

# AN EMPIRICAL FRAMEWORK FOR MATCHING WITH IMPERFECT COMPETITION

MONS CHAN, KORY KROFT, AND ISMAEL MOURIFIÉ

*The University of Toronto, The University of Toronto & NBER, and the University of Toronto*

**ABSTRACT.** This paper considers a static, many-to-one matching model of the labor market. Firms face inelastic labor supply curves and hence charge an endogenous firm-specific markdown below marginal product. We assume that firms operate in an oligopsony labor market and thus allow for strategic interactions in wage setting. We provide a tractable characterization of the equilibrium and demonstrate existence and uniqueness. This characterization of the model equilibrium allows us to derive a rich set of comparative statics and then to gauge the relative contributions of worker skill, preference for amenities and strategic interaction on equilibrium wage inequality. We also illustrate identification of structural parameters using matched employer-employee data on the population of Danish workers.

**Preliminary, please do not circulate without the authorization.**

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## EXTENDED ABSTRACT

It is a well known fact that observationally similar workers earn different wages working at different firms. A recent literature has investigated the role of labor market power in generating such earnings differences across workers. One strand of this literature has focused on settings that allow for rich heterogeneity across workers and firms, but has maintained the assumption that firms are “atomistic” and thus abstract from strategic interactions in wage setting between firms (Card, Cardoso, Heining and Kline 2018; Lamadon, Mogstad and Setzler 2020).<sup>1</sup> Thus, these frameworks are unable to shed light on the connection between employer concentration and wages, as emphasized by Benmelech, Bergman and Kim (2020), Rinz (2020), Azar et al (2020), and Azar, Marinescu, and Steinbaum (2020). Another strand of the literature has considered settings where firms have market power and there are strategic interactions in wage setting, but largely abstract from skill and preference heterogeneity across workers (Berger, Herkenhoff and Mongey 2019; Jarosch, Nimczik and Sorkin 2020). As such, these papers do not capture differences in earnings due to standard competitive forces such as human capital, Roy sorting and/or compensating differentials and thus cannot shed any light on earnings inequality due to worker effects and sorting (see Abowd, Kramarz, and Margolis (1999), Card, Heining and Kline (2013), Bonhamme, Lamadon and Manresa (2019)).

The objective of this paper is to develop a quantitative framework that features both strategic interactions between firms in labor markets while at the same time allowing for rich heterogeneity across workers and firms and thus a role for skill differences and preferences for non-wage job characteristics or amenities. Using this quantitative framework, we consider identification of the model parameters, estimate the model using matched employee-employer data from Denmark and use the estimated model to perform counterfactual analyses.

We develop a static, many-to-one matching model of the labor market with imperfect competition building on Rosen (1986), Boal and Ransom (1997), Bhaskar et al. (2002), Card et al. (2018) and Lamadon, Mogstad and Setzler (2020). On one side of the market are a finite number of heterogeneous firms. On the other side of the market are a large number of workers with heterogeneous skills and preferences. Worker skills are allowed to be match-specific, meaning that the same employee might be more productive working for a specific firm compared to other firms. This enables our model to capture key features of the Roy model. Workers have preferences over wages and employer amenities (both deterministic and stochastic), and choose a firm (or unemployment) to maximize utility. The heterogeneity in deterministic non-pecuniary preferences along the vertical dimension implies that wages will reflect compensating differentials, similar to Rosen (1986). The heterogeneity in stochastic non-pecuniary preferences along the horizontal dimension implies that firms face upward-sloping labor supply curves giving rise to imperfect competition and market power. Given this market power, firms optimally markdown wages below the marginal revenue product of labor.<sup>2</sup>

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<sup>1</sup>The importance of having an empirical framework with strategic interactions has been emphasized by Card et al (2018, section F).

<sup>2</sup>One difference between our framework and that of Rosen (1986) is we take amenities to be exogenous and the only choice variable for firms is wages. On the other hand, Rosen assumes

There are two main sources of labor market power in our model of imperfect competition. The first source is employer differentiation due to differences in workers' idiosyncratic preference for amenities. This arises due to imperfect information since employers cannot observe the idiosyncratic part of workers' preferences and thus, cannot perfectly wage discriminate and extract all workers surplus. This allows firms to set wages below the competitive level while at the same time creates rents for infra-marginal workers at the firm. The second source is employer concentration due to the finite number of firms in the market. This implies that firms consider their impact on the market wage level and best respond to changes in the wages of other firms. This contrasts with models featuring monopsonistic competition, such as Lamadon, Mogstad and Setzler (2020) where only the first source of market power is operative and the labor supply elasticity and hence the markdown is constant. In our model the labor supply elasticity depends on both a shape parameter characterizing heterogeneity in worker preferences (employer differentiation) as well as the labor market shares which are endogenous to wages in the labor market (employer concentration). We show that ignoring employer concentration leads one to overestimate the markdown. Berger, Herkenhoff and Mongey (2019) capture strategic interactions in their framework; however, their framework does not allow for worker-level heterogeneity and only allows for a limited form of strategic interactions; in particular, while their model allows firms to be dominant in their "local" market, it does not allow them to be dominant in the overall economy. We show that this assumption also naturally leads one to overestimate the true markdown but with a lower bias than the one estimated under the "atomistic" firm assumption.

First, we provide a tractable equilibrium characterization for our matching model with imperfect competition without restricting the level of strategic interactions. We provide general conditions on the workers unobserved heterogeneity distribution and firms production functions under which the model equilibrium exists and is unique. For uniqueness, on the worker side, we require a shape restriction on the workers labor supply elasticities, which trivially holds in the widely used Nested Logit framework; on the firm side, we require that production functions are additively separable in labor of different types but allow for decreasing returns to scale and imperfect substitution across labor types. In the case of non-separable production functions, we characterize a set of testable implications under which the equilibrium is unique. In addition, we establish that under the same conditions, there exist globally convergent methods (Gauss-siedel or Jacobi iteration) that allows one to compute the unique equilibrium of the model. This has an important empirical advantage, since efficiently solving the equilibrium model will allow us to identify some key structural parameters of interest and to perform a series of counterfactual analyses in order to understand how different features of our model contribute to the observed wage distribution.

Next, we use the equilibrium characterization to derive a set of comparative statics. First, we show that firms' strategic interactions in wage setting amplifies the pass-through effect of a firm-specific productivity shock on equilibrium wages. Intuitively, a productivity shock to one firm in that wages are exogenous from the firm's perspective, and firms choose the value of the amenities. Additionally, in Rosen the preference for the amenity does not vary across firms, unlike our setting where it does.

the market has spillover effects onto other firms which has feedback effects. Thus, one cannot use firm-specific shocks to identify the labor supply elasticity, as initially discussed in Berger, Herkenhoff and Mongey (2019). In particular, we derive a lower bound for an exogenous change in the total factor productivity (TFP) of a firm on wages of a given worker type. This lower bound captures the following two cases. First, there is a single firm in each local market and a large number of local markets. In this case, firms internalize the effects of a wage change on the local market wage index, but there are no strategic interactions. Second, firms are atomistic in their local market and so do not take into account the effects of their wage setting on local market wage index. Next, we consider a firm-specific amenities shock. We show that the equilibrium effect on the firm’s wages is ambiguous. While an increase in amenities directly lower the wages at the firm, this causes other firms in the market to increase their wages through a competition effect and this feeds back to increase wages at the original firm.

Second, we consider the normative implications of our framework and defined the social welfare function. A key result is show that our framework suggests a very natural measure of concentration – the “generalized concentration index” (GCI) – which is the reciprocal of the generalized entropy discussed in Galichon and Salanié (2015). In particular, we establish a connection between the social welfare function in our model and the CGI. This is useful since it allows for a better understanding of how changes in market concentration affect social welfare. In the case of Nested Logit preferences, the GCI is a weighted function of “within nest” concentration values, and a “between nest” component. As pointed out in Maasoumi and Slottje (2003), this type of decomposability of a concentration index is very useful when there is heterogeneity across local markets as it allows one to more accurately pinpoint the main sources of concentration and examine the potentially heterogeneous impact of policy changes, such as minimum wage reforms, on particular markets, as well as on overall concentration. It is worth noting that the widely used Herfindahl index (HHI) index does not have this decomposability feature.

Our paper relates to and builds on several strands of the literature. First, our paper builds on and contributes to the growing literature on imperfect competition in labor markets.<sup>3</sup> Several papers have estimated firm-specific labor supply elasticities using the pass-through of firm-specific productivity shocks under an assumption of monopsonistic competition (which implies constant pass-through of shocks) with estimates typically ranging between 4-6 (Azar et al. 2019, Kline et al. 2019, Lamadon, Mogstad and Setzler 2019, Dube et al. 2019, Kroft et al. 2020, and Huneus, Kroft and Lim 2021). Berger, Herkenhoff and Mongey (2019) show that with strategic interactions in wage setting, the standard approach to identifying the “structural” firm-specific labor supply elasticity using pass-through of firm-level shocks is no longer valid and develop an alternative reduced-form indirect inference approach. Staiger, Spetz and Phibbs (2010) use an exogenous change in wages

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<sup>3</sup>Models of imperfect competition in the labor market have recently attracted interest because of their ability to explain various labor market features, such as wage dispersion for identical workers, the correlation between firm characteristics (such as size) and wages, the lack of an impact of the minimum wage on employment, and the prevalence of gender and racial wage gaps. See Manning (2003) for an excellent overview of the literature.

at Veterans Affairs hospitals as a natural experiment and estimate that labor supply to individual hospitals highly inelastic and also find that non-VA hospitals who were not affected by the legislated change responded by changing their own wages suggesting a role for strategic interactions. Our contribution to this literature is to formally provide an identification strategy for the structural labor supply elasticity in the presence of strategic interactions.

Our paper closely relates to the literature on matching models. Most of the existing theoretical papers that study the existence and uniqueness of equilibrium in many-to-one matching models differ mainly in terms of whether there are transfers and whether workers are gross substitutes or complements. Kelso and Crawford (1982) consider an imperfect transferable utility (TU) model where workers are gross substitutes, while Hatfield and Milgrom (2005) extend their model to a more general framework including non-transferable utility (NTU) (but do not consider complementarities). Pycia (2012) allows workers to be complements in the firms production functions and peer effects in an ex-post Nash-bargaining model. It is also noteworthy that these papers and most of their extensions do not consider unobserved heterogeneity and more importantly consider a competitive equilibrium market with perfect information.<sup>4</sup> Our contribution to this literature is to consider a wage-posting model with worker-level unobserved heterogeneity and imperfect information. None of the existence results in the matching literature directly apply to our context. A related paper is Azevedo (2014) who considers an imperfectly competitive many-to-one matching market. However, he does not consider unobserved heterogeneity and he mostly focuses on the case where firms compete on quantities given exogenously fixed wages.

Although our paper does not incorporate dynamic considerations, it relates to the search-and-matching literature which incorporate firm and worker heterogeneity. Search frictions are an important source of employer market power as emphasized by Burdett and Mortensen (1998), Postel-Vinay and Robin (2002), and Taber and Vejlin (2018).<sup>5</sup> Much of this literature focuses on the extent to which the correlation between worker and firm fixed effects in the AKM wage equation reveals information about the nature of sorting between workers and firms. Our paper is most closely related to Taber and Vejlin (2016) in terms of the broader objective of decomposing wage inequality into a skill component, a preference component, and imperfect competition. One important difference is that because our model is static, we do not consider human capital that is accumulated while working; we only allow for human capital that is exogenous and comes from investment in skills prior to working. However, while matching in most dynamic search models is one-to-one due to tractability, our static framework features many-to-one matching.<sup>6</sup>

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<sup>4</sup>Rare exceptions which consider unobserved heterogeneity but assuming a competitive equilibrium market with perfect information are Dupuy et al (2017, 2018).

<sup>5</sup>Other papers in this literature include Eeckhout and Kircher (2011), Lopes de Melo (2013), Lentz (2010), Lise, Meghir and Robin (2016), Bagger and Lentz (2016), and Hagedorn, Law and Manovski (2017).

<sup>6</sup>An exception is Eeckhout and Kircher (2018) who consider a frictional model with large firms.

Lastly, our paper relates to the literature on compensating differentials (See Taber and Vejlin (2020), Lavetti and Schmutte (2017), and Sorkin (2018)). This literature considers models that typically assume perfect competition and show that the equilibrium wage gap between two equally productive workers who are marginal at their firms is driven by their different valuation of firm amenities. Empirically this gap is therefore used to price non-income job characteristics. Our contribution is to allow for compensating differentials alongside imperfect competition, which is similar to Lamadon, Mogstad and Setzler (2019), but in an environment with strategic interactions.<sup>7</sup> Our approach to recover non-pecuniary preferences for amenities is to use the matching between workers and firms. This is similar to the traditional IO approach which uses product-market shares to identify brand preferences.

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<sup>7</sup>See for instance the discussion in Brown (1980, section V).