the importance of imperfect competition in the US labor market by estimating the size of rents earned by American firms and workers from ongoing employment relationships. To this end, we construct a matched employer-employee panel dataset by combining the universe of US business and worker tax records for the period 2001–2015. Using this panel data, we identify and estimate a model of the labor market that allows us to draw inference about imperfect competition, compensating differentials, and rent sharing. We also use the model to quantify the relevance of nonwage job characteristics and imperfect competition for inequality and tax policy, to assess the economic determinants of worker sorting, and to offer a unifying explanation of key empirical features of the US labor market.

In Section I, we develop the equilibrium model of the labor market. This model builds on work by Rosen (1986); Boal and Ransom (1997); Bhaskar, Manning, and To (2002); Manning (2005); and Card et al. (2018). Competitive labor market theory requires firms to be wage takers so that labor supply to the individual firm is perfectly elastic. The evidence that idiosyncratic productivity shocks to a firm transmit to the earnings of its workers is at odds with this theory (see, e.g., Guiso, Pistaferri, and Schivardi 2005). To allow labor supply to be imperfectly elastic, we let employers compete with one another for workers who have heterogeneous preferences over amenities. Since we allow these amenities to be unobserved to the analyst, they can include a wide range of characteristics, such as distance of the firm from the worker's home, flexibility in the work schedules, the type of tasks performed, the effort required to perform these tasks, the social environment in the workplace, and so on.[1]

The importance of workplace amenities has long been recognized in the theory of compensating differentials (Rosen 1986). This is a theory of vertical differentiation: some employers offer better amenities than others. Employers that offer favorable amenities can attract labor at lower than average wages, whereas employers offering unfavorable amenities need to pay premiums as offsetting compensation in order to attract labor. Our model combines this vertical differentiation with horizontal employer differentiation: workers have different preferences over the same workplace amenities. As a result of this preference heterogeneity, the employer faces an upward sloping supply curve for labor, implying wages are an increasing function of firm size. We assume employers do not observe the idiosyncratic taste for amenities

[1] There is limited empirical evidence on which nonwage characteristics matter the most. However, survey data from Maestas et al. (2018) point to the importance of flexibility in work schedules, the type of tasks performed, and the amount of effort required. The analysis of Marinescu and Rathelot (2018) suggests distance of the firm from the workers' home may be important. Chen et al. (2020) use field experiments to estimate high willingness to pay for flexibility in work schedules.

of any given worker. This information asymmetry implies employers cannot price discriminate with respect to workers' reservation values. Instead, if a firm becomes more productive and thus wants to increase its size, the employer needs to offer higher wages to all workers of a given type. As a result, the equilibrium allocation of workers to firms creates surplus or rents to inframarginal workers.

The size of rents depends on the slope of the labor supply curve facing the firm. The steeper the labor supply curve, the more important amenities are for workers' choices of firms as compared to wages. Therefore, imperfect competition as measured by rents increases in the progressivity of labor income taxes and in the variability of the idiosyncratic taste for amenities. However, the existence of rents does not imply the equilibrium allocation of workers to firms is inefficient. In our model, the market allocation will be inefficient if the firms differ in wage-setting power, and, as a result, differ in the extent to which they mark down wages relative to the marginal product. To allow for such differences, we let workers view firms as closer substitutes in some markets than others. This structure on the workers' preferences captures that workplace characteristics are likely to vary systematically across firms depending on location and industry.

In Section II, we describe the business and worker tax records, which provide us with panel data on the outcomes and characteristics of US firms and workers. The firm data contain information on revenues and expenditures on intermediate inputs as well as industry codes and geographical identifiers. We merge the firm dataset with worker tax records, creating the matched employer-employee panel data. The key variables we draw from worker tax returns are the number of employees and their annual earnings at each employer.

In Section III, we demonstrate how the model is identified from the data. To increase our confidence in the empirical findings from the model, we allow for rich unobserved heterogeneity across workers with respect to preferences and productivity and between firms in terms of technology and amenities. Even so, it is possible to prove identification of the parameters of interest given the panel data of workers and firms. For example, the rents earned by workers can be measured given data on earnings and the elasticity of the labor supply curve specific to the firm. These elasticities can be recovered from estimates of the pass-through of firm shocks to incumbent workers' earnings. As another example, the correlation structure in a worker's tastes for the amenities of firms in the same market can be identified by comparing estimates of the pass-through rates of shocks specific to the firm versus common to the market. Estimates of worker effects, firm effects, and worker sorting allow us to recover the productivity of workers, the compensating differentials due to the vertical differentiation of firms, and the extent to which preferences for amenities vary by worker productivity. To determine whether productive workers and firms are complements in production, we take advantage of the estimated interaction coefficients between worker and firm effects recovered from changes in earnings when workers move between employers.

Section IV discusses the estimation procedure, parameter estimates, and fit. The model yields four key findings that we discuss in Section V. First, there is a significant amount of rents and imperfect competition in the US labor market due to horizontal employer differentiation. Workers are, on average, willing to pay 13 percent of their wages to stay in the current jobs. Comparing these worker rents to those earned by employers suggests that total rents are divided relatively equally between firms and workers. Second, the evidence of small firm effects does not imply that labor markets are competitive or that rents are negligible. Instead, firm effects are small because productive firms tend to have good amenities, which pushes down the wages that these firms have to pay. As a result of these compensating differentials, firms contribute much less to earnings inequality than what is predicted by the variance of firm productivity only. Third, a key reason why better workers are sorting into better firms is production complementarities, not heterogeneous tastes for workplace amenities. These complementarities are important to explain the significant inequality contribution from worker sorting. Fourth, the monopsonistic labor market creates significant misallocation of workers to firms. We estimate that a tax reform that would eliminate labor and tax wedges would increase total welfare by 5 percent and total output by 3 percent.

The insights from our paper contribute to a large and growing literature on firms and labor market inequality, reviewed by Card et al. (2018). A number of studies show that trends in wage dispersion closely track trends in productivity dispersion across industries and workplaces (Faggio, Salvanes, and Van Reenen 2010; Dunne et al. 2004; Barth et al. 2016). While this correlation might reflect that some of the productivity differences across firms spill over to wages, it could also be driven by changes in the degree to which workers of different quality sort into different firms (see, e.g., Murphy and Topel 1990; Gibbons and Katz 1992; Abowd, Kramarz, and Margolis 1999; Gibbons et al. 2005). To address the sorting issue, a growing body of work has taken advantage of matched employer-employee data. Some studies use this data to estimate the pass-through of changes in the value added of a firm to the wages of its workers, while controlling for time-invariant firm and worker heterogeneity.[2] These studies typically report estimates of pass-through rates in the range of 0.05–0.20. We complement this work by providing evidence of the pass-through rates for a broad set of firms in the United States with a variety of empirical approaches, and by showing how the estimated pass-through of firm and market-level shocks can be used to draw inferences about imperfect competition, rents, and allocative inefficiency.

Another set of studies use the matched employer-employee data to estimate the additive worker and firm effects wage model proposed by Abowd, Kramarz, and Margolis (1999).[3] We complement this work by extending the Abowd, Kramarz, and

[2] See, e.g., Guiso, Pistaferri, and Schivardi (2005); Card, Devicienti, and Maida (2014); Card et al. 2018; Carlsson, Messina, and Skans (2016); Balke and Lamadon (2020); and Friedrich et al. (2019). A concern with this approach is that measures of firm productivity may reflect a number of factors. Some studies have therefore examined the pass-through of specific, observable changes. For example, Van Reenen (1996) studies how innovation affects firms' profit and workers' wages. He also investigates patents as a source of variation, but finds them to be weakly correlated with profits. Building on this insight, Kline et al. (2019) studies the incidence of patents that are predicted to be valuable. See also their correction of the reported findings (Kline et al., 2021). A related literature has examined the wage and productivity effects of adoption of new technology in firms (see Akerman, Gaarder, and Mogstad 2015, and the references therein).

[3] Song et al. (2019) and Sorkin (2018) provide estimates using the approach of Abowd, Kramarz, and Margolis (1999) for the United States. A recent literature addresses the concern that estimates of firm effects will be biased upward and estimates of worker sorting will be biased downward when using the approach of Abowd, Kramarz, and Margolis (1999) due to limited worker mobility across firms. Our main estimates use the bias-correction approach of Bonhomme, Lamadon, and Manresa (2019) while alternative bias-correction approaches by Andrews et al. (2008) and Kline, Saggio, and Sølvsten (2020) are considered in our online Appendix. See Bonhomme et al. (2020) for a comparison of bias-correction procedures using data from several countries.

Margolis (1999) model to allow for both firm-worker interactions and time-varying firm effects, which enable us to economically interpret the firm effects in terms of rents and compensating differentials, understand the sources of worker sorting, and clarify the contribution of firm productivity shocks to earnings inequality.

Our paper also relates to a literature that tries to measure the role of compensating differentials for wage-setting and earnings inequality. This literature is reviewed in Taber and Vejlin (2020) and Sorkin (2018). Much of the existing evidence comes from hedonic regressions of earnings on one or more observable nonwage characteristics of jobs, employers, or industries, interpreting the regression coefficients as the market prices of those amenities. Typical estimates of these coefficients are small in magnitude and sometimes of the wrong sign (see the discussion by Bonhomme and Jolivet 2009). These estimates could be severely biased, either due to correlations between observed amenities and unobserved firm characteristics or because of assortative matching (on unobservables) between workers and firms (see, e.g., the discussion by Ekeland, Heckman, and Nesheim 2004). Several recent studies have used panel data in an attempt to address these concerns. Like us, Taber and Vejlin (2020), Lavetti and Schmutte (2018), and Sorkin (2018) take advantage of matched longitudinal employer-employee data to allow for unobserved heterogeneity across firms.

Our paper differs from the existing literature on compensating differentials in several ways. One important difference is that amenities, in our model, create both vertical and horizontal employer differentiation. The latter generates imperfect competition, wage-setting power and rents; the former acts as standard compensating differentials. By comparison, compensating differentials have typically been analyzed in models with perfect competition or search frictions (see, e.g., Mortensen 2003). Our paper also allows for ex ante worker heterogeneity in productivity and preferences that generates sorting between firms and workers, in contrast to, for example, Sorkin (2018). Our estimates suggest that worker heterogeneity and sorting are empirically important features of the US labor market which are necessary to take into account to understand the determinants of earnings inequality. By taking our model to the data, we are able to quantify the relative importance of amenities versus production complementarities for worker sorting and earnings inequality. Lastly, our paper differs in that we move beyond the impact of amenities on wages and worker sorting, examining also the implications for tax policy and allocative efficiency. In our model, wages are taxed but amenities are not. Thus, progressive taxation on labor income may distort the worker's decision of which firm and market to work in. We analyze, theoretically and empirically, the consequences of this distortion and how changes in the tax system may help improve the allocation of workers to firms.[4]

[4] Tax theory in the Mirrlees (1971) tradition generally assumes that labor markets are perfectly competitive. A notable exception is Cahuc and Laroque (2014) who develop a model for optimal taxation under monopsonistic markets. See also Powell and Shan (2012) and Powell (2012) who argue that marginal tax rates distort the relative value of amenities to wages. There is also a literature that considers tax design in situations with search frictions. See Yazici and Sleet (2017) and the references therein.

I. Model of the Labor Market

This section develops an equilibrium model of the labor market. We begin by describing the primitives of the model, including the heterogeneous preferences and productivity of the workers and the heterogeneous technology and nonwage characteristics of the firms. Once the primitives are described, we define the environment, derive the labor supply and demand functions, and show that there exists a unique equilibrium. Next, we discuss the sorting of workers to firms, before deriving the key structural equations to be taken to the data. Lastly, we show the mapping between these equations and the key economic quantities of interest, including rents, compensating differentials, and sources of allocative inefficiency.

A. *Agents, Preferences, and Technology*

The economy is composed of a large number of workers indexed by i and a large set of firms indexed by $j = 1, \ldots, J$. Each firm belongs to a market $r(j)$. Let J_r denote the set of firms in market r. We will rely on the approximation that firms employ many workers and that each market has many firms. For tractability, we assume that workers, firms and markets face exogenous birth-death processes that ensure stationarity in the productivity distributions of workers, firms and markets.

Worker Productivity and Preferences.—Workers are heterogeneous both in preferences and productivity. Workers are characterized by a permanent skill level X_i. In period t, worker i with skill X_i has the following preferences over alternative firms j and earnings W:

$$u_{it}(j, W) = \log \tau W^{\lambda} + \log G_j(X_i) + \beta^{-1} \epsilon_{ijt},$$

where $G_j(X)$ denotes the value that workers of quality X are expected to get from the amenities that firm j offers, and ϵ_{ijt} denotes worker i's idiosyncratic taste for the amenities of firm j. The parameters (τ, λ) describe the tax function that maps wages to income available for consumption. Section IVC shows that this parsimonious tax function well approximates the US tax system.

This specification of preferences allows for the possibility that workers view firms as imperfect substitutes. Fixing worker quality X, the preference term $G_j(X)$ gives rise to *vertical* employer differentiation: some employers offer good amenities while other employers have bad amenities. Our preference specification combines this vertical differentiation with *horizontal* employer differentiation: workers are heterogeneous in their preferences over the same firm. This horizontal differentiation has two distinct sources. The first is that $G_j(X)$ varies freely across values of X. Thus, we permit systematic heterogeneity in the preferences for a given firm depending on the permanent component of worker productivity. The second is the idiosyncratic taste component $\beta^{-1} \epsilon_{ijt}$. The importance of this second source of horizontal differentiation is governed by the parameter β. As β becomes smaller, $\beta^{-1} \epsilon_{ijt}$ becomes more dispersed and thus horizontal differentiation becomes more important in determining the worker's preferred firm.

We assume that $(\epsilon_{i1t}, \ldots, \epsilon_{iJt}) \equiv \vec{\epsilon}_{it} \sim \Xi(\vec{\epsilon} | \vec{\epsilon}_{it-1}, X_i)$ follows a Markov process with independent innovations across individuals. This assumption does not imply strong restrictions on the copula of workers' skills and preferences over time (and, by extension, the patterns of mobility across firms by worker quality). We assume, however, that the (cross-sectional) distribution of $\vec{\epsilon}_{it}$ has a nested logit structure in each period:

$$F(\vec{\epsilon}_{it}) = \exp\left[-\sum_r \left(\sum_{j \in J_r} e^{-\frac{\epsilon_{ijt}}{\rho_r}}\right)^{\rho_r}\right].$$

This structure allows the preferences of a given worker to be correlated across alternatives within each nest. In the empirical analysis, we specify the nest as the combination of industry and region, and refer to it as a market. The parameter ρ_r measures the degree of independence in a worker's taste for the alternative firms within market r; i.e., $\rho_r = \sqrt{1 - \mathrm{corr}(\epsilon_{ijt}, \epsilon_{ij't})}$ if $r(j) = r(j') = r$. Thus, $\rho_r = 0$ if each worker views firms within the same market as perfect substitutes, while $\rho_r = 1$ if the worker views these firms as completely independent alternatives.

Firm Productivity and Technology.—We let firms differ not only in workplace amenities but also in terms of productivity and technology. We start by introducing the total efficiency units of labor at the firm:

$$L_{jt} = \int X^{\theta_j} \cdot D_{jt}(X)\, dX,$$

where X^{θ_j} tells us the efficiency of a worker of quality X in firm j. The component $D_{jt}(X)$ is the mass of workers with productivity X demanded by the firm.

The value added (revenues minus expenditure on intermediate inputs) Y_{jt} generated by firm j in period t is determined by the production function

$$Y_{jt} = A_{jt} L_{jt}^{1-\alpha_{r(j)}},$$

where A_{jt} is the firm's total factor productivity (TFP) and $1 - \alpha_{r(j)}$ is the firm's returns to scale. The returns to scale depends on the total efficiency units of labor (reflecting both the quality and quantity of labor), and we let it vary freely across markets to allow for differences in technology. Our specification of the value-added production function abstracts from capital, or equivalently, assumes that capital can be rented at some fixed price. However, the specification does not require the product market to be competitive. As shown in online Appendix A.6, it is possible to derive the same specification of the value-added production function (and, by extension, labor demand) if firms have price-setting power in the product market.

It is useful to express the productivity component A_{jt} as

$$A_{jt} = \bar{A}_{r(j)t} \tilde{A}_{jt} = \bar{P}_{r(j)} \bar{Z}_{r(j)t} \tilde{P}_j \tilde{Z}_{jt},$$

where $\bar{A}_{r(j)t}$, $\bar{P}_{r(j)}$, and $\bar{Z}_{r(j)t}$ represent the overall, the permanent, and the time-varying components of productivity that are shared by all firms in market r; while $\tilde{A}_{jt}$, $\tilde{P}_j$, and $\tilde{Z}_{jt}$ denote the overall, the permanent, and the time-varying components that are specific to firm j. Let $W_{jt}(X)$ denote the wage that firm j offers to workers of quality X in period t and $B_{jt} = \int W_{jt}(X)\, D_{jt}(X)\, dX$ denote the wage bill of the firm, i.e., the total sum of wages paid to its workers. The profit of the firm is then given by $\Pi_{jt} = Y_{jt} - B_{jt}$.

B. *Information, Wages, and Equilibrium*

We consider an environment where all labor is hired in a spot market and ϵ_{ijt} is private information to the worker. Hence, the wage may depend on the worker's attributes X, but not her value of ϵ_{ijt}. Given the set of offered wages $\mathbf{W}_t = \{W_{jt}(X)\}_{j=1,\ldots,J}$ by all firms, worker i chooses a firm j to maximize her utility u_{it} in each period:

$$j(i,t) \equiv \operatorname*{argmax}_j u_{it}\big(j, W_{jt}(X_i)\big). \tag{1}$$

We introduce a wage index at the level of the market r defined by

$$I_{rt}(X) \equiv \left(\sum_{j' \in J_r} \left(\tau^{1/\lambda} G_{j'}(X)^{1/\lambda} W_{j't}(X)\right)^{\frac{\lambda\beta}{\rho_r}}\right)^{\frac{\rho_r}{\lambda\beta}}, \tag{2}$$

from which we can derive the probability that an individual of type X chooses to work at firm j given all offered wages in the economy:

$$\Pr\big[j(i,t) = j | X_i = X, \mathbf{W}_t\big] = \frac{I_{r(j)t}(X)^{\lambda\beta}}{\sum_{r'} I_{r't}(X)^{\lambda\beta}} \left(\tau^{1/\lambda} G_j(X)^{1/\lambda} \frac{W_{jt}(X)}{I_{r(j)t}(X)}\right)^{\frac{\lambda\beta}{\rho_{r(j)}}}.$$

We consider an equilibrium where the firm views itself as infinitesimal within the market.[5] Thus, given the total mass of workers N and the stationary cross-sectional distributions of X, $M(X)$, employer j considers the following firm-specific labor supply curve when setting wages $W_{jt}(X)$:

$$S_{jt}(X, W) \equiv NM(X) \frac{I_{r(j)t}(X)^{\lambda\beta}}{\sum_{r'} I_{r't}(X)^{\lambda\beta}} \left(\tau^{1/\lambda} G_j(X)^{1/\lambda} \frac{W}{I_{r(j)t}(X)}\right)^{\frac{\lambda\beta}{\rho_{r(j)}}}.$$

This means the firm ignores the negligible effect of changing its own wages on the market-level wage index $I_{rt}(X)$. Then each firm chooses labor demand $D_{jt}(X)$ by setting wages $W_{jt}(X)$ for each type of worker X to maximize profits subject to labor supply $S_{jt}(X, W)$:

$$\Pi_{jt} = \max_{\{W_{jt}(X)\}_X} A_{jt} \left(\int X^{\theta_j} D_{jt}(X)\, dX\right)^{1-\alpha_{r(j)}} - \int W_{jt}(X)\, D_{jt}(X)\, dX, \tag{3}$$

subject to

$$D_{jt}(X) = S_{jt}\big(X, W_{jt}(X)\big) \quad \text{for all } t, j, X.$$

[5] See Berger, Herkenhoff, and Mongey (2019) for an analysis of strategic interactions in the firms' wage setting. See also Jarosch, Nimczik, and Sorkin (2019), who develop a search framework with large firms. However, identification is difficult in models with strategic behavior in the wage setting.

From this environment, the definition of equilibrium naturally follows.

DEFINITION 1: *Given firm characteristics* $\left\{\alpha_{r(j)}, A_{jt}, \theta_j\right\}_{j,t}$, *worker distributions* $N, M(\cdot)$, *preference parameters* $\left(\beta, \rho_r, G_j(\cdot)\right)$, *and tax parameters* (λ, τ); *we define the equilibrium as the worker decisions* $j(i,t)$, *market-level wage indices* $I_{rt}(X)$, *firm-specific labor supply curves* $S_{jt}(X, W)$, *wages* $W_{jt}(X)$, *and labor demand* $D_{jt}(X)$ *such that:*

(*i*) *Workers choose firms that maximize their utility, as defined in equation* (*1*).

(*ii*) *Firms choose labor demand* $D_{jt}(X)$ *by setting wages* $W_{jt}(X)$ *for each worker quality* X *to maximize profits subject to the labor supply constraint* $S_{jt}(X, W)$, *as described in equation* (*3*).

(*iii*) *The market-level wage indices* $I_{rt}(X)$ *are generated from the workers' optimal decisions* $j(i,t)$, *as described in equation* (*2*).

In Lemma 2 in online Appendix A.1, we show the uniqueness of the equilibrium that proves useful in the estimation of the model and is needed for the counterfactual analyses.

C. *Sorting in Equilibrium*

To understand how workers may sort in our model, it is important to note that we do not restrict the relationship between amenities $G_j(X)$, permanent productivity components $(\bar{P}_{r(j)}, \tilde{P}_j)$, and technology $(\theta_j, \alpha_{r(j)})$. As a result, our model permits multiple sources of systematic sorting of worker quality and firm productivity in equilibrium.

One source of sorting is that we allow workers of different quality X to be differentially productive across different firms j. For example, if more productive firms have greater θ in the production function, the marginal product of high quality workers is relatively high at more productive firms, so that worker quality and firm productivity are strong complements in production (i.e., strict log supermodularity, as in Shimer and Smith 2000 and Eeckhout and Kircher 2011). Empirically, we will find evidence that more productive firms have greater θ and, therefore, conclude that worker quality is strongly complementary with firm productivity. Thus, firms with high productivity offer relatively high (log) wages to workers with high X, which contributes to a disproportionate employment of high ability workers in productive firms.

A second source of systematic worker sorting is captured by the amenity term $G_j(X)$ in the preference specification. This specification allows the valuation of the amenities of a given firm to vary freely across worker quality X, and it allows the valuation of amenities for a given worker quality X to vary freely across firms. Empirically, we will find that productive firms tend to have better amenities, and that high ability workers tend to value amenities more than low ability workers. This contributes to a disproportionate employment of high quality workers in productive firms.

When assessing the sorting patterns, it is important to observe that our model does not imply that the most productive firms (either in terms of A or θ) hire all workers (in total or of a given quality X) in the economy. One reason for this is we find that the labor supply curve is upward sloping ($\beta < \infty$), so the marginal cost of labor is increasing in the number of workers. Another reason is that we find that firms face diminishing returns to scale in labor ($1 - \alpha_r < 1$), which implies that the marginal product of labor is decreasing in the number of workers.

D. *Structural Equations*

As shown in Proposition 1 in online Appendix A.1, our model delivers the following structural equations for (log of) wages, value added, and wage bill of firm $j \in J_r$:

$$w_j(x,\bar{a},\tilde{a}) = \theta_j x + c_r - \alpha_r h_j + \frac{1}{1+\alpha_r\lambda\beta}\bar{a} + \frac{1}{1+\alpha_r\lambda\beta/\rho_r}\tilde{a}, \tag{4}$$

$$y_j(\bar{a},\tilde{a}) = (1-\alpha_r)h_j + \frac{1+\lambda\beta}{1+\alpha_r\lambda\beta}\bar{a} + \frac{1+\lambda\beta/\rho_r}{1+\alpha_r\lambda\beta/\rho_r}\tilde{a}, \tag{5}$$

$$b_j(\bar{a},\tilde{a}) = c_r + (1-\alpha_r)h_j + \frac{1+\lambda\beta}{1+\alpha_r\lambda\beta}\bar{a} + \frac{1+\lambda\beta/\rho_r}{1+\alpha_r\lambda\beta/\rho_r}\tilde{a}; \tag{6}$$

where we use lower case letters to denote logs (e.g., $x \equiv \log(X)$), c_r is a market-specific constant that is equal to $\log\big((1-\alpha_r)\lambda\beta/\rho_r\big)/(1+\lambda\beta/\rho_r)$, and h_j is the solution to a fixed point equation. As shown in Lemma 3 in online Appendix A.1, h_j depends on the firm's amenity terms but does not depend on $\tilde{a}$ or $\bar{a}$. These equations describe how the *potential* outcomes of workers and firms are determined; that is, they tell us the realizations of $w_j(x)$, y_j, and b_j that would have been experienced had worker productivity x, firm TFP $\tilde{a}$, and market TFP $\bar{a}$ been exogenously set.

The equations in (4)–(6) show that $w_j(x,\bar{a},\tilde{a})$, $y_j(\bar{a},\tilde{a})$, and $b_j(\bar{a},\tilde{a})$ depend on the same three components: the component of productivity that is specific to the firm $\tilde{a}$, the component of productivity that is common to firms in the same market $\bar{a}$, and an amenity component h_j. In addition, $w_j(x,\bar{a},\tilde{a})$ depends on the worker's own productivity x. Moreover, workers with the same x who work in different firms can be paid differentially depending on the firm-specific parameter θ_j. As expected, if a firm j becomes more productive ($\tilde{a}$ or $\bar{a}$ increases) then $y_j(\bar{a},\tilde{a})$ increases. Because firm j has become more productive, it will demand more labor, raising $w_j(x,\bar{a},\tilde{a})$ and $b_j(\bar{a},\tilde{a})$.

Combining equations (4)–(6), we obtain a structural equation for the log efficiency units of labor of firm $j \in J_r$:

$$\ell_j(\bar{a},\tilde{a}) = h_j + \frac{\lambda\beta}{1+\alpha_r\lambda\beta}\bar{a} + \frac{\lambda\beta/\rho_r}{1+\alpha_r\lambda\beta/\rho_r}\tilde{a}, \tag{7}$$

where h_j (see definition in Lemma 3 in online Appendix A.1) can be interpreted as the efficiency units of labor the firm would have if $\tilde{a}$ and $\bar{a}$ were exogenously set to zero. The key component of h_j is the vertical differentiation of firms due to the amenities. All else equal, better amenities raise the size of the firm, thus increasing its wage bill and value added. Furthermore, h_j also reflects worker composition, which depends both on the horizontal amenity differentiation of firms, as captured by $G_j(X)$; and on the complementarity in production, as captured by θ_j.

Another important feature of the structural equations (4)–(6) is that they are additive in the arguments $\theta_j x$, h_j, $\bar{a}$, and $\tilde{a}$. This additivity is useful for several reasons. First, it makes it straightforward to quantify the relative importance of the determinants of worker and firm outcomes. Second, it forges a direct link between the structural log wage equation and the log-additive fixed effect models discussed in Section IVD. This link will help interpret the sources of variation in log earnings through the lens of the model. Third, it facilitates identification of the parameters of the model, as shown in Section III.

E. *Rents*, *Compensating Differentials*, *and Allocative Inefficiencies*

We conclude the presentation of the model by showing the mapping between the structural equations and the key economic quantities of interest, including rents, compensating differentials, and sources of allocative inefficiency.

Worker Rents.—In our model, rents are due to the idiosyncratic taste component ϵ_{ijt} that gives rise to horizontal differentiation of firms, upward sloping labor supply curves, and employer wage-setting power. We assume that employers do not observe the idiosyncratic taste for amenities of any given worker. This information asymmetry implies that firms cannot price discriminate with respect to workers' reservation wages. As a result, the equilibrium allocation of workers to firms creates surpluses or rents for inframarginal workers, defined as the excess return over that required to change a decision, as in Rosen (1986). In our model, worker rents may exist at both the firm and the market level.

RESULT 1: *We define the* **firm-level rents** *of worker* i, R^w_{it}, *as the surplus she derives from being inframarginal at her current choice of firm. Given her equilibrium choice* $j(i,t)$, R^w_{it} *is implicitly defined by*

$$u_{it}\big(j(i,t), W_{j(i,t),t}(X_i) - R^w_{it}\big) \;=\; \max_{j' \neq j(i,t)} u_{it}\big(j', W_{j',t}(X_i)\big).$$

As shown in Lemma 4 in online Appendix A.2, *expected worker rents at the firm level are*

$$E\big[R^w_{it}\,|\,j(i,t) \;=\; j\big] \;=\; \frac{1}{1+\lambda\beta/\rho_{r(j)}}E\big[W_{jt}(X_i)\,|\,j(i,t) \;=\; j\big].$$

RESULT 2: *We define the* **market-level rents** *of worker* i, R^{wm}_{it}, *as the surplus derived from being inframarginal at her current choice of market. Given her equilibrium choice of market* $r\big(j(i,t)\big)$, R^{wm}_{it} *is implicitly defined by*

$$u_{it}\big(j(i,t), W_{j(i,t),t}(X_i) - R^{wm}_{it}\big) \;=\; \max_{j' | r(j') \neq r(j(i,t))} u_{it}\big(j', W_{j',t}(X_i)\big).$$

As shown in Lemma 4 in online Appendix A.2, expected worker rents at the market level are

$$E\left[R_{it}^{wm} \mid j(i,t) = j\right] = \frac{1}{1+\lambda\beta} E\left[W_{jt}(X_i) \mid j(i,t) = j\right].$$

Market-level rents exceed firm-level rents whenever the next best firm is in the same market as the current choice of firm. If the preferences of a given worker are independent across firms within each market, then the next best firm will almost surely be in a different market. If, on the other hand, these preferences are correlated then there could well exist other firms within the same market that are close substitutes to the current firm. The next best firm may then be in the same market as the current choice of firm, in which case R_{it}^{wm} will exceed R_{it}^{w}.

To interpret the measure of firm-level rents and link it to compensating differentials, it is useful to express R_{it}^{w} in terms of reservation wages. The worker's reservation wage for her current choice of firm is defined as the lowest wage at which she would be willing to continue working in this firm. Substituting preferences into the above definition of R_{it}^{w} for a worker whose current firm is j and next best option is j', it follows that

$$\begin{aligned}\underbrace{\log W_{j(i,t),t}(X_i)}_{\text{current wage}} - \underbrace{\log\left(W_{j(i,t),t}(X_i) - R_{it}^{w}\right)}_{\text{reservation wage}} = {} & \underbrace{\log W_{j(i,t),t}(X_i)}_{\text{current wage}} - \underbrace{\log W_{j'(i,t),t}(X_i)}_{\text{wage at best outside option}} \\ & + \underbrace{\log G_{j(i,t)}^{1/\lambda}(X_i)\, e^{\frac{1}{\lambda\beta}\epsilon_{ij(i,t)t}}}_{\text{current amenities}} \\ & - \underbrace{\log G_{j'(i,t)}^{1/\lambda}(X_i)\, e^{\frac{1}{\lambda\beta}\epsilon_{ij'(i,t)t}}}_{\text{amenities at best outside option}}.\end{aligned}$$

The average worker choosing firm j may be far from the margin of indifference and would maintain the same choice even if her current firm offered significantly lower wages.

Compensating Differentials.—By definition, marginal workers are indifferent between the current choice of firm and the next best option. They earn no rents as their reservation wages equal the actual wages paid by their current firms. The equilibrium allocation of workers to firms is such that utility gains (or losses) of marginal workers due to the amenities of their firms are exactly offset by wage differentials. Thus, wage differentials across firms for the same worker define the equalizing or compensating differentials.

RESULT 3: *Consider worker i of type X whose current firm is j and best outside option is j′ and who is marginal at the current firm (that is,* $R_{it}^{w} = 0$*). The* **compensating differential** *between j and j′ for a worker of type X is then defined as*

$$\begin{aligned} CD_{jj't}(X) = u_{it}\left(j', W_{jt}(X)\right) - u_{it}\left(j, W_{jt}(X)\right) &= \log W_{j't}(X) - \log W_{jt}(X) \\ &= \left(\theta_{j'} - \theta_j\right)x + \psi_{j't} - \psi_{jt},\end{aligned}$$

where the second equality becomes the fact that worker i is marginal, and the last equality follows from equation (4) and defining the firm effect ψ_{jt} as

$$\psi_{jt} \equiv c_r - \alpha_r h_j + \frac{1}{1+\alpha_r\lambda\beta}\bar{a}_{r(j),t} + \frac{1}{1+\alpha_r\lambda\beta/\rho_r}\tilde{a}_{jt}. \tag{8}$$

For any two firms j and j', there exists a distribution of compensating differentials. This distribution arises because of differences in technology across firms that interact with the distribution of worker types X. If θ_j does not vary across firms, there is only one compensating differential per employer, ψ_{jt}, which is paid to all workers independent of their productivity.

Employer Rents.—The equilibrium allocation of workers to firms may also create surpluses or rents for employers. The employer rents arise because of the additional profit the firm can extract by taking advantage of its wage-setting power. To measure employer rents, we therefore compare the profit Π_{jt} the firm actually earns to what it would have earned if the employer solved the firm's problem under the assumption that the labor supply it faced was perfectly elastic. In other words, wages, profits, and employment are such that $D_{jt}^{pt}(X)$ solves the firm's profit maximization given $W_{jt}^{pt}(X)$:

$$\Pi_{jt}^{pt} = \max_{\{D_{jt}^{pt}(X)\}_X} A_{jt}\left(\int X^{\theta_j}\cdot D_{jt}^{pt}(X)\,dX\right)^{1-\alpha_{r(j)}} - \int D_{jt}^{pt}(X)\cdot W_{jt}^{pt}(X)\,dX.$$

The only difference in the firm's problem in this counterfactual environment is that the firm does not take into account its wage-setting power through the upward-sloping labor supply curve. In other words, the firm behaves as if it faces a perfectly elastic labor supply curve, i.e., as if it was a "price taker"; thus the superscript *pt*. Similarly, we define $W_{jt}^{ptm}(X)$, $D_{jt}^{ptm}(X)$, and Π_{jt}^{ptm} as the equilibrium outcome when all firms in a market act as price takers.

RESULT 4: *We define the* **employer rents** *at the firm level R_{jt}^{f} and at the market level R_{jt}^{fm} as the additional profit that firm j in market r derives by taking advantage of its wage-setting power:*

$$R_{jt}^{f} = \Pi_{jt} - \Pi_{jt}^{pt} = \left(1 - \frac{\alpha_r(\rho_r+\lambda\beta)}{\rho_r+\alpha_r\lambda\beta}\left(\frac{\lambda\beta}{\rho_r+\lambda\beta}\right)^{-\frac{(1-\alpha_r)\lambda\beta}{\rho_r+\alpha_r\lambda\beta}}\right)\Pi_{jt},$$

$$R_{jt}^{fm} = \Pi_{jt} - \Pi_{jt}^{ptm} = \left(1 - \frac{\alpha_r(\rho_r+\lambda\beta)}{\rho_r+\alpha_r\lambda\beta}\left(\frac{\lambda\beta}{\rho_r+\lambda\beta}\right)^{-\frac{(1-\alpha_r)\lambda\beta}{1+\alpha_r\lambda\beta}}\right)\Pi_{jt};$$

where the latter equality in each equation is shown in Lemmas 5 and 6 in online Appendix A.3.

To understand how and why employer rents may differ at the firm and the market level, recall that ρ_r measures the degree of independence in a worker's taste for the alternative firms within market r. If $\rho_r = 1$, the worker views these firms as completely independent alternatives, and the rents at the firm level equal the rents at the market level. In contrast, if $\rho_r = 0$ then each worker views firms within the same market as perfect substitutes. In this case, firms do not get any rents from imperfect competition at either the firm or the market level. For values of ρ between zero and one, the rents at the market level will strictly exceed the rents at the firm level.

It is important to observe that R^f_{jt} and R^{fm}_{jt} do not necessarily represent ex ante rents. Suppose, for example, that each employer initially chooses the amenities offered to the workers by deciding on the firm's location, the working conditions, or both. Next, the employers compete with one another for the workers who have heterogeneous preferences over the chosen amenities. These heterogeneous preferences give rise to wage-setting power which employers can use to extract additional profits or rents. Of course, the existence of such ex post rents could simply be returns to costly choices of amenities.

Empirically, it is difficult to credibly distinguish between ex ante and ex post employer rents. It would require information (or assumptions) about how firms choose and pay for the amenities offered to workers. Given our data, we are severely limited in the ability to distinguish between ex ante and ex post rents. Instead, we assume firms are endowed with a fixed set of amenities, or, more precisely, we restrict amenities to be fixed over the estimation window. It is important to note what is *not* restricted under this assumption. First, it does not restrict whether or how amenities $G_j(\underline{X})$ relate to the technology parameters $\alpha_{r(j)}$, θ_j or the productivity components $\tilde{P}_j, \overline{P}_{r(j)}$. Second, it neither imposes nor precludes that employers initially choose amenities to maximize profits. Indeed, it is straightforward to show that permitting firms to initially choose amenities would not affect any of our estimates. Nor would it matter for the interpretation of any result other than whether R^f_{jt} and R^{fm}_{jt} should be viewed as ex ante or ex post rents.

Wedges and Allocative Inefficiencies.—We conclude the model section by investigating the questions of whether and in what situations the equilibrium allocation of workers to firms will be inefficient. We present here the key results, and refer to online Appendix A.4 for details and derivations. To draw conclusions about allocative inefficiencies, we compare the allocation and outcomes in the monopsonistic labor market to those that would arise in a competitive (Walrasian) labor market. By a competitive market, we mean that there are no taxes ($\lambda = \tau = 1$) and that all firms act as price takers, as if they faced perfectly elastic labor supply curves. This comparison allows us to draw inferences about allocative inefficiencies within and between markets.

Within each market, there is a tax wedge that arises because $\lambda < 1$. It is the only source of allocative inefficiency at this level, distorting the worker's ranking of firms in favor of those with better amenities. As λ decreases and thereby the wage tax becomes more progressive, amenities become more valuable relative to (pretax) wages. Thus, with progressive taxation, firms with better amenities can hire workers at relatively low wages, and, therefore, get too many workers as compared to the allocation in the competitive labor market. Between markets, allocative inefficiencies may arise not only because of the tax wedge but also due to differences in labor wedges across markets, where the labor wedge is the ratio of the marginal revenue product of labor to the wage. To understand the latter source of inefficiencies, consider the special case when $\lambda = 1, \beta > 0$, and ρ_r is nonzero but the same across all markets. In this case, taxes are proportional but there are still labor wedges and rents in the economy. However, the labor wedges will be the same across all markets. As a consequence, the monopsonistic market allocation of workers to firms is identical to the allocation one would obtain in the competitive equilibrium. A corollary of this result is that tax wedges are the only source of allocative inefficiencies if one assumes a standard logit structure on the distribution of $\vec{\epsilon}_{it}$ (as in, for example, Card et al. 2018).

With the nested logit structure on the distribution of $\vec{\epsilon}_{it}$, allocative inefficiencies across markets may arise because ρ_r can vary across markets, implying that workers may view firms as closer substitutes in some markets than others. This will create differences across markets in the wage-setting power of firms, and so in their abilities to mark down wages. Markets facing an elastic labor supply curve (i.e., low value of ρ_r) will have relatively high wages and, as a result, attract too many workers compared to the allocation in the competitive equilibrium. Progressive taxation will amplify any differences in ρ_r across markets, leading to an even larger misallocation of workers to firms.

To improve the allocation of workers to firms, the government can change the tax system in two ways. First, a less progressive tax system (i.e., increase λ) may reduce the misallocation that arises from the tax wedge. Second, letting τ vary across markets may improve the allocation of workers by counteracting differences in the wage-setting power of firms. For example, τ could vary across markets (defined as the combination of geographical area and industry) due to state income taxes or because of subsidies to certain industries or regions.[6] After estimating the parameters of the model, we perform, in Section V, counterfactual analyses that quantify the impacts of such tax reforms on the equilibrium allocation and outcomes, including earnings, output and welfare. In interpreting these results, it is important to note that we assume firms initially choose amenities $G_j(X)$, but do not change $G_j(X)$ in response to counterfactuals. With better data on, and an instrument for, amenities, it would be interesting to extend this analysis to allow for firms to adjust amenities in response to these counterfactuals.

II. Data Sources and Sample Selection

A. *Data Sources*

Our empirical analyses are based on a matched employer-employee panel dataset with information on the characteristics and outcomes of US workers and firms. This data is constructed by linking US Treasury business tax filings (IRS 2021a) with worker-level filings (IRS 2021b) for the years 2001–2015. Below, we briefly describe data sources, sample selection, and key variables; while details about data construction and the definition of each of the variables are given in online Appendix B.

[6] Income taxes vary considerably across geographic regions. For example, the 2015 state income tax rates were 0 percent in Florida and Texas, between 3 and 4 percent in Illinois and Pennsylvania, and above 5 percent in Massachusetts and North Carolina (Tax Foundation 2015). Moreover, the US Empowerment Zone Program provides a 20 percent wage subsidy (up to a cap) to firms located in a designated disadvantaged location (IRS 2004). Furthermore, minimum wages vary considerably across regions.

Business tax returns include balance sheets and other information from forms 1120 (C-corporations), 1120S (S-corporations), and 1065 (partnerships). The key variables that we draw on from the business tax filings are the firm's employer identification number (EIN) and its value added, commuting zone, and industry code. Value added is the difference between receipts and the cost of goods sold. Commuting zone is constructed using the ZIP code of the firm's business filing address. Industry is defined as the first two digits of the firm's North American Industry Classification System (NAICS) code. In our baseline specification, we define a market as the combination of an industry and a commuting zone, with alternative market definitions provided in sensitivity checks. We will occasionally aggregate these markets into "broad markets" according to the combination of census regions (Midwest, Northeast, South, and West) and broad sectors (goods and services).

Earnings data are based on taxable remuneration for labor services reported on form W-2 for direct employees and on form 1099 for independent contractors. Earnings include wages and salaries, bonuses, tips, exercised stock options, and other sources of income deemed taxable by the Internal Revenue Service. These forms are filed by the firm on behalf of the worker and provide the firm-worker link. All monetary variables are expressed in 2015 dollars, adjusting for inflation using the consumer price index (Federal Reserve Board of St Louis, 2021).

B. *Sample Selection*

In each year, we start with all individuals aged 25–60 who are linked to at least one employer. Next, we define the worker's firm as the EIN that pays her the greatest direct (W-2) earnings in that year. This definition of a firm conforms to previous research using the US business tax records (see, e.g., Song et al. 2019). The EIN defines a corporate unit for tax and accounting purposes. It is a more aggregated concept than an establishment, which is the level of analysis considered in recent research on US census data (see, e.g., Barth et al. 2016), but a less aggregated concept than a parent corporation. As a robustness check, we investigate the sensitivity of the estimated firm wage premiums to restricting the sample to EINs that appear to have a single primary establishment. These are EINs for which the majority of workers live in the same commuting zone. It is reassuring to find that the estimated firm wage premiums do not materially change when we use this restricted sample.

Since we do not observe hours worked or a direct measure of full-time employment, we follow the literature by including only workers for whom annual earnings are above a minimum threshold (see, e.g., Song et al. 2019). In the baseline specification, this threshold is equal to $15,000 per year (in 2015 dollars), which is approximately what people would earn if they worked full-time at the federal minimum wage. As a robustness check presented in our online Appendix, we investigate the sensitivity of our results to other choices of a minimum earnings threshold. We further restrict the sample to firms with nonmissing value added, commuting zone, and industry. The full sample includes 447.5 (39.2) million annual observations on 89.6 (6.5) million unique workers (firms).

In parts of the analysis, we consider two distinct subsamples. The first subsample, which we refer to as the *stayers sample*, restricts the full sample to workers observed with the same employer for eight consecutive years. This restriction is needed to allow for a flexible specification of how the worker's earnings evolve over time. Specifically, we omit the first and last years of these spells (to avoid concerns over workers exiting and entering employment during the year, confounding the measure of annual earnings) and analyze the remaining six-year spells. Furthermore, the stayers sample is restricted to employers that do not change commuting zone or industry during those eight years. Lastly, we restrict the stayers sample to firms with at least ten such stayers and markets with at least ten such firms, which helps to ensure sufficient sample size to perform the analyses at both the firm and the market levels. The stayers sample includes 35.1 (6.5) million spells on 10.3 (1.5) million unique workers (firms).

The second subsample, which we refer to as the *movers sample*, restricts the full sample to workers observed at multiple firms.[7] That is, it is not the same EIN that pays the worker the greatest direct (W-2) earnings in all years. Following previous work, we also restrict the movers sample to firms with multiple movers. This restriction might help reduce limited mobility bias and makes it easier to compare the estimates of firm effects across methods (as the approach of Kline, Saggio, and Sølvsten 2020 requires at least two movers per firm).[8] The movers sample includes 32.1 (3.6) million unique workers (firms).

Online Appendix Table A.1 compares the size of the baseline, the stayers, and the movers samples. Detailed summary statistics of these samples of linked firms and workers are given in online Appendix Table A.2. The samples are broadly similar, both in the distribution of earnings but also in firm-level variables such as value added, wage bill, size, and the distribution across regions and sectors. The most noticeable differences are that the stayers have, on average, somewhat higher earnings and tend to work in firms with higher value added.

III. Identification

We now describe how to take our model to the data, providing a formal identification argument while summarizing, in Table 1, the parameters needed to recover a given quantity of interest and the moments used to identify these parameters. Our results reveal that many of these quantities do not require knowledge of all the structural parameters. Thus, some of our findings may be considered more reliable than others.

A. *Rents of Workers and Employers*

It follows from Results 1, 2, and 4 that the expected rents of workers and employers depend on the parameters $\left(\beta, \rho_r, \alpha_r\right)$ and the data $\left(Y_{it}, W_{it}, j_{it}, r_{it}\right)$. Our identification argument therefore proceeds by showing how these parameters can be identified from the panel data on workers and firms. However, before we present the formal identification argument, it is useful to consider what one can and cannot

[7] Note that, since workers outside the movers sample are not necessarily stayers for eight consecutive years (e.g., due to a year in which earnings at the primary employer are below the full-time equivalence threshold, or aging in or out of the sample), the stayers sample is a subset of the nonmovers sample.

[8] See our online Appendix for such a comparison and an analysis of limited mobility bias.

Table 1—Quantities of Interest, Model Parameters, and Targeted Moments

Name		Unique parameters	Mean estimate	Moments of the data	
Panel A. Rents and scale					
Idiosyncratic taste parameter	β	1	4.99	Market pass-through	$\frac{E[\Delta\bar{y}_{rt}(\bar{w}_{rt+e}-\bar{w}_{rt-e'})\mid S_i=1]}{E[\Delta\bar{y}_{rt}(\bar{y}_{rt+e}-\bar{y}_{rt-e'})\mid S_i=1]}$
Taste correlation parameter	ρ_r	8	0.70	Net pass-through	$\frac{E[\Delta\tilde{y}_{jt}(\tilde{w}_{it+e}-\tilde{w}_{it-e'})\mid S_i=1,r(j)=r]}{E[\Delta\tilde{y}_{jt}(\tilde{y}_{jt+e}-\tilde{y}_{jt-e'})\mid S_i=1,r(j)=r]}$
Returns to scale parameter	α_r	8	0.21	Labor share	$E[b_{j(i,t)}-y_{j(i,t)}\mid r(j)=r]$
Name		**Unique parameters**	**Var. estimate**	**Moments of the data**	
Panel B. Firm and worker heterogeneity					
Time-varying firm premium	ψ_{jt}	10,669,602	0.02	Structural wage equation	$E[w_{it}-\frac{1}{1+\lambda\beta}\bar{y}_{r,t}-\frac{\rho_r}{\rho_r+\lambda\beta}\tilde{y}_{j,t}\mid r(j)=r]$
Firm-specific technology parameter	θ_j	10	0.04		
Worker quality	x_i	61,670,459	0.31	Wage changes around moves	$E[w_{it+1}\mid j\rightarrow j']-E[w_{it}\mid j'\rightarrow j]$ $E[w_{it}\mid j'\rightarrow j]-E[w_{it+1}\mid j\rightarrow j']$
Amenity efficiency units at neutral TFP	h_j	1,953,915	0.14		
Time-varying firm-specific TFP	$\tilde{a}_{jt}$	10,669,602	0.14	Total labor input and	$\ell_{jt}=\log\sum X_i^{\theta_j}$ and ψ_{jt}
Time-varying market-specific TFP	$\bar{a}_{rt}$	111,829	0.12	time-varying firm premium	
Name		**Unique parameters**	**Var. estimate**	**Moments of the data**	
Panel C. Model counterfactuals					
Preferences for amenities for:	$g_j(X)$	6,974,519	0.20	Firm size	$\Pr[j]$
Firm j for workers of quality X				Firm composition	$\Pr[x\mid k(j)=k]$
Market r for workers of quality X				Market composition	$\Pr[x\mid r(j)=r]$

Note: This table displays the model parameters and the moments targeted in their estimation.

identify directly from an ideal experiment. This consideration clarifies the necessary assumptions even with an ideal experiment and the additional ones needed in the absence of such an experiment.

Ideal Experiment.—To see how one may recover (β,ρ_r,α_r), consider the structural equations (4) and (5) that express wages $w_j(x,\bar{a},\tilde{a})$ and value added $y_j(\bar{a},\tilde{a})$ as functions of model primitives $\Gamma = (\bar{p}_r,\tilde{p}_j,g_j(x),x_i)$ and potential firm and market-level productivity outcomes $(\bar{a},\tilde{a})$. Suppose we were able to independently and exogenously change $\tilde{a}$, the component of productivity that is specific to a firm, and $\bar{a}$, the component of productivity that is common to all firms in a market. As evident from equations (4) and (5), exogenous changes in $\tilde{a}$ and $\bar{a}$ affect both the wages a firm offers to its workers of a given quality, $w_j(x,\bar{a},\tilde{a})$, and the firm's value added, $y_j(\bar{a},\tilde{a})$. We can express the ratio of these effects as

$$\frac{\partial w_j(x,\bar{a},\tilde{a})}{\partial\tilde{a}}\left(\frac{\partial y_j(\bar{a},\tilde{a})}{\partial\tilde{a}}\right)^{-1} = \frac{1}{1+\lambda\beta/\rho_r} \equiv \gamma_r,$$

$$\frac{\partial w_j(x,\bar{a},\tilde{a})}{\partial\bar{a}}\left(\frac{\partial y_j(\bar{a},\tilde{a})}{\partial\bar{a}}\right)^{-1} = \frac{1}{1+\lambda\beta} \equiv \Upsilon;$$

where we refer to γ_r and Υ as the firm-level and market-level pass-through rates.

Since λ is a known (or pre-estimated) tax parameter, β and ρ_r can be identified from these two equations. In this ideal experiment, the pass-through of value added $y_j(\bar{a},\tilde{a})$ to wages $w_j(x,\bar{a},\tilde{a})$ of an $\bar{a}$ induced change would identify β. Similarly, given this parameter, the pass-through of $y_j(\bar{a},\tilde{a})$ to $w_j(x,\bar{a},\tilde{a})$ of an $\tilde{a}$ induced change would identify ρ_r. Importantly, in this framework, we only need to be able to induce a change in productivity then observe how value added and wages change; we do not need to observe productivity directly.

Next, equations (5) and (6) imply

$$E\left[y_{jt} - b_{jt} \mid j \in J_r\right] = -c_r = -\log(1-\alpha_r) - \log\left(\frac{\lambda\beta/\rho_r}{1+\lambda\beta/\rho_r}\right). \tag{9}$$

Since $E\left[y_{jt} - b_{jt} \mid j \in J_r\right]$ can be estimated directly from the data, and λ is known, it follows that α_r is identified given (β,ρ_r), which are in turn identified from (γ_r,Υ). Thus, the key challenge for identifying (β,ρ_r,α_r) is to identify (γ_r,Υ).

While it is not feasible to perform such an ideal experiment, it is possible to achieve identification of (β,ρ_r,α_r) either by using the panel data to construct internal instruments (i.e., instruments implied by model restrictions) or by finding external instruments (instruments based on data other than or external to the data generating process of our model). We now discuss identification with these two types of instruments in turn.

Difference-in-Difference Illustration of Internal Instruments.—Before presenting the formal identification argument behind the internal instruments, we graphically illustrate how such instruments can be constructed through difference-in-difference (DiD) strategies.

Consider first how to recover the market-level pass-through rate, Υ. Let $\bar{y}_{rt}$ denote market-level average log value added and $\bar{w}_{rt}$ denote market-level average log earnings for the sample of stayers in market r. Suppose for simplicity that workers can be assigned to two groups of firms in year t: one half has $\Delta\,\bar{y}_{r(i)t} = +\delta$ (treatment group) and the other half has $\Delta\,\bar{y}_{r(i)t} = -\delta$ (control group). Implicitly conditioning on stayers $(S_i = 1)$ at firms in region r $(j(i,t) = j \in J_r)$, we construct the following estimand:

$$\frac{E\left[\bar{w}_{rt+e} - \bar{w}_{rt-e'} \mid +\delta\right] - E\left[\bar{w}_{rt+e} - \bar{w}_{rt-e'} \mid -\delta\right]}{E\left[\bar{y}_{rt+e} - \bar{y}_{rt-e'} \mid +\delta\right] - E\left[\bar{y}_{rt+e} - \bar{y}_{rt-e'} \mid -\delta\right]},$$

where $e+t$ is a postperiod e years after t and $t-e'$ is a preperiod e' years before t. The numerator is a DiD estimand for market-level changes in log earnings while the denominator is DiD estimand for market-level changes in log value added. As shown formally below, the ratio of these DiD estimands recover Υ if amenities are fixed over time (at least within the estimation window) and the measurement error in value added, if any, is transitory. Under these assumptions, the observed market-level changes in value added and log earnings (within firms and workers) surrogate for the ideal experiment.

In Figure 1, we visualize and assess this DiD strategy at the market level. The blue line in this figure is constructed as follows: in any given calendar year t, we (i)

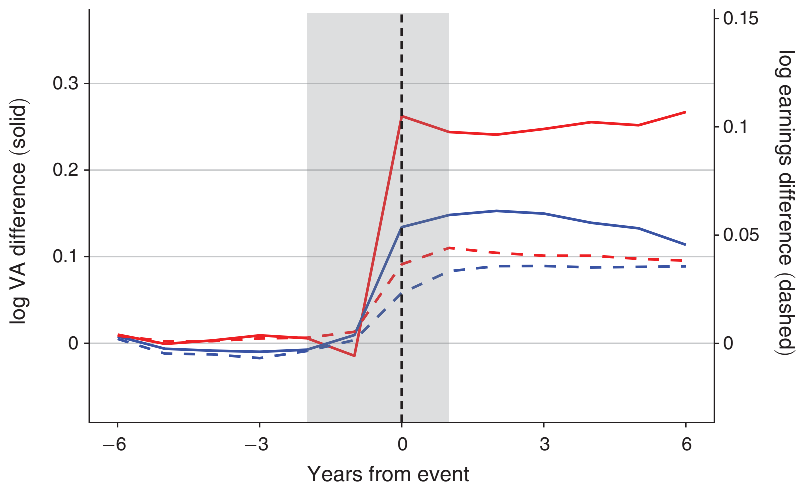

Figure 1. DiD Representation of the Estimation Procedure

Notes: This figure displays the mean differences in log value added (VA; solid lines) and log earnings (dashed lines) between firms that receive an above-median versus below-median log value-added change at event time zero. Results are presented for the measures of log value added and log earnings net of market interacted with year effects (red lines) and for the averages of log value added and log earnings by market and year (blue lines). The shaded area denotes the time periods during which the orthogonality condition need not hold in the identification of the permanent pass-through rate.

order markets according to the increase $\Delta\bar{y}_{rt}$; (ii) separate the firms at the median in the worker-weighted distribution of $\Delta\bar{y}_{rt}$, letting the upper half constitute the treatment markets and the lower half the control markets; and (iii) plot the differences in $\bar{y}_{rt+e}$ between these two groups in period $e = 0$ as well as in the years before ($e < 0$) and after ($e > 0$). We perform these steps separately for various calendar years, weighting each market by the number of workers. The solid (dashed) blue line represents the difference in log value added (earnings) for the treatment and control markets.

By construction, the treatment and control groups differ in the value-added growth from period $t-1$ to period t. On average, markets in the treatment group experience about 13 percentage points larger growth in value added as compared to markets in the control group. Furthermore, we find a similar trend in both log value added and log earnings between the treatment and control groups before $e = -2$ and after $e = 2$. In other words, markets that experienced large growth in value added and earnings in period 0 are no more or less likely to experience growth in value added or earnings in periods -6 to -3 or in periods 3 to 6. This observation of common trends between the treatment and control groups at the market level supports our assumption that the measurement error is transitory.

To recover the market-level pass-through rate γ_r, we apply the same logic as above, taking the ratio of a DiD estimand for firm-level changes in log earnings to a DiD estimand for firm-level changes in log value added. This ratio recovers γ_r under the same assumptions as above, except now applied to the firm level. To visualize and assess this DiD strategy, consider the red lines of Figure 1. These lines are constructed using firm-level deviations from market-level averages. We plot value-added deviations $\tilde{y}_{jt} \equiv y_{jt} - \bar{y}_{rt}$ (solid line) and earnings deviations $\tilde{w}_{it} \equiv$

$w_{it} - \bar{w}_{rt}$ (dashed line), splitting firms into the treatment and control groups at the median in the distribution of $\Delta \tilde{y}_{jt}$ and weighting each firm by the number of workers. We find that firms that experienced large growth in value added in period 0 are no more or less likely to experience growth in value added or earnings in periods -6 to -3 or in periods 3 to 6. This observation of common trends between the treatment and control groups at the market level supports our assumption that the measurement error is transitory.

Formal Identification Using Internal Instruments.—We now turn to the formal identification argument for the internal instruments to identify (γ_r, Υ). To this end, we specify a process for the productivity shocks to firms. Suppose that firm productivity evolves as a unit root process at both the firm level and market level:[9]

$$\tilde{a}_{jt} = \tilde{p}_j + \tilde{z}_{jt}, \quad \text{where} \quad \tilde{z}_{jt} = \tilde{z}_{jt-1} + \tilde{u}_{jt}; \tag{10}$$

$$\bar{a}_{rt} = \bar{p}_r + \bar{z}_{rt}, \quad \text{where} \quad \bar{z}_{rt} = \bar{z}_{rt-1} + \bar{u}_{rt}. \tag{11}$$

To ensure relevance of the internal instrument, we first assume that productivity shocks exist. Denoting the variance of $\tilde{u}$ by $\sigma^2_{\tilde{u}}$ and the variance of $\bar{u}$ by $\sigma^2_{\bar{u}}$, we require the following.

ASSUMPTION 1: *The variances of productivity shocks at the firm and market levels are strictly positive*; *i.e.*, $\sigma^2_{\tilde{u}} > 0$ *and* $\sigma^2_{\bar{u}} > 0$.

We also allow for measurement error ν_{jt} in the observed value added in the form of a transitory component with finite time dependence; i.e., $y_{jt} = y_j(\bar{a}_{r(j)t}, \tilde{a}_{jt}) + \nu_{jt}$. It is necessary to invoke some restrictions on the relationships between the primitives. Denoting the history of time-varying unobservables at time t by $\Omega_t \equiv \{\tilde{u}_{jt'}, \bar{u}_{rt'}, \epsilon_{ijt'}\}_{i,j,r,t' \leq t}$, we assume the following.

ASSUMPTION 2: *The value-added measurement error* ν_{jt} *is* (*i*) *mean independent of* Ω_T, *i.e*, $E[\nu_{jt} | \Omega_T] = 0$; *and* (*ii*) *has finite time dependence*, *i.e.*, $E[\nu_{jt}\nu_{jt'} | \Omega_T] = 0$ *if* $|t - t'| \geq 2$.

We also allow for measurement errors v_{it} in earnings; i.e., $w_{it} = w_{j(i,t)}(x_i, \bar{a}_{r(j(i,t))t}, \tilde{a}_{j(i,t)t}) + v_{it}$. We then make the following assumption.

ASSUMPTION 3: *The wage measurement error* v_{it} *is mean independent of value-added measurement error and* Ω_T; *i.e.*, $E[v_{it} | \nu_{j1}, \ldots, \nu_{jT}, \Omega_T] = 0$.

Under Assumptions 2 and 3, we derive in online Appendix C.1 the following moment conditions that identify (γ_r, Υ):

$$E\Big[\Delta \tilde{y}_{jt}\big(\tilde{w}_{it+e} - \tilde{w}_{it-e'} - \gamma_r(\tilde{y}_{jt+e} - \tilde{y}_{jt-e'})\big) | S_i = 1, j(i) = j \in J_r\Big] = 0, \tag{12}$$

[9] The assumption of a unit root process for productivity can be replaced by any process with persistence beyond the persistence of the measurement error in value added.

$$(13)\quad E\Big[\Delta\,\bar{y}_{rt}\big(\bar{w}_{rt+e} - \bar{w}_{rt-e'} - \Upsilon(\bar{y}_{rt+e} - \bar{y}_{rt-e'})\big)|S_i = 1, j(i) = j \in J_r\Big] = 0;$$

for $e \geq 2, e' \geq 3$, where $\bar{y}_{rt} \equiv E\big[y_{jt}|S_i = 1, j(i,t) = j \in J_r\big]$ and $\bar{w}_{rt} \equiv E\big[w_{it}|S_i = 1, j(i) = j \in J_r\big]$ are market-level means, $\tilde{w}_{it} = w_{it} - \bar{w}_{rt}$ and $\tilde{y}_{jt} = y_{jt} - \bar{y}_{rt}$ are deviations from market-level means, and $S_i = 1$ denotes a worker who does not change firms between $t - e'$ and $t + e$. These moment conditions are equivalent to regressions of long differences in log earnings on long differences in log value added, instrumented by short differences in log value added. In addition, Assumption 1 ensures the rank condition and consequently the identifiability of these parameters.

To interpret these assumptions, it is useful to return to Figure 1. From Assumption 2, the growth in value added should be the sum of a permanent component and a transitory, mean-reverting component. Due the transitory component, $\Delta\,\bar{y}_{rt}$ could be correlated with $\Delta\,\bar{y}_{rt+e}$ at $e = -2, \ldots, 2$. However, $\Delta\,\bar{y}_{rt}$ should be orthogonal to $\Delta\,\bar{y}_{rt+e}$ in the periods before $e = -2$ and after $e = 2$. Consistent with this orthogonality condition, Figure 1 shows a very similar trend in log value added between the treatment and control groups at these periods. By similar reasoning in Assumption 3, $\Delta\,\bar{y}_{rt}$ should be orthogonal to $\Delta\,\bar{w}_{rt+e}$ in the periods before $e = -2$ and after $e = 2$. Consistent with this orthogonality condition, Figure 1 shows a very similar trend in log earnings between the treatment and control groups at these periods.

It is useful to observe what is and is not being restricted by Assumptions 2 and 3 that deliver the internal instruments. Importantly, these assumptions permit arbitrary correlation between the components of Γ, that is $\big(\bar{p}_r, \tilde{p}_j, g_j(x), x_i\big)$. As a result, our model allows for rich heterogeneity of both firms and workers, and systematic sorting of different workers into different firms. However, Assumption 2 implies that worker-specific innovations to productivity are independent across coworkers and orthogonal both to innovations to firm productivity and to idiosyncratic taste realizations. Moreover, worker-specific wage measurement error is independent of the choice of firm, and, thus, does not matter for worker mobility. This is key to identifying the pass-through rates of firm shocks by looking at changes over time in the earnings of incumbent workers.

Identification Using External Instruments.—To complement the analyses based on internal instruments, we also use external instruments that allow us to relax assumptions on the joint process of amenities, firm productivity, and measurement error in value added. In particular, we can allow both firm-specific and market-specific amenities to vary over time as well as unrestricted dependence over time in the value-added measurement error. The key limitation of the external instruments is that we only have a firm-specific shock for a single industry, not all industries in the economy.

To see why external instruments can achieve identification under weaker assumptions, we derive the wage equation in the presence of time-varying firm $\big(\tilde{g}_{jt}\big)$ and market $\big(\bar{g}_{rt}\big)$ level amenities. As shown in Lemma 8 in online Appendix A.5, the structural wage equation is the same as in (6) except for the amenity term h_j which is now time-varying and given by

$$h_{jt} = \check{h}_{j(i,t)} + \frac{\alpha_{r(i,t)}\beta}{1 + \alpha_{r(i,t)}\lambda\beta}\bar{g}_{r(i,t)t} + \frac{\alpha_{(i,t)}\beta/\rho_{(i,t)}}{1 + \alpha_{r(i,t)}\lambda\beta/\rho_r}\tilde{g}_{j(i,t)t},$$

and can be aggregated at the market level to $\bar{h}_{rt} \equiv E\left[h_{jt} | j \in J_r\right]$.

Suppose we observe an instrument for firm-level TFP $\tilde{a}$, denoted $\tilde{\Lambda}_{jt}$, satisfying the following firm-level condition.

ASSUMPTION 4: *The firm-level instrument $\tilde{\Lambda}_{jt}$ is relevant for firm-level productivity changes, $E\left[\tilde{\Lambda}_{jt}\left(\tilde{a}_{j(i),\, t+e} - \tilde{a}_{j(i),\, t-e}\right) | S_i = 1, j(i) = j \in J_r\right] \neq 0$; and exogenous of changes in firm-level amenities h_{jt}, $E\left[\tilde{\Lambda}_{jt}\left(h_{j(i),\, t+e} - h_{j(i),\, t-e'}\right) | S_i = 1, j(i) = j \in J_r\right] = 0$.*

Furthermore, suppose we observe a market-level instrument for market-level TFP $\bar{a}$, denoted $\bar{\Lambda}_{rt}$, satisfying the following market-level condition.

ASSUMPTION 5: *The market-level instrument $\bar{\Lambda}_{rt}$ is relevant for market-level productivity changes, $E\left[\bar{\Lambda}_{rt}\left(\bar{a}_{rt+e} - \bar{a}_{rt-e}\right) | S_i = 1, j(i) = j \in J_r\right] \neq 0$, and exogenous of changes in market-level amenities $\bar{h}_{rt}$, $E\left[\bar{\Lambda}_{rt}\left(\bar{h}_{rt+e} - \bar{h}_{rt-e}\right) | S_i = 1, j(i) = j \in J_r\right] = 0$.*

Impose Assumptions 4 and 5 and invoke the restrictions on the measurement errors from Assumptions 2 and 3. Then it follows directly that equation (12) recovers γ_r using $\tilde{\Lambda}_{jt}$ instead of $\Delta \tilde{y}_{jt}$, and equation (13) recovers Υ using $\bar{\Lambda}_{rt}$ instead of $\Delta \bar{y}_{rt}$. See online Appendix C.3 for additional details.

In the empirical implementations below, we consider two external instruments. We estimate the firm-level pass-through γ_r in the construction sector using the research design of Kroft et al. (2021). In particular, we instrument for changes in value added using plausibly exogenous product demand shocks at the firm level generated by government procurement auction outcomes. We estimate the market-level pass-through Υ using a shift-share research design in the tradition of Bartik (1991) and Blanchard and Katz (1992). In particular, we instrument for changes in market-level value added using industry-wide value-added growth shocks interacted with the past concentration of that industry's value added across commuting zones.

B. *Quality of Workers and Technology and Amenities of Firms*

To draw inferences about compensating differentials and the sources of wage inequality, we need to recover the quality of workers as well as the technology and amenities of firms. The identification argument consists of three steps. First, we use equations (4) and (8), which show that the variation in log earnings can be decomposed into firm effects (ψ_{jt}), interactions between worker quality (x) and firm complementarities (θ_j), and the pass-through of productivity shocks from firms to workers. We demonstrate how to use the observed changes in earnings for workers moving across firms to separately identify each of these components. Second, we combine these results with equation (7) and the parameters $(\beta, \rho_r, \alpha_r, \lambda)$ identified in the previous subsection to decompose the variation in firm effects into the time-varying TFP components at the firm level ($\tilde{a}_{jt}$) and the market level ($\bar{a}_{rt}$) as well as the amenity component (h_j). Lastly, we use equations (10) and (11) to recover the permanent components of TFP at the firm level $(\tilde{p}_j)$ and market level $(\bar{p}_r)$, as well as the variances of TFP shocks at the firm level $\left(\sigma^2_{\tilde{u}}\right)$ and market level $(\sigma^2_{\bar{u}})$.

We now go through these three steps, referring to online Appendix C.4 for derivations and additional details. Consider first how to recover the time-invariant firm-specific earnings premium ψ_j as well as the firm-worker interaction parameter θ_j using the earnings of movers. To do so, we remove time-varying firm- and market-level components of earnings, which allows us to express the expected earnings of worker i in firm j in terms of only x_i, ψ_j, and θ_j:

$$E\left[\underbrace{w_{it} - \left(\frac{1}{1+\lambda\beta}(\bar{y}_{rt} - \bar{y}_{r1}) + \frac{\rho_r}{\rho_r + \lambda\beta}(\tilde{y}_{jt} - \tilde{y}_{j1})\right)}_{w^a_{it}} \middle| j(i,t) = j \in J_r\right] = \theta_j x_i + \psi_j; \tag{14}$$

where we refer to w^a_{it} as adjusted log earnings, and for $j \in J_r$ we define the firm fixed effect as

$$\psi_j \equiv c_r - \alpha_r h_j + \frac{1}{1+\lambda\beta}\tilde{p}_r + \frac{\rho_r}{\rho_r + \lambda\beta}\bar{p}_j. \tag{15}$$

The fixed effect ψ_j is the common wage intercept in the firm that can be attributed to permanent productivity and amenities.

The structure of the adjusted log earnings equation (14) matches the model of earnings of Bonhomme, Lamadon, and Manresa (2019) and implies the following set of moments:

$$E\left[\left(\frac{w^a_{it+1}}{\theta_{j'}} - \frac{\psi_{j'}}{\theta_{j'}}\right) - \left(\frac{w^a_{it}}{\theta_j} - \frac{\psi_j}{\theta_j}\right) \middle| j(i,t) = j, j(i,t+1) = j'\right] = 0.$$

Bonhomme, Lamadon, and Manresa (2019) show that this set of moments uniquely identifies $\left(\psi_j, \theta_j\right)$ if a rank condition holds that workers moving to a firm are not of the exact same quality as workers moving from that firm; i.e.,

$$E\left[x_i \,|\, j(i,t) = j, j(i,t+1) = j'\right] \neq E\left[x_i \,|\, j(i,t) = j', j(i,t+1) = j\right].$$

We test this rank condition and find that it holds in our data. Given $\left(\psi_j, \theta_j\right)$, x_i is identified from $E\left[\left(w^a_{it} - \psi_{j(i,t)}\right)/\theta_{j(i,t)} \,|\, i\right]$. The estimates of x_i and θ_j allow us to construct the total efficiency units of labor for each firm, which together with the time-varying part of the wage premium at the firm give us a linear system of equations in $h_j, \tilde{a}_{jt}$, and $\bar{a}_{rt}$ for each firm and time. Using the process assumptions on $\tilde{a}_{jt}$ and $\tilde{a}_{rt}$ and the market-level normalization of p_j, we can then identify $(\bar{p}_r, \tilde{p}_j, \sigma^2_{\tilde{u}}, \sigma^2_{\bar{u}})$. See online Appendix C.4 for further details.

C. *Amenities and Worker Preferences*

To make inference about welfare and to perform counterfactuals, it is necessary to also recover the preference term $G_j(X)$. This is done through a revealed preference argument: holding wages fixed, firms with favorable amenities (for a given type of worker) are able to attract more workers (of that type). Conditional on wages, the size and composition of firms and markets should therefore be informative about unobserved amenities.

We formalize this intuition in Lemma 9 in online Appendix C.5, showing that $G_j(X)$ can be identified from data on the allocation of workers to firms and markets. Using the probability that workers choose to work for firm j conditional on selecting market r, $\Pr\left[j(i,t) = j \,|\, X, r(j) = r\right]$, we consider two firms j and j' in the same market r. The differences in size and composition of these firms depend on the gaps in wages and amenities:

$$\underbrace{\lambda\left((\theta_j - \theta_{j'})x_i + \psi_j - \psi_{j'}\right)}_{\text{wage gap}} + \underbrace{\log G_j(X) - \log G_{j'}(X)}_{\text{amenity gap}}$$
$$= \frac{\rho_r}{\beta} \underbrace{\log \frac{\Pr\left[j(i,t) = j | X, r(j) = r\right]}{\Pr\left[j(i,t) = j' | X, r(j') = r\right]}}_{\text{relative size by worker type}},$$

where ρ_r / β is the inverse (pretax) firm-specific labor supply elasticity. Since both the wage gap and the within-market elasticity are already identified, we can recover the value of amenities up to a common market factor by comparing the size and composition of firms. Using a similar argument, we show in online Appendix C.5 that comparing the size and composition of firms across markets allows us to pin down the common market factor.

IV. Estimation Procedure, Parameter Estimates, and Fit

We now present the estimates of the key empirical quantities, including the pass-through rates, the worker and firm effects, and the sorting of workers to firms. Armed with these estimates, we empirically recover and discuss the key model parameters, such as the labor supply curve, the firms' technology, TFP, and amenities, as well as the workers' preferences and productivity. The estimation procedure follows closely the identification arguments laid out in Section III and summarized in Table 1, mostly replacing the population moments with their sample counterparts. In the estimation, however, we impose a few additional restrictions on the heterogeneity of workers, firms and markets. These restrictions are not necessary for identification, but they help reduce the number of parameters to estimate. We now describe these restrictions before presenting the parameter estimates, assessing the fit of the model, and examining overidentifying restrictions.

A. *Empirical Specification*

We begin by restricting the market-specific parameters α_r and ρ_r to be the same within broad markets (as defined in Section II). The restriction on α_r means the scale parameter can vary freely across (but not within) broad regions and sectors of the economy. The assumption on ρ_r restricts the nested logit structure of the preferences. Recall that the parameter ρ_r measures the degree of independence in a worker's taste for alternative firms within the nest. We specified the nest as the combination of commuting zone and two-digit industry. We now restrict the parameter ρ_r to be the same for all nests within each broad market. As a result, labor wedges may vary across but not within broad regions and sectors. In online Appendix Table A.5, we demonstrate that the estimates of $(\beta, \rho_r, \alpha_r)$ and rent shares are robust to alternative definitions of nests, such as states instead of commuting zones and three-digit rather than two-digit industries.

A second set of restrictions is that we draw the firm-specific components θ_j and ψ_j from a discrete distribution. We follow Bonhomme, Lamadon, and Manresa (2019) in using a two-step grouped fixed-effects estimation, which consists of a classification and an estimation step. In a first step, firms are classified into groups indexed by k based on the empirical earnings distribution using the k-means clustering algorithm. The k-means classification groups together firms whose earnings distributions are most similar.[10] Then, in a second step, we estimate the parameters $\theta_{k(j)}$ and $\psi_{k(j)}$. In the baseline specification, we assume there exist ten firm types. We view the assumption of discrete heterogeneity as a technique for dimensionality reduction in the estimation. The estimates of firm effects do not change materially if we instead allow for 20, 30, 40, or 50 firm types (see our online Appendix).

Lastly, we also make the following discreteness assumption for the systematic components of firm amenities:

$$G_j(X) \;=\; \bar{G}_{r(j)}\,\tilde{G}_j\,G_{k(j)}(X),$$

where we define the firm class $k(j)$ within market r using the classification discussed above interacted with the market. This multiplicative structure reduces the number of parameters we need to estimate while allowing for systematic differences in amenities across firms and markets $\left(\tilde{G}_j, \bar{G}_{r(j)}\right)$ and heterogeneous tastes according to the quality of the worker $G_{k(j)}(X)$. As a result, amenities may still generate sorting of better workers to more productive firms, and compensating differentials may still vary across firms, markets, and workers. For estimation purposes, we take advantage of the derivations in online Appendix C.5, which express the preference components $\left(\bar{G}_{r(j)}, \tilde{G}_j, G_{k(j)}(X)\right)$ as functions of the size and composition of firms and markets. In the estimation of $G_k(X)$, we discretize the distribution of X into ten points of support by ranking the estimated values of X and evenly grouping workers into ten bins. In the estimation of $\bar{G}_r$, we also group markets into ten different market types based on their realized empirical distribution of earnings, using the same k-means algorithm as discussed above.

B. *Estimates of the Pass-Through Rates*

We now present the estimates of the pass-through rates, finding that the internal and the external instruments give very similar results.

[10] Here, we follow Bonhomme, Lamadon, and Manresa (2019). Concretely, we use a weighted k-means algorithm with 100 randomly generated starting values. We use the firms' empirical distributions of log earnings on a grid of 10 percentiles of the overall log-earnings distribution.

TABLE 2—ESTIMATES OF PASS-THROUGH RATES AND LABOR SUPPLY ELASTICITIES

Panel A	Firm-level estimation	
Instrumental variable	Pass-through ($E[\gamma_r]$)	Implied elasticity
Internal instrument:	0.13	6.52
Lagged firm-level value-added shock under MA(1) errors	(0.01)	(0.56)
External instrument:	0.14	6.02
Procurement auction shock at firm level	(0.07)	(3.37)

Panel B	Market-level estimation	
Instrumental variable	Pass-through (Υ)	Implied elasticity
Internal instrument:	0.18	4.57
Lagged market-level value-added shock under MA(1) errors	(0.03)	(0.80)
External instrument:	0.19	4.28
Shift-share industry value-added shock	(0.04)	(1.13)

Notes: This table summarizes estimates of the pass-through rates and implied pretax labor supply elasticities when using internal or external instrumental variables. Panel A provides these estimates at the firm level, while panel B provides these estimates at the market level.

Estimates Using Internal Instruments.—In Table 2, we use the internal instruments to estimate the pass-through rates and the implied labor supply elasticities at both the firm and market levels. We directly implement the sample counterpart to equation (12) at the firm level under the assumption that measurement errors follow an MA(1) process ($e = 2, e' = 3$). We allow γ_r, and thus ρ_r, to vary by broad market, where a broad market is a set of markets.[11] In practice, we consider eight broad markets defined by a census region and goods versus services sectors (see Section II). Similarly, we directly implement the sample counterpart to equation (13) to estimate Υ.

In the first row of panel A, we estimate that the average firm-level pass-through rate γ_r is about 0.13 with a standard error of about 0.01. This suggests that the earnings of an incumbent worker increases by 1.3 percent if her firm experiences a 10 percent permanent increase in value added, controlling for common shocks in the market. The firm-level pass-through rate implies a firm-level (pretax) labor supply elasticity of about 6.5. This estimate implies that, holding all other firms' wage offers fixed, a 1 percent increase in a firm's wage offer increases that firm's employment by 6.5 percent.[12]

In the first row of panel B, we estimate that the market-level pass-through rate Υ is about 0.18 with a standard error of about 0.03. This suggests that the earnings of incumbent workers increases by 1.8 percent if all firms in their market experience a 10 percent permanent increase in value added. This finding highlights the importance of distinguishing between shocks that are specific to workers in a given firm versus those that are common to workers in a market. The market-level pass-through rate

[11] We estimate γ_r and Υ separately for each cohort t and then average across t. By doing so, we avoid the problem pointed out by Callaway and Sant'Anna (2021) that cohorts can be negatively weighted in pooled cohort DiD estimators.

[12] This estimate is at the upper end of the range of estimates found in a recent empirical literature. Card et al. (2018) pick 4 percent as the preferred value in their calibration exercise. A related literature using experimentally manipulated piece rates for small tasks typically finds labor supply elasticities in the 2–6 percent range (Caldwell and Oehlsen 2018; Dube, Manning, and Naidu 2020; Sokolova and Sorensen 2020).

implies a market-level (pretax) labor supply elasticity of about 4.6. This estimate implies that, if all firms in a market increase their wage offers by 1 percent, each firm's employment in the market increases by 4.6 percent.

In online Appendix D.1, we provide a number of specification and robustness checks for the pass-through estimates using internal instruments. First, we show that the firm-level and market-level pass-through rates are not sensitive to using an MA(2) specification rather than an MA(1) specification for the transitory shock process, which is consistent with previous work (see, e.g., Guiso, Pistaferri, and Schivardi 2005; Friedrich et al. 2019). Second, when allowing for transitory shocks to value added to also pass-through to earnings, we find very small pass-through rates of transitory shocks while the pass-through rates for permanent shocks are not materially affected. Third, in online Appendix Figure A.1, we explore robustness of the pass-through estimates across subsamples of workers, finding that the pass-through rates do not vary that much by the worker's age, previous wage, gender, or tenure. Fourth, while value added is a natural measure of firm performance (see the discussion by Guiso, Pistaferri, and Schivardi 2005), it is reassuring to find that the estimates of the pass-through rates are broadly similar if we measure firm performance by operating profits; earnings before interest, tax and depreciation (EBITD); or value added net of reported depreciation of capital. We also show that the estimated pass-through rates are in the same range as our baseline result if we exclude multinational corporations or exclude the largest firms.

Lastly, to compare with existing work (e.g., Guiso, Pistaferri, and Schivardi 2005), we also consider estimating the restricted specification that imposes $\gamma_r = \Upsilon, \forall r$. In our model, this is equivalent to imposing $\rho_r = 1, \forall r$, so that idiosyncratic worker preferences over firms are uncorrelated within markets. The estimated pass-through rate is then 0.14, which is broadly similar to the existing literature that ignores the distinction between firm- and market-level shocks.

Estimates Using External Instruments.—Our analyses so far have relied on statistical processes of earnings and value added. An advantage of our approach is that it provides both a market-level and a firm-level instrument for each firm, allowing us to draw inference for the entire population. While we have provided a number of diagnostics and sensitivity checks that support our approach, the identifying assumptions remain debatable. To examine the sensitivity of our results to the assumptions on the statistical processes for value added and earnings—and thereby improve the quality and credibility of our analyses—we now provide complementary analyses based on external instruments.

To recover the firm-level pass-through and labor supply elasticity, we take advantage of the same research design as Kroft et al. (2021), except we apply it to our estimation sample and parameters of interest.[13] In particular, we examine how firms in the construction sector respond to a plausibly exogenous shift in product demand through a DiD design that compares first-time procurement auction winners to the

[13] The main limitation of the approach using external instruments is that the instrument may only be available for a subsample of firms. The instrument of Kroft et al. (2021) is only defined for the construction industry, which may not be nationally representative. To investigate this possibility, we apply the internal instruments design to the construction industry, finding a firm-level pass-through rate of about 0.15 and a firm-level labor supply elasticity of about 5.5, which are similar to the estimates for the full sample.

firms that lose, both before and after the auction. Formally, consider the cohort of firms that received a procurement contract in year t ($\mathcal{D}_{jt} = 1$) and the set of comparison firms that bid for a procurement in year t but lost ($\mathcal{D}_{jt} = 0$). Let e denote an event time relative to t and $\bar{e}$ denote the omitted event time. For each event time $e = -4, \ldots, 4$, the DiD regression is implemented as

$$w_{jt+e} = \underbrace{\sum_{e' \neq \bar{e}} \mathbf{1}\{e' = e\}\, \mu_{te'}}_{\text{event time fixed effect}} + \underbrace{\sum_{j'} \mathbf{1}\{j' = j\}\, \psi_{j't}}_{\text{firm fixed effect}} + \underbrace{\sum_{e' \neq \bar{e}} \mathbf{1}\{e' = e\}\, \mathcal{D}_{jt} \vartheta_{te'}}_{\text{treatment status by event time}} + \underbrace{\nu_{jte}}_{\text{residual}}.$$

We report the average across t of the estimated ϑ_{te} parameter, which can be interpreted as the average treatment effect on the treated for those firms receiving an exogenous demand shock.[14] We use the same regression model to estimate the effects of an exogenous demand shock on log value added. The ratio of the effects on log mean earnings and log value added is the pass-through rate. We cluster standard errors at the firm level and find a strong first stage coefficient; see online Appendix C.3 for additional details. Using this external instrument, we find in the second row of panel A in Table 2 a firm-level pass-through rate of 0.14 and labor supply elasticity of about six, which are very similar to our baseline estimates under Assumptions 2–3.

In order to provide instrumental variable estimates of the market-level pass-through and labor supply elasticity, we follow Bartik (1991) and Blanchard and Katz (1992) in constructing a shift-share instrument. Let cz denote a commuting zone and ind denote a two-digit NAICS industry, and recall that a market is defined by the pair (cz, ind) in our main specification. Let $\bar{Y}_{cz,ind,t}$ denote the total value added in the (cz, ind) at time t, and $\bar{Y}_{ind,t} \equiv \sum_{cz} \bar{Y}_{cz,ind,t}$ denote aggregate industry value added. Then, the shift-share total value-added shock to the commuting zone is constructed as $\sum_{ind} S_{cz,ind,t_0} \zeta_{ind,t}$, where $S_{cz,ind,t} \equiv \bar{Y}_{cz,ind,t} / \sum_{ind} \bar{Y}_{cz,ind,t}$ is the exposure of the cz to a particular ind (the "share" component), $\zeta_{ind,t} \equiv \log \bar{Y}_{ind,t} - \log \bar{Y}_{ind,t-\tau}$ is the log change in industry value added (the "shift" component), and we measure the share component at the earliest period in the sample. To estimate the market-level pass-through, we regress the log change in earnings per stayer in the commuting zone on the log change in total value added in the commuting zone, instrumented by the shift-share value-added shock. We find a strong first stage; see online Appendix C.3 for additional details. We find in the second row of panel B in Table 2 a market-level pass-through rate of 0.19 and labor supply elasticity of about 4.3, which are very close to our baseline estimates under Assumptions 2 and 3.

C. *Estimates of the Parameters Needed to Recover Rents*

Once we have estimates of firm-level and market-level pass-through rates (γ_r, Υ) and tax progressivity λ, we can recover the model parameters $(\beta, \rho_r, \alpha_r)$ needed to identify rents. We begin by estimating the tax progressivity parameter λ as well as the proportional tax parameter τ outside the model. In each year, we regress log

[14] We estimate ϑ_{te} for all t and e and then average across t, using the delta method to compute standard errors (which are clustered at the firm level j to account for serial correlation). By doing so, we avoid the problem pointed out by Callaway and Sant'Anna (2021) that cohorts can be negatively weighted in pooled cohort DiD estimators.

net household income (earnings plus other income minus taxes) on log household gross income (earnings plus other income) for our sample. The construction of these income measures is detailed in online Appendix B. The intercept from this regression gives us τ while λ is identified from the slope coefficient. We estimate τ of around 0.89 whereas λ is estimated to be about 0.92.[15] In a proportional tax-transfer system, λ is equal to one and $(1 - \tau)$ is the proportional effective tax rate. By contrast, if $0 < \lambda < 1$, then the marginal effective tax rate is increasing in earnings. Thus, our estimate indicates modest progressivity in the US tax system. Online Appendix Figure A.2 shows how well our parsimonious tax function approximates the effective tax rates implicit in the complex US tax-transfer system. Comparing predicted log net income from the regression to the observed log net income across the distribution of log gross income, we find this specification provides an excellent fit.

Armed with λ, we can identify $(\beta, \rho_r, \alpha_r)$ using the pretax labor supply elasticities at the firm level and market level summarized in Table 2 and the equations in Section IIIA. We estimate the (posttax) market-level labor supply elasticity β to be 4.99. This finding suggests considerable variability across workers in the idiosyncratic tastes for firms. We estimate the average ρ_r across markets to be 0.70. This implies a substantial correlation of about 0.5 in the idiosyncratic tastes of workers across firms within the same industry and location. We estimate the average α_r across markets to be 0.21. This indicates that returns to labor $1 - \alpha_r$ are about 0.79 on average, consistent with modestly diminishing returns.

In online Appendix Figure A.3(a), we report the estimates of (posttax) firm-level labor supply elasticities from the main specification. On average, this elasticity is about 7.3. Behind this average, however, there is important variation. Empirically, labor supply is most inelastic in the goods sector (which has lower rates of unionization) and more elastic in the Northeast (which has lower rates of right-to-work law coverage). These results are consistent with stronger institutions that favor workers being associated with less wage-setting power of firms. However, these are only correlational patterns and may not be given a causal interpretation.

In online Appendix Table A.5, we demonstrate that the estimates of $(\beta, \rho_r, \alpha_r)$ as well as the rent shares are robust to various alternative market definitions. First, we show that the estimates of β and the average rent shares are robust to shutting down broad market heterogeneity (that is, restricting $\rho_r = \bar{\rho}$ and $\alpha_r = \bar{\alpha}$). Next, we find that the results are materially unchanged when, instead of NAICS two-digit codes, we define the industry to be more aggregated (NAICS supersectors) or less aggregated (NAICS three-digit codes). Lastly, we demonstrate that the results are materially unchanged when, instead of commuting zones, we define the geographic units to be more aggregated (states) or less aggregated (counties).

D. *Worker Heterogeneity*, *Firm Wage Premiums*, *and Worker Sorting*

We estimate worker effects x_i, firm wage premiums $\psi_{j(i)}$, and firm-worker interaction parameters $\theta_{j(i)}$ following closely Section IIIB. To do so, we first construct adjusted log earnings w_{it}^a using equation (14) and the estimates of $(\beta, \rho_r, \alpha_r, \lambda)$ discussed in

[15] These results mirror closely existing US estimates of τ and λ (Guner, Kaygusuz, and Ventura 2014; Heathcote, Storesletten, and Violante 2017).

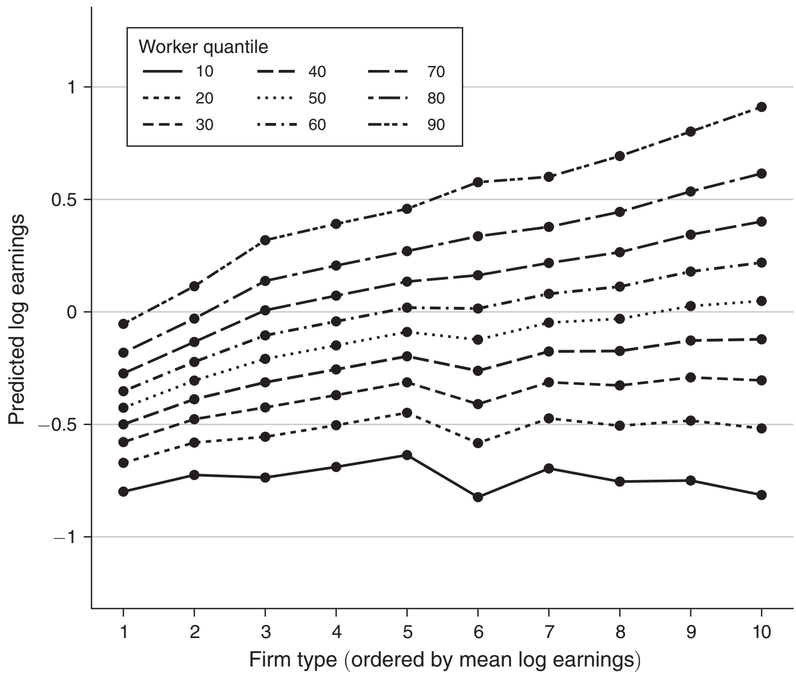

Figure 2. Predicted Log Earnings from the Estimated Model

Notes: In this figure, we summarize the estimates of worker ability x_i, time-invariant firm premiums $\psi_{k(j)}$, and firm-worker interactions $\theta_{k(j)}$ for ten firm groups k. On the y-axis, we plot the predicted log earnings for each firm type using the estimated equation $\psi_k + \theta_k \cdot x_q$, where each quantile in the distribution of worker types x_q is presented as a separate line. On the x-axis, firm types are ordered in ascending order, where "lower" and "higher" types refer to low and high mean log earnings.

the previous subsection.[16] Given the classification of firms into groups discussed above, we implement the estimating equations provided in online Appendix C.4 on w_{it}^a in order to recover $\left(\psi_{k(j)}, \theta_{k(j)}\right)$ for each group k. Then, given $\left(\psi_k, \theta_k\right)$, we recover x_i from equation (14), as described in Section IIIB.[17]

Figure 2 summarizes the estimates (see our online Appendix for further details). On the y-axis, we plot the predicted log earnings for each firm type using the equation $\psi_k + \theta_k x_q$, where each quantile in the distribution of worker types x_q is presented as a separate line. On the x-axis, firm types are ordered in ascending order of mean log earnings. If $\psi_{k(j)}$ did not vary across firm types k, the typical worker would not experience an upward slope when moving from lower to higher firm types. We find a weakly positive slope, indicating some role for time-invariant firm

[16] In a preliminary step, we regress log earnings on a full set of indicators for calendar years and a cubic polynomial in age, where we follow Card et al. (2018) in restricting the age profile to be flat at age 40. Thus, w_{it} is log earnings net of age effects and common aggregate time trends. We verify that the two-way fixed-effect estimates are nearly identical if jointly estimating the age and year effects with the firm and worker fixed effects.

[17] Note that $\left(\psi_{k(j)}, \theta_{k(j)}\right)$ are estimated using the movers in the connected set of firms, while x_i is estimated for both movers and nonmovers in this connected set. Since x_i is estimated using an average over time for a given worker, the estimated variance in x_i may be upward biased due to serial correlation in earnings measurement errors or finite sample bias. In our online Appendix, we derive and estimate the bias in the estimated variance of x_i for the case in which the error process is unit root plus MA(0), finding a small bias for our panel length.

fixed effects. If $\theta_{k(j)}$ did not vary across firm types, then the lines in this plot would have the same slope for lower and higher worker types. Instead, the results show clear evidence that higher worker types experience a more positive slope across firm types. As shown in online Appendix C.4, the parameters governing nonlinearities are identified from comparing the gains from moving from a low to a high type of firm for workers of different quality. As evident from Figure 2, the gains from such a move are considerably larger for better workers. For example, moving from the lowest to the highest type of firm increases earnings by 15, 47, and 80 percentage points for individuals at the 20, 50, and 80 percentiles of worker quality.

To compare and interpret the estimates of x_i, ψ_{jt}, and θ_j, we rearrange equation (14) so that we can decompose log earnings as

$$w_{it} = \underbrace{\bar{\theta}(x_i - \bar{x})}_{\tilde{x}_i} + \underbrace{\psi_{j(i,t),t} - \psi_{j(i,t)}}_{\tilde{\psi}_{j(i,t),t}} + \underbrace{\left(\psi_{j(i,t)} + \theta_{j(i,t)}\bar{x}\right)}_{\tilde{\psi}_{j(i,t)}} + \underbrace{\left(\theta_{j(i,t)} - \bar{\theta}\right)(x_i - \bar{x})}_{\varrho_{ij(i,t)}} + v_{it},$$

where $\bar{\theta} \equiv E\left[\theta_{j(i,t)}\right]$ and $\bar{x} \equiv E[x_i]$. This equation decomposes the earnings of worker i in period t into four distinct components: $\tilde{x}_i$ gives the direct effect of the quality of worker i (evaluated at the average firm), $\tilde{\psi}_{j(i,t),t}$ is the time variation in the firm premium due to the pass-through of value-added shocks, $\tilde{\psi}_{j(i,t)}$ represents the average effect of firm j (evaluated at the average worker), $\varrho_{ij(i,t)}$ captures the interaction effect between the productivity of firm j and the quality of worker i, and v_{it} is the measurement error.

Using this representation, we obtain a variance decomposition of log earnings:

$$\begin{aligned} \mathrm{var}[w_{it}] = {} & \underbrace{\mathrm{var}[\tilde{x}_i]}_{\text{i) Worker Quality: 71.6\%}} + \underbrace{\mathrm{var}\left[\tilde{\psi}_{j(i,t)}\right]}_{\text{ii) Firm Effects: 4.3\%}} + \underbrace{2\mathrm{cov}\left[\tilde{x}_i, \tilde{\psi}_{j(i,t)}\right]}_{\text{iii) Sorting: 13.0\%}} \\ & + \underbrace{\mathrm{var}[v_{it}]}_{\text{iv) Meas. Error: 10.0\%}} + \underbrace{\mathrm{var}\left[\varrho_{ij(i,t)}\right] + 2\mathrm{cov}\left[\tilde{x}_i + \tilde{\psi}_{j(i,t)}, \varrho_{ij(i,t)}\right]}_{\text{v) Interactions: 0.9\%}} \\ & + \underbrace{\mathrm{var}\left[\tilde{\psi}_{j(i,t),t}\right] + 2\mathrm{cov}\left[\tilde{x}_i, \tilde{\psi}_{j(i,t),t}\right]}_{\text{vi) Time-varying Effects: 0.3\%}} . \end{aligned}$$

The first conclusion is that the most important determinant of earnings inequality is worker quality, which explains about 72 percent of the variation in log earnings. The second conclusion is that firm fixed effects explain around 4 percent of the variation in log earnings, with a standard deviation of firm effects of about 0.12. In order to place the firm effect estimates in context, we compare them to the literature on the effects of job displacement. The majority of these studies focus on the United States and find that long-run earnings losses from a job displacement are around 10-20 percent (see the survey by Couch and Placzek 2010). Thus, a job displacement has about the same effect on earnings as moving to a firm that is one standard deviation lower in the bias-corrected firm effects distribution.

The third conclusion is that the US economy is characterized by strong sorting of high quality workers to high paying firms, with a correlation of 0.37 between worker and firm fixed effects. Indeed, sorting explains about three times as much of the variation in log earnings as firm fixed effects on their own. The fourth conclusion is that the dispersion of interaction effects across firms explains about 1 percent of earnings inequality.[18] The final conclusion is that the time-varying component of firm effects due to the pass-through of TFP shocks at the firm level and market level explains less than half of a percent of earnings inequality, indicating a small role for the pass-through of shocks in cross-sectional earnings inequality.

In online Appendix D.2, we discuss a number of specification checks. First, we consider estimating the model when excluding firm-worker interactions (imposing $\theta_j = \bar{\theta}$) or excluding time-varying effects (imposing $\gamma_r = \Upsilon = 0$). Second, we assess the degree of limited mobility bias in our data. Third, we consider increasing the number of groups in the *k*-means algorithm from the baseline value of 10 up to 50 in increments of 10, finding that the estimates are not sensitive to the number of groups. Fourth, we compare estimates for two distinct time periods, finding that the variance decomposition estimates change little over time. Fifth, we consider a number of checks on the reliability of the estimates of the interaction parameters θ_j. These include a comparison between our estimates and the interaction effects that arise due to observed worker heterogeneity and a check against data on hourly wages instead of annual earnings.

E. *Estimates of Remaining Parameters and Overidentification Checks*

We conclude this section by discussing estimates of the remaining parameters. We recover TFP and amenity components $\left(\tilde{a}_{jt}, \bar{a}_{rt}, h_j\right)$ from the estimates of $\left(x_i, \psi_j, \theta_j\right)$ using the approach explained in Section IIIB. Given estimated TFP and amenities, we can use them to construct predicted values of firm effects, value added, efficiency units of labor, and wage bill. In online Appendix Figure A.4, we compare the observed and the predicted values of these variables in order to examine the model fit. We make this comparison separately according to the actual and predicted firm size.[19] It is reassuring that the model fits them well.

As an overidentification check, in online Appendix Figure A.5, we take advantage of the fact that there are two distinct methods to identify the amenity component h_j. One possibility is the baseline approach discussed in Section IIIB, which recovers it from the equation for firm wage premiums. Another possibility is to use the fixed-point definition of h_j as a function of $(\tilde{P}_j, \bar{P}_r, G_j(X))$, as shown in Lemma 3 in online Appendix A.1. This definition comes from the equilibrium constraint of the model, which we do not directly use in the baseline estimation. Online Appendix Figure A.5 shows that the estimates of h_j we obtain from solving the equilibrium constraint of the model are very similar to the baseline estimates. This finding increases our confidence in the moment conditions implied by our economic model.

[18] Using a random effects approach, Woodcock (2015) also provides a decomposition with firm-worker interactions in the United States. He also finds that interactions explain less variation than firm effects. However, the approach of Woodcock (2015) requires that match heterogeneity is purely idiosyncratic. By contrast, we find systematic deviations from the linear model in a way that is structurally related to other sources of heterogeneity, such as worker effects and firm effects.

[19] Note that firm effects and efficiency units of labor are targeted directly, while the relationship with firm size is not, so subfigures (b and c) in online Appendix Figure A.4 are only untargeted in the relationship with firm size. The other subfigures are untargeted in both dimensions.

As another overidentification check, we combine the earnings equation (4) with the equation for the wage bill (6) (instead of value-added equation (5)) to estimate the firm-specific labor supply elasticity using our internal instruments. This does not alter the conclusion that each firm is facing an economically and statistically significant upward-sloping labor supply curve. In other words, firms have considerable wage-setting power. In terms of magnitudes, we estimate a firm-specific labor supply elasticity above six based on value-added changes and around five based on wage bill changes. Given the precision we have, however, one may want to be cautious in drawing strong conclusions about meaningful differences between these point estimates.

V. Empirical Insights from the Model

We now present five sets of empirical insights from the estimated model. These insights require an explicit model of the labor market, and, thus, they may be susceptible to model misspecification. As shown in Section III, however, many of the insights do not require knowledge of all the structural parameters. Thus, some of our findings may be considered more reliable than others. To make this clear, we first present the findings that rely on the least assumptions and then move to those that require additional restrictions on the functioning of the labor market.

A. *Rents and Labor Wedges*

Our first set of insights from the estimated model is about the rents and labor wedges that arise due to imperfect competition in the labor market. Table 3 presents estimates of the size of rents earned by American firms and workers from ongoing employment relationships. We report national averages and refer to online Appendix Table A.7 for the market-specific results.

We find evidence of a significant amount of rents and imperfect competition in the US labor market due to horizontal employer differentiation. At the firm level, we estimate that workers are, on average, willing to pay 13 percent of their annual earnings to stay in their current jobs. This corresponds to about \$5,400 per worker. By comparison, firms earn, on average, 11 percent of profits from rents (with profits being measured as value added minus the wage bill). This amounts to about \$5,800 per worker in the firm. Thus, we conclude that firm-level rents from imperfect competition in the labor market are split equally between employers and their workers.

At the market level, we estimate that rents are considerably larger than firm-level rents. Workers are, on average, willing to pay about \$7,300 (18 percent of their annual earnings) to avoid having to work for a firm in a different market, which is almost \$1,900 more than they would pay to avoid having to work for a different firm in the same market. The relatively large market-level rents reflect that firms within the same market are more likely to be close substitutes than firms in different markets. At the market-level, rents are again split almost evenly between firms and their workers.

In online Appendix Figure A.3, we show that labor wedges are significant and vary substantially across markets. On average, the marginal revenue product of labor is 15 percent higher than the wage. Furthermore, the labor wedges are most pronounced in the goods sector (which have higher values of ρ_r). In the Western

TABLE 3—ESTIMATES OF RENTS AND RENT SHARING (NATIONAL AVERAGES)

	Rents and rent shares			
	Firm level		Market level	
Workers' rents				
Per-worker dollars	5,447	(395)	7,331	(1,234)
Share of earnings	13%	(1%)	18%	(3%)
Firms' rents				
Per-worker dollars	5,780	(1,547)	7,910	(1,737)
Share of profits	11%	(3%)	15%	(3%)
Workers' share of rents	49%	(4%)	48%	(3%)

Notes: This table displays our main results on rents and rent sharing. Standard errors are in parentheses and are estimated using 40 block bootstrap draws in which the block is taken to be the market.

region of the United States, for example, the labor wedge is 6 percentage points larger for firms in the goods sector as compared to those in the service sector.

B. *Compensating Differentials*

The estimates of rents suggest the average American worker is far from the margin of indifference in her choice of firm, and would maintain the same choice even if her current firm offered significantly lower wages. In other words, the average worker considers amenities important to her choice of firm. This finding does not, however, imply marginal workers view the amenities of the current firm as much better or much worse than those offered by other firms. The second insight from our estimated model is the quantification of the preferences for amenities of marginal workers, as captured by the compensating differentials.

The estimates of the expected compensating differentials are displayed in online Appendix Figure A.6. To estimate these quantities, we randomly draw two firms, j and j', from the overall distribution of firms (where each firm is drawn with probability proportional to its size). Using Result 3, we compute the compensating differential between j and j' for a worker of given quality x as $\psi_{j'} + x\theta_{j'} - \psi_j - x\theta_j$. We repeat this procedure for many draws of firms.

The solid horizontal line in online Appendix Figure A.6 shows the mean absolute value of compensating differentials for marginal workers. For two randomly drawn firms, the one with worse amenities can be expected to pay an additional 18 percent in order to convince marginal workers (of average quality) to accept the job. There is, however, considerable heterogeneity in compensating differentials according to worker quality. The upward-sloping solid line shows how the expected compensating differential varies with worker quality. For high quality workers (ninety-fifth percentile in the national distribution), the expected compensating differential is as large as 30 percent. By comparison, marginal workers of low quality (fifth percentile in the national distribution) require less than 10 percent additional pay to work in the firm with unfavorable amenities.

The dashed lines of online Appendix Figure A.6 display the compensating differentials across firms within a market. To compute these quantities, we use the same procedure as above, except we now compare firms within each market. For two randomly drawn firms in the same market, the one with worse amenities can be expected to pay an additional 14 percent in order to convince marginal workers (of average quality) to accept the job. This suggests that three-quarters of compensating differentials reflect differences in amenities within, rather than between, markets.

C. *Understanding Firm Effects and Their Implications for Inequality*

The third set of insights from our estimated model shed light on why different firms pay identical workers differentially and the implications of firm premiums for inequality in wages versus total compensation (inclusive of amenities). As evident from equation (8), variation in the firm effects ψ_{jt} depends not only on the heterogeneity in firm amenities, but also on the differences in productivity across firms as well as the covariance between productivity and amenities within firms. The reason is that firms have wage-setting power, which generates a positive relationship between the firm's productivity and the wages it pays. To quantify the importance of these sources, consider the decomposition

$$\begin{aligned} \operatorname{var}\left(\psi_{j(i,t),t}\right) = & \underbrace{\operatorname{var}\left(c_r - \alpha_r h_{j(i,t)}\right)}_{\text{Amenities}} + \underbrace{\operatorname{var}\left(\frac{1}{1+\alpha_r\lambda\beta}\bar{a}_{rt} + \frac{1}{1+\alpha_r\lambda\beta/\rho_r}\tilde{a}_{j(i,t),t}\right)}_{\text{TFP}} \\ & + \underbrace{2\operatorname{cov}\left(c_r - \alpha_r h_{j(i,t)}, \frac{1}{1+\alpha_r\lambda\beta}\bar{a}_{rt} + \frac{1}{1+\alpha_r\lambda\beta/\rho_r}\tilde{a}_{j(i,t),t}\right)}_{\text{Covariance between amenities and TFP}}. \end{aligned}$$

These components can be broken down between and within broad markets and, within broad markets, further decomposed within and between markets.[20]

The results from these decompositions are reported in Table 4. The first panel reports results from our preferred approach described in Section IIIB. The second panel reports results from the standard approach of Abowd, Kramarz, and Margolis (1999), which may suffer from bias due limited worker mobility across firms and rules out firm-worker interactions. We find that the shares of the variance in firm effects explained by each component are fairly insensitive across these alternative estimation procedures. Either way, the results suggest substantial variation in amenities and productivity across firms. If one were to ignore the covariance between amenities and productivity, the considerable heterogeneity in amenities and productivity across firms would imply that firm effects should have a large contribution to inequality. However, productive firms tend to have good amenities, which act as compensating differentials and push wages down in productive firms. As a result, firm effects explain only a few percent of the overall variation in log earnings. For example, firm effects within detailed markets explain 3.1 percent of the variation in log earnings, which is much less than predicted by the variances of firm productivity (8.6 percent) and amenities (7.1 percent).

[20] Recall that a broad market is a census region interacted with a broad sector (goods or services), while a market is a commuting zone interacted with a two-digit NAICS industry.

Table 4—Decomposition of the Variation in Firm Premiums

	Between broad markets	Within broad markets: Between detailed markets	Within broad markets: Within detailed markets
Panel A. Preferred specification			
Total	0.4%	2.0%	3.1%
Decomposition			
Amenity differences	16.0%	7.8%	7.1%
TFP differences	15.5%	11.9%	8.6%
Amenity-TFP covariance	−31.1%	−17.7%	−12.6%
Panel B. Log-additive fixed effects specification			
Total	0.6%	2.8%	6.6%
Decomposition			
Amenity differences	15.7%	6.5%	7.2%
TFP differences	14.6%	13.2%	10.0%
Amenity-TFP covariance	−29.8%	−16.9%	−10.5%

Notes: This table displays our estimates of the decomposition of time-varying firm premium variation in three levels: variation between broad markets, between detailed markets (within broad markets), and between firms (within detailed markets). Broad markets are defined as the combination of census regions and broad sectors, and detailed markets are defined as the combination of industries and commuting zones. We decompose the variation in time-varying firm premiums into the contributions from amenity differences, TFP differences, and the covariance between amenity and TFP differences. All components are expressed as shares of log earnings variation. The first panel reports results from our preferred approach described in Section IIIB. The second panel reports results from the standard approach to estimate firm effects, as in Abowd, Kramarz, and Margolis (1999), which may suffer from bias due to limited worker mobility across firms and does not permit firm-worker interactions.

The positive correlation between TFP and amenities gives a negative contribution to earnings inequality, as indicated by the negative terms reported in the last row of Table 4. Since labor supply is upward sloping, more productive firms must offer greater total compensation per worker (inclusive of amenities) than smaller firms to achieve their optimal size. Since TFP and amenities are positively correlated, high TFP firms disproportionately offer compensation through amenities rather than wages. Thus, earnings inequality would be even greater if amenities were uncorrelated with TFP, since high TFP firms would rely more heavily on paying higher wages instead of higher amenities.

D. *Understanding Why Different Workers Sort into Different Firms*, *and the Implications of This Sorting for Inequality*

We now present the fourth insight from our estimated model: Production complementarities are important both to understand why better workers are sorting into better firms and to explain the significant inequality contribution from worker sorting.

To understand how we reach these conclusions, recall that the data reveal positive sorting between worker and firm fixed effects, which contributes significantly to inequality in earnings (see the discussion in Section IVD and our online Appendix). In Figure 3 panel A, we present the sorting of workers to firms in our data. In this figure, firm types are ordered along the x-axis in ascending order of mean log earnings. On the y-axis, we rank workers by their worker effects x_i and divide them into five equally sized quintile groups. The bars present the share of workers within each firm type belonging to each quintile group. Figure 3 panel A reveals that the highest

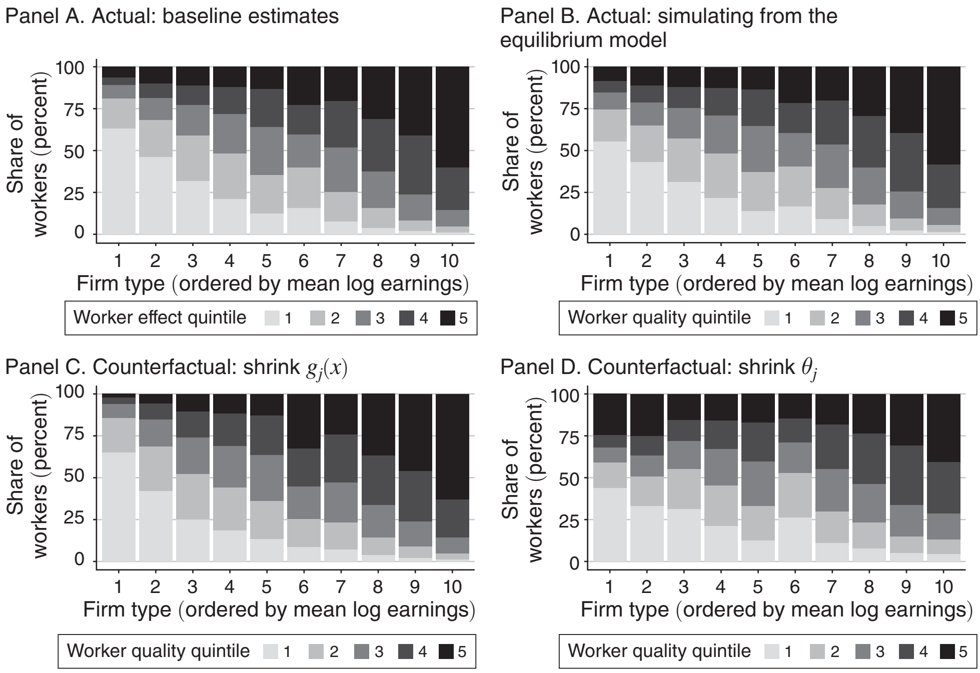

Figure 3. Actual and Counterfactual Composition of the Workforce by Firm Types

Notes: In this figure, we first compare the baseline estimates of the worker quality composition by firm type from the equation for firm wage premiums (15) in panel A versus those estimated using the equilibrium constraint by solving the fixed-point definition of h_j as a function of $(\tilde{P}_j, \bar{P}_r, G_j(X))$, as shown in Lemma 3 in online Appendix A.1, then simulating the sorting of workers to firms (panel B). Then, we reduce the heterogeneity across firms in amenities or production complementarities by replacing either $g_j(x)$ with $(1-s)\,g_j(x) + s\,\bar{g}_j$ or θ_j with $(1-s)\,\theta_j + s\bar{\theta}$, where $\bar{g}_j = E_x[g_j(x)]$, $\bar{\theta} = E[\theta_j]$, then resimulate the equilibrium. Here, $s \in [0,1]$ is the shrink rate with $s = 0$ corresponding to the baseline model. We report the quality of the workforce by firm type for the counterfactual economies with $s = 1/2$ for either amenities (panel C) or production complementarities (panel D).

quality workers are vastly overrepresented at the highest paying firms. For example, in the lowest firm type, less than 10 percent of workers belong to the top quality quintile group. By contrast, in the highest firm type, about 60 percent of workers belong to the top group.

To build confidence in the estimated pattern of sorting, we exploit that there are two distinct methods to estimate sorting. One possibility is the baseline approach discussed in Section IIIB, which recovers worker and firm fixed effects from the equation for firm wage premiums (14) and uses the allocation of workers to firms observed in the data. Another possibility is to use the fixed-point definition of h_j as a function of the estimated values of $(\tilde{P}_j, \bar{P}_r, G_j(X))$, as shown in Lemma 3 in online Appendix A.1, then simulate the allocation of worker quality to firm types using only estimated model parameters. This approach relies on the equilibrium constraint of the model, which we do not directly use in the baseline estimation. The results from this simulation are presented in Figure 3 panel B. The strong similarity between panels A and B in Figure 3 serves as an overidentification check that increases our confidence in the moment conditions implied by our economic model.

As discussed in Section IC, there are several possible reasons why better workers are overrepresented in higher paying firms. One possible reason is that productive firms have better amenities, and high ability workers may value amenities more than low ability workers. Another possible reason is complementarities in production, which lead productive firms to offer relatively high wages to better workers and thus incentivizes better workers to sort into productive firms. We now perform counterfactuals that help quantify the importance of these distinct reasons for sorting.

In the counterfactuals we consider, we reduce the heterogeneity across firms in amenities or production complementarities by replacing either $g_j(x)$ with $(1-s)\,g_j(x) + s\,\bar{g}_j$ or θ_j with $(1-s)\,\theta_j + s\bar{\theta}$, where $\bar{g}_j = E_x\big[g_j(x)\big]$ and $\bar{\theta} = E\big[\theta_j\big]$. Here, $s \in [0,1]$ is the shrink rate with $s = 0$ corresponding to the baseline model. By reducing the heterogeneity in production complementarities, we are effectively making amenities more important for the allocation of workers to firms (and vice versa). Keeping ψ_{jt} fixed at baseline values $(s = 0)$, we solve for the counterfactual allocation of workers to firms given the chosen counterfactual values of $g_j(x)$ or θ_j.

Figure 3 panels C and D illustrate the importance of amenities versus production complementarities for the sorting of workers to firms. Here, we solve the equilibrium counterfactual economies with $s = 1/2$ for either amenities (panel C) or production complementarities (panel D). The results suggest that production complementarities are the key reason why better workers are sorting into higher paying firms. Online Appendix Figure A.7 complements these results by plotting estimates of $\operatorname{corr}\big(x_i, \psi_{j(i,t)}\big)$ and $2\operatorname{cov}\big(x_i, \psi_{j(i,t)}\big)$ for counterfactual economies with many values of s. These findings indicate that production complementarities are the driving force of the strong positive correlation between worker and firm effects and the significant inequality contribution from worker sorting.

E. *Implications of Imperfect Competition for Progressive Taxation and Allocative Efficiency*

Our final set of insights from the model are to quantify the misallocation of workers to firms that arise because of the monopsonistic labor market, and to empirically illustrate how this misallocation may be corrected through tax policy.

As discussed in Section IE, there are two types of wedges. Within each market, there is a tax wedge that arises because there is a progressive tax on wages but not on amenities. As λ decreases and thereby the wage tax becomes more progressive, amenities become more valuable relative to (pretax) wages. This distorts the worker's ranking of firms in favor of those with better amenities. Thus, with progressive taxation, firms with better amenities can hire workers at relatively low wages, and, therefore, get too many workers as compared to the allocation in the competitive labor market. Between markets, allocative inefficiencies may arise not only because of the tax wedge but also due to differences in labor wedges across markets. This is because the labor supply curves and, as a result, the wage markdowns vary systematically across markets.

As shown in Section IE, the government can improve the allocation of workers to firms in two ways. First, a less progressive tax system may reduce the misallocation that arises from the tax wedge. Second, letting the tax rates vary across markets may improve the allocation by counteracting the differences in the wage-setting power of firms. We now use the estimated model to perform a counterfactual that quantifies the impacts of such a tax reform on the equilibrium allocation and outcomes, including wages, output and welfare.

The counterfactual we consider involves two changes to the monopsonistic labor market. First, we eliminate the tax wedge in the first-order condition, which distorts the worker's ranking of firms in favor of those with better amenities. This is done by setting the tax progressivity $(1-\lambda)$ equal to zero. Second, we remove the labor wedges in the first-order conditions of the firms. These wedges cause misallocation of workers across firms with different degrees of wage-setting power. As shown in Lemma 7 in online Appendix A.4, labor wedges can be eliminated by setting τ_r equal to the labor wedge $1+\rho_r/(\lambda\beta)$ in each market r. After changing these parameters of the model, we solve for the new equilibrium allocation and outcomes, including wages, output and welfare. For a set of wages $\{W_{jt}(X)\}_{j,t}$ and a tax policy (λ,τ), we define the welfare as

$$\mathcal{W}_t = E\Big[\max_j u_{it}\big(j,(1+\phi_t)\tau W_{jt}(X_i)^{\lambda}\big)\Big],$$

where ϕ_t is the government spending rule set so that the government budget clears and profits and tax revenues are distributed among all the workers in proportion to their earnings:

$$\underbrace{\phi_t \cdot E\big[\tau W_{jt}(X_i)^{\lambda}\big]}_{\text{redistribution}} = \underbrace{\frac{1}{N}\sum \Pi_{jt}}_{\text{profits}} + \underbrace{E\big[W_j(X_i) - \tau W_j(X_i)^{\lambda}\big]}_{\text{government revenue}}.$$

In other words, we redistribute aggregate profits and government tax revenues to workers in a nondistortionary way.

The results are presented in Table 5. They suggest the monopsonistic labor market creates significant misallocation of workers to firms. Eliminating labor and tax wedges increases total welfare by 5 percent and total output by 3 percent. When we decompose this change by performing the counterfactuals one at a time, we find that 4 percentage points of the welfare gains are due to eliminating the labor wedge while the remaining 1 percentage point is due to eliminating the tax wedge. We also find that removing these wedges would increase the sorting of better workers to higher paying firms and lower the rents that workers earn from ongoing employment relationships. When we decompose this change by performing the counterfactuals one at a time, we find that nearly all of the change in sorting is due to eliminating the tax wedge, with the labor wedge having a small impact on sorting.

In interpreting these results, it is important to recall that we assume firms initially may choose amenities $g_j(x)$, but they do not change $g_j(x)$ in the counterfactuals. With better data on, and an instrument for, amenities, it would be interesting to extend this analysis to allow for firms to adjust amenities in response to these counterfactuals.

VI. Conclusion

The goal of our paper was to quantify the importance of imperfect competition in the US labor market by estimating the size of rents earned by American firms and workers from ongoing employment relationships. To this end, we constructed a matched

Table 5—Consequences of Eliminating Tax and Labor Wedges

		Monopsonistic labor market (1)	No labor or tax wedges (2)	Difference between (1) and (2)
Log of expected output	$\log E[Y_{jt}]$	11.38	11.41	0.03
Total welfare (log dollars)		12.16	12.21	0.05
Sorting correlation	$\text{corr}(\psi_{jt}, x_i)$	0.44	0.47	0.03
Labor wedges	$1 + \frac{\rho_r}{\beta\lambda}$	1.15	1.00	−0.15
Worker rents (as share of earnings):				
Firm level	$\frac{\rho_r}{\rho_r + \beta\lambda}$	13.3%	12.4%	−0.9%
Market level	$\frac{1}{1 + \beta\lambda}$	18.0%	16.7%	−1.3%

Notes: This table compares the monopsonistic labor market to a counterfactual economy which differs in two ways. First, we eliminate the tax wedge in the first order condition by setting the tax progressivity $(1 - \lambda)$ equal to zero. Second, we remove the labor wedges in the first order conditions of the firms by setting τ_r equal to the labor wedge $1 + \rho_r/(\lambda\beta)$ in each market r. After changing these parameters of the model, we solve for the new equilibrium allocation and outcomes, including wages, output, and welfare. Results are displayed for output, welfare, the sorting correlation, the mean labor wedge, and worker rents.

employer-employee panel dataset by combining the universe of US business and worker tax records for the period 2001–2015. Using this panel data, we identified and estimated an equilibrium model of the labor market with two-sided heterogeneity where workers view firms as imperfect substitutes because of heterogeneous preferences over nonwage job characteristics. The model allowed us to draw inference about imperfect competition, compensating differentials and rent sharing. We also used the model to quantify the relevance of nonwage job characteristics and imperfect competition for inequality and tax policy, to assess the economic determinants of worker sorting, and to offer a unifying explanation of key empirical features of the US labor market.

When considering the interpretation and generality of our study, we emphasize a few caveats and extensions. One of these is that we focus on distortions in the allocation of workers to firms and markets. However, tax and labor wedges may also distort the choices of whether and how much to work. Relatedly, we do not consider unemployment, and, as a result, we are reluctant to draw conclusions about how imperfect competition matters for the impact of minimum wages. Doing so is an important but challenging task, as it requires identification of the value of nonemployment and a nonlinear supply curve. We also assume the labor market is a spot market and, thus, we are unable to analyze the role of long-term contracts and firm insurance against shocks.[21] Furthermore, our structural model makes several simplifying assumptions, partly because of data availability but also to prove identification. For example, we abstract from observed heterogeneity in preferences and skills and, moreover, model individual behavior, and hence do not consider any interdependencies between spouses in the choices of whether and where to work.[22]

[21] See Balke and Lamadon (2020) for a model and empirical analysis of long-term contracts and firm insurance.

[22] Autor et al. (2019) and Blundell et al. (2016) estimate a life cycle model with two earners jointly making consumption and labor supply decisions. Their findings suggest an important role for consumption smoothing through household labor supply.

Moreover, we assume no mobility costs or search frictions, and we do not explicitly model human capital investments or work experience. While incorporating these features would be interesting, it would also present severe challenges to identification, especially if one allows for two-sided heterogeneity. Additionally, we focus on the wage-setting power of firms, and the analyses do not incorporate that firms may have price-setting power in the product market. Extending the model to allow for both forms of imperfect competition and how they interact is an important avenue for future research.[23] Lastly, we consider an equilibrium where each firm views itself as infinitesimal within the market. This assumption is motivated by the fact that very few firms in the United States have a large share of the local labor market (as measured by commuting zone). Thus, optimizing firms would essentially ignore the negligible effect of changing their own wages on the overall supply of workers to the market as a whole. However, if labor markets are sufficiently segmented (geographically or by industry), it is possible that strategic interactions can play an important role.[24]

REFERENCES

Abowd, John M., Francis Kramarz, and David N. Margolis. 1999. "High Wage Workers and High Wage Firms." *Econometrica* 67 (2): 251–333.

Akerman, Anders, Ingvil Gaarder, and Magne Mogstad. 2015. "The Skill Complementarity of Broadband Internet." *Quarterly Journal of Economics* 130 (4): 1781–1824.

Andrews, Martyn J., Leonard Gill, Thorsten Schank, and Richard Upward. 2008. "High Wage Workers and Low Wage Firms: Negative Assortative Matching or Limited Mobility Bias?" *Journal of the Royal Statistical Society: Series A* (*Statistics in Society*) 171 (3): 673–97.

Autor, David, Andreas Kostøl, Magne Mogstad, and Bradley Setzler. 2019. "Disability Benefits, Consumption Insurance, and Household Labor Supply." *American Economic Review* 109 (7): 2613–54.

Balke, Neele, and Thibaut Lamadon. 2020. "Productivity Shocks, Long-Term Contracts and Earnings Dynamics." Unpublished.

Barth, Erling, Alex Bryson, James C. Davis, and Richard Freeman. 2016. "It's Where You Work: Increases in Earnings Dispersion across Establishments and Individuals in the US." *Journal of Labor Economics* 34 (S2): S67–97.

Bartik, Timothy J. 1991. "Who Benefits from State and Local Economic Development Policies?" Kalamazoo, MI: W.E. Upjohn Institute.

Berger, David W., Kyle F. Herkenhoff, and Simon Mongey. 2019. "Labor Market Power." NBER Working Paper 25719.

Bhaskar, V., Alan Manning, and Ted To. 2002. "Oligopsony and Monopsonistic Competition in Labor Markets." *Journal of Economic Perspectives* 16 (2): 155–74.

Blanchard, Olivier Jean, and Lawrence F. Katz. 1992. "Regional Evolutions." *Brookings Papers on Economic Activity* 23 (1): 1–75.

Blundell, Richard, Monica Costa Dias, Costas Meghir, and Jonathan Shaw. 2016. "Female Labor Supply, Human Capital, and Welfare Reform." *Econometrica* 84 (5): 1705–53.

Boal, William M., and Michael R. Ransom. 1997. "Monopsony in the Labor Market." *Journal of Economic Literature* 35 (1): 86–112.

Bonhomme, Stéphane, Kerstin Holzheu, Thibaut Lamadon, Elena Manresa, Magne Mogstad, and Bradley Setzler. 2020. "How Much Should We Trust Estimates of Firm Effects and Worker Sorting?" NBER Working Paper 27368.

Bonhomme, Stéphane, and Grégory Jolivet. 2009. "The Pervasive Absence of Compensating Differentials." *Journal of Applied Econometrics* 24 (5): 763–95.

[23] Kroft et al. (2021) analyze imperfect competition in both the labor and the product market in the US construction industry.

[24] See Berger, Herkenhoff, and Mongey (2019) for an analysis of strategic interactions in the firms' wage setting and Jarosch, Nimczik, and Sorkin (2019) for a search framework with large firms. However, identification of such interaction effects is challenging with two-sided heterogeneity.

Bonhomme, Stéphane, Thibaut Lamadon, and Elena Manresa. 2019. "A Distributional Framework for Matched Employer Employee Data." *Econometrica* 87 (3): 699–739.
Cahuc, Pierre, and Guy Laroque. 2014. "Optimal Taxation and Monopsonistic Labor Market: Does Monopsony Justify the Minimum Wage?" *Journal of Public Economic Theory* 16 (2): 259–73.
Caldwell, Sydnee, and Emily Oehlsen. 2018. "Monopsony and the Gender Wage Gap: Experimental Evidence from the Gig Economy." Unpublished.
Callaway, Brantly, and Pedro H. C. Sant'Anna. 2021. "Difference-in-Differences with Multiple Time Periods." *Journal of Econometrics* 225 (2): 200–30.
Card, David, Ana Rute Cardoso, Joerg Heining, and Patrick Kline. 2018. "Firms and Labor Market Inequality: Evidence and Some Theory." *Journal of Labor Economics* 36 (S1): S13–70.
Card, David, Francesco Devicienti, and Agata Maida. 2014. "Rent-Sharing, Holdup, and Wages: Evidence from Matched Panel Data." *Review of Economic Studies* 81 (1): 84–111.
Carlsson, Mikael, Julián Messina, and Oskar Nordström Skans. 2016. "Wage Adjustment and Productivity Shocks." *Economic Journal* 126 (595): 1739–73.
Chen, Kuan-Ming, Claire Ding, John A. List, and Magne Mogstad. 2020. "Reservation Wages and Workers Valuation of Job Flexibility: Evidence from a Natural Field Experiment." NBER Working Paper 27807.
Couch, Kenneth A., and Dana W. Placzek. 2010. "Earnings Losses of Displaced Workers Revisited." *American Economic Review* 100 (1): 572–89.
Dube, Arindrajit, Alan Manning, and Suresh Naidu. 2020. "Monopsony and Employer Mis-optimization Explain Why Wages Bunch at Round Numbers." Unpublished.
Dunne, Timothy, Lucia Foster, John Haltiwanger, and Kenneth R. Troske. 2004. "Wage and Productivity Dispersion in United States Manufacturing: The Role of Computer Investment." *Journal of Labor Economics* 22 (2): 397–429.
Eeckhout, Jan, and Philipp Kircher. 2011. "Identifying Sorting – In Theory." *Review of Economic Studies* 78 (3): 872–906.
Ekeland, Ivar, James J. Heckman, and Lars Nesheim. 2004. "Identification and Estimation of Hedonic Models." *Journal of Political Economy* 112 (1): S60–109.
Faggio, Giulia, Kjell G. Salvanes, and John Van Reenen. 2010. "The Evolution of Inequality in Productivity and Wages: Panel Data Evidence." *Industrial and Corporate Change* 19 (6): 1919–51.
Federal Reserve Bank of St. Louis. 2021. "U.S. Bureau of Labor Statistics, Consumer Price Index for All Urban Consumers: All Items in U.S. City Average [CPIAUCSL]." https://fred.stlouisfed.org/series/CPIAUCSL (accessed March 2021).
Friedrich, Benjamin, Lisa Laun, Costas Meghir, and Luigi Pistaferri. 2019. "Earnings Dynamics and Firm-Level Shocks." NBER Working Paper 25786.
Gibbons, Robert, and Lawrence F. Katz. 1992. "Does Unmeasured Ability Explain Inter-industry Wage Differentials?" *Review of Economic Studies* 59 (3): 515–35.
Gibbons, Robert, Lawrence F. Katz, Thomas Lemieux, and Daniel Parent. 2005. "Comparative Advantage, Learning, and Sectoral Wage Determination." *Journal of Labor Economics* 23 (4): 681–723.
Guiso, Luigi, Luigi Pistaferri, and Fabiano Schivardi. 2005. "Insurance within the Firm." *Journal of Political Economy* 113 (5): 1054–87.
Guner, Nezih, Remzi Kaygusuz, and Gustavo Ventura. 2014. "Income Taxation of U.S. Households: Facts and Parametric Estimates." *Review of Economic Dynamics* 17 (4): 559–81.
Hamermesh, Daniel S. 1999. "Changing Inequality in Markets for Workplace Amenities." *Quarterly Journal of Economics* 114 (4): 1085–1123.
Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante. 2017. "Optimal Tax Progressivity: An Analytical Framework." *Quarterly Journal of Economics* 132 (4): 1693–1754.
Internal Revenue Service (IRS). 2004. *Tax Incentives for Distressed Communities* (*Publication 954*). Washington, DC: IRS.
Internal Revenue Service (IRS). 2021a. "Business Tax Files, 2001–2015." United States Department of Treasury. https://www.irs.gov/statistics/soi-tax-stats-joint-statistical-research-program (last accessed March 2021).
Internal Revenue Service (IRS). 2021b. "Individual Tax Files, 2001–2015." United States Department of Treasury. https://www.irs.gov/statistics/soi-tax-stats-joint-statistical-research-program (last accessed March 2021).
Jarosch, Gregor, Jan Sebastian Nimczik, and Isaac Sorkin. 2019. "Granular Search, Market Structure, and Wages." NBER Working Paper 26239.
Kline, Patrick, Neviana Petkova, Heidi Williams, and Owen Zidar. 2019. "Who Profits from Patents? Rent-Sharing at Innovative Firms." *Quarterly Journal of Economics* 134 (3): 1343–404.
Kline, Patrick, Neviana Petkova, Heidi Williams, and Owen Zidar. 2021. "Corrigendum to 'Who Profits from Patents?" Unpublished.

Kline, Patrick, Raffaele Saggio, and Mikkel Sølvsten. 2020. "Leave-out Estimation of Variance Components." *Econometrica* 88 (5): 1859–98.

Kroft, Kory, Yao Luo, Magne Mogstad, and Bradley Setzler. 2021. "Imperfect Competition and Rents in Labor and Product Markets: The Case of the Construction Industry." NBER Working Paper 27325.

Lamadon, Thibaut, Magne Mogstad, and Bradley Setzler. 2022. "Imperfect Competition, Compensating Differentials, and Rent Sharing in the US Labor Market." American Economic Association [publisher], Inter-university Consortium for Political and Social Research [distributor]. https://doi.org/10.3886/E146661V1.

Lavetti, Kurt, and Ian M. Schmutte. 2018. "Estimating Compensating Wage Differentials with Endogenous Job Mobility." Unpublished. https://www.bc.edu/content/dam/bc1/schools/mcas/economics/pdf/seminars/CDEM_v21.pdf.

Maestas, Nicole, Kathleen J. Mullen, David Powell, Till Von Wachter, and Jeffrey B. Wenger. 2018. "The Value of Working Conditions in the United States and Implications for the Structure of Wages." NBER Working Paper 25204.

Manning, Alan. 2005. *Monopsony in Motion: Imperfect Competition in Labor Markets.* Princeton: Princeton University Press.

Manning, Alan. 2011. "Imperfect Competition in the Labor Market." In *Handbook of Labor Economics 4,* edited by David Card and Orley Ashenfelter, 973–1041. Amsterdam: Elsevier.

Marinescu, Ioana, and Roland Rathelot. 2018. "Mismatch Unemployment and the Geography of Job Search." *American Economic Journal: Macroeconomics* 10 (3): 42–70.

Mas, Alexandre, and Amanda Pallais. 2017. "Valuing Alternative Work Arrangements." *American Economic Review* 107 (12): 3722–59.

Mirrlees, James A. 1971. "An Exploration in the Theory of Optimum Income Taxation." *Review of Economic Studies* 38 (114): 175–208.

Mortensen, Dale T. 2003. *Wage Dispersion: Why Are Similar Workers Paid Differently?* Cambridge, MA: MIT Press.

Murphy, Kevin M., and Robert H. Topel. 1990. "Efficiency Wages Reconsidered: Theory and Evidence." In *Advances in the Theory and Measurement of Unemployment*, edited by Yoram Weiss and Gideon Fishelson, 204–40. New York: Springer.

Pierce, Brooks. 2001. "Compensation Inequality." *Quarterly Journal of Economics* 116 (4): 1493–1525.

Powell, David. 2012. "Compensating Differentials and Income Taxes Are the Wages of Dangerous Jobs More Responsive to Tax Changes than the Wages of Safe Jobs?" *Journal of Human Resources* 47 (4): 1023–54.

Powell, David, and Hui Shan. 2012. "Income Taxes, Compensating Differentials, and Occupational Choice: How Taxes Distort the Wage-Amenity Decision." *American Economic Journal: Economic Policy* 4 (1): 224–47.

Rosen, Sherwin. 1986. "The Theory of Equalizing Differences." In *Handbook of Labor Economics*, Vol. 1, edited by Orley C. Ashenfelter and Richard Layard, 641–92. Amsterdam: Elsevier.

Shimer, Robert, and Lones Smith. 2000. "Assortative Matching and Search." *Econometrica* 68 (2): 343–69.

Sokolova, Anna, and Todd Sorensen. 2021. "Monopsony in Labor Markets: A Meta-Analysis." IZA Discussion Paper 11966.

Song, Jae, David J. Price, Fatih Guvenen, Nicholas Bloom, and Till von Wachter. 2019. "Firming Up Inequality." *Quarterly Journal of Economics* 134 (1): 1–50.

Sorkin, Isaac. 2018. "Ranking Firms Using Revealed Preference." *Quarterly Journal of Economics* 133 (3): 1331–93.

Taber, Christopher, and Rune Vejlin. 2020. "Estimation of a Roy/Search/Compensating Differential Model of the Labor Market." *Econometrica* 88 (3): 1031–69.

Tax Foundation. 2015. *State Individual Income Tax Rates and Brackets for 2015.* Washington, DC: Tax Foundation.

Van Reenen, John. 1996. "The Creation and Capture of Rents: Wages and Innovation in a Panel of UK Companies." *Quarterly Journal of Economics* 111 (1): 195–226.

Wiswall, Matthew, and Basit Zafar. 2018. "Preference for the Workplace, Investment in Human Capital, and Gender." *Quarterly Journal of Economics* 133 (1): 457–507.

Woodcock, Simon D. 2015. "Match Effects." *Research in Economics* 69 (1): 100–121.

Yazici, Hakki, and Christopher Sleet. 2017. "Taxation, Redistribution and Frictional Labor Supply." Unpublished.