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DISCUSSION PAPER SERIES

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# Social Comparisons in Oligopsony

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## ABSTRACT

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### **Social Comparisons in Oligopsony**

A large body of evidence suggests that social comparisons matter for workers' valuation of the wage they receive. The consequences of social comparisons in imperfectly competitive labor markets are less well understood. We analyze an oligopsonistic model of the labor market where workers derive (dis-) utility from comparing their own wage with wages paid at other firms. As social comparisons become more prevalent all workers are paid higher wages, the wage distribution becomes more equal, and employment shifts to high productivity firms. Moreover, the total wage bill and output increase, while aggregate profits decline. Overall welfare rises. Our theoretical results have implications for estimating the elasticity of the labor supply curve facing a firm.

**JEL Classification:** D62, J22, J42

**Keywords:** social comparisons, status seeking, oligopsony, wage distribution, functional income distribution, welfare

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# 1 Introduction

Thinking about the working of labor markets as a place of imperfect competition is probably “... more “natural” and less forced”, as Manning (2003, p. 11) puts it, than applying the competitive model. Analytical approaches including frictions due to some sort of monopsony power (Robinson, 1933; Bhaskar and To, 1999; Bhaskar et al., 2002) or owing to matching imperfections (Diamond, 1982; Pissarides, 1985; Burdett and Mortensen, 1998) have become important tools for analyzing labor markets. Typically, however, those models build on preferences of workers such that only own wage payments are driving the decision to supply labor. Although there is widespread evidence that workers do not only derive positive utility from their own wages but that also comparisons with coworkers affect well-being, job and wage satisfaction, and behavior at the workplace (see, e.g., Brown et al., 2008; Clark et al., 2009; Card et al., 2012; Godechot and Senik, 2015; Goerke and Pannenberg, 2015), little is known about the effects of other-regarding preferences in oligopsonistic labor markets.

In this contribution, we consider an oligopsonistic labor market where workers undertake wage comparisons. We analyze the effects of wage comparisons on wages, the wage and functional income distribution, the structure of employment, output, and welfare. Our main findings are that with social comparisons all workers are paid higher wages than in the absence of such preferences. In addition, the wage distribution becomes more equal, employment at high productivity firms increases and decreases at low productivity firms. Moreover, the aggregate wage bill and output rise, while total profits decline. We finally show that welfare, defined as the sum of firms’ profits and workers’ utility, increases with more intense social comparisons.

Market power by firms such that they are not facing a completely elastic labor supply leads to wages at which workers are expropriated, an insight already propagated by Pigou (1929). Our findings, as outlined above, suggest that social comparisons can partly compensate for the negative consequences arising to workers from the market power of firms. Contrary to monopsony, firms compete to some extent for labor with other firms in oligopsony. The

less pronounced labor market frictions are, the more they compete for workers who by assumption have heterogeneous preferences for a given number of employers. What social comparisons add is fiercer competition between firms as workers attach lower utility to a firm that pays less than its competitors. Consequently, the strategic complementarity in the wage setting of firms in an oligopsonistic market is strengthened by workers' preferences being subject to social comparisons. We show this by holding market frictions constant throughout, and analyzing the consequences for labor allocation arising from various degrees of social comparisons. The way we think about the allocation of heterogeneous firms in our model lets wages increase with social comparisons by the same absolute amount for high and low productivity firms so that workers at high productivity firms gain relatively less than workers at low productivity firms. The resulting relative wage compression explains the findings regarding the structure of employment and the functional income distribution. While overall employment does not change, since this is given in our model, low productivity firms will employ fewer workers and high productivity firms more workers as social comparisons becomes more prevalent. A direct upshot is that overall output increases from which workers benefit disproportionately, so that total profits decline at the expense of a higher wage sum. Moreover, welfare increases. We further argue at the end of our contribution that these predictions qualitatively continue to hold if we extend our set-up and allow for unemployment.

Our results that social comparisons lead to fiercer competition for labor between firms in oligopsony has implications for the estimation of labor supply elasticities to the firm. Such work has been pioneered by Nelson (1973) and Sullivan (1989), and has become center stage for empirically determining whether and to which extent there is imperfect competition in the labor market. Our theoretical findings suggest that when workers derive utility from comparing their own wage with wages paid at other firms, the inverse labor supply curve to an individual firm becomes flatter. Therefore, not taking into account social comparisons may understate the actual degree of frictions in the labor market, i.e. part of the variation in the elasticity of the labor supply curve to an individual firm may be explained by social

comparisons rather than frictions.

We proceed by reviewing earlier contributions in Section 2. We continue by setting up our model in Section 3, present the results in Section 4, and conclude in Section 5.

## 2 Literature review

Economists have realized for a long time that relative concerns matter for economic behavior. Already Adam Smith defined consumption goods in relative terms in the *Wealth of Nations* when he wrote that necessities are “...not only the commodities which are indispensably necessary for the support of life, but whatever the custom of the country renders it indecent for creditable people, even of the lowest order, to be without.” (Smith, 1776, Book V, Ch. II, Part 2). Veblen (2003, ch. 2: Pecuniary emulation, p. 24) noted in 1899 that “Relative success, tested by an invidious pecuniary comparison with other men, becomes the conventional end of action.” Similarly Pigou (1903, p. 60) discusses social preferences, and concerns for relative pay have been put forward by Keynes (1936, ch. 2) as a potential cause for wage stickiness.

More recently, the labor supply effects of social comparisons have been analyzed in a variety of settings. One of the main analytical predictions resulting from these contributions is that if individuals exhibit jealousy or envy (in the sense of Dupor and Liu 2003), labor supply will be excessive with consequences for growth (Liu and Turnovsky, 2005), taxation (Persson, 1995; Ireland, 2001; Corneo, 2002; Aronsson and Johansson-Stenman, 2014, 2015), provision of public goods (Aronsson and Johansson-Stenman, 2008; Wendner and Goulder, 2008), and the impact of multiple or different types of social concerns (Aronsson and Johansson-Stenman, 2013; Mujcic and Frijters, 2015). This is the case because individuals do not take into account that an expansion of labor supply which raises their own income reduces relative income of others, thus making them worse off and enticing them to expand their income generating activities. Frank (1984) and Schor (1991), e.g., provide a detailed illustration.

Theoretically, the consequences of social comparisons with respect to labor supply have generally been looked at in the context of competitive markets. A prominent contribution is Dufwenberg et al. (2011) who describe conditions under which social preferences do not affect market allocations. However, there are some exceptions, that is, analyses of social preferences in the context of imperfectly competitive markets. Desiraju et al. (2007) and von Siemens (2010) study the impact of social comparisons in a monopsony. They are interested in workers' sorting behavior into particular jobs, and firms' profits when workers have private information on their ability or social preferences. In von Siemens (2012) it is then shown that social comparisons have an effect on market outcomes even when competition is increased. Goerke and Hillesheim (2013) assume firm-specific trade unions which represent individuals with preferences exhibiting concerns for social comparisons. Since trade unions raise wages above the market-clearing level, labor demand and actual hours of work decline. Hence, unions can internalize the impact of social comparisons. Furthermore, Mauleon et al. (2014) show that trade unions which bargain over wages with a firm selling its product in an oligopolistic market will achieve higher wage outcomes if the strength of wage comparisons become more pronounced. Higher wages, in turn, reduce employment, output and profits. In addition, and taking up an approach proposed by Oswald (1979), there are a number of contributions in which the utility of a specific trade union is negatively affected by the wage bargained by other unions. These investigations generally focus on the impact of such union rivalry on wages, employment and other macroeconomic outcomes (cf. Gylfason and Lindbeck, 1984; Dixon, 1988; Strøm, 1995; De la Croix et al., 1994), but do not analyze how two types of market imperfections interact.<sup>1</sup> Finally, expanding on the notion of fair wages (c.f. Akerlof and Yellen, 1990), the consequences of social comparisons on effort choices and the wage setting behavior of firms have been analyzed in an efficiency

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<sup>1</sup>Woo (2011; 2016) introduces status effects with respect to consumption goods into models of imperfect product market competition. The prediction of over-consumption obtained for competitive settings may no longer arise in oligopoly or if there is monopolistic competition. Guo (2005) obtains a similar finding in that the tax rate inducing first-best consumption may not be positive on account of the product market imperfection.



wage context (Charness and Kuhn, 2007). However, the interaction of firms on the labor market has not played a role.

Empirically, only a few previous papers have examined the role of relative income on labor supply, using data for the United States. For example, Neumark and Postlewaite (1998) show that women’s decision to supply labor depends on their sisters’ employment decision and Park (2010) finds that relative income of husbands plays an important role in the labor supply decisions of married women. Pérez-Asenjo (2011) demonstrates that the probability of working full-time instead of part-time, of labor force participation, and working hours decline with relative income. Moreover, Bracha et al. (2015) present empirical evidence for students that information about relative pay tends to reduce labor supply of those male subjects paid a lower wage. Finally, Breza et al. (2016) conducted a field experiment with Indian manufacturing workers to, *inter alia*, analyse the effect of relative wages on attendance. They show that workers who receive a relatively low wage are more likely not to turn up for work than workers who earn high relative wages.

In sum, the labor market distortions due to (a) social comparisons and (b) firms having market power on the labor market have been considered intensively, but separately. In the present contribution, we focus on the interaction of these two, well-established deviations from the benchmark model of perfect competition.

### **3 Model**

#### **3.1 General set-up**

Our theoretical framework is an oligopsonistic labor market in which workers do not only derive utility from their own wage but also from comparing themselves with other workers. In particular, we consider a model where firms are price takers on the output market but have market power on the labor market. The firms’ labor supply schedule is imperfectly elastic because jobs have different non-wage characteristics. When workers decide for which

firm to work they do not only take into account the wages and non-wage characteristics but also how the wage they would get at a particular firm compares to wages of other workers.

More specifically, we follow Bhaskar and To (1999; 2003) and assume that workers with mass one and of equal ability but with different preferences regarding job characteristics are distributed uniformly on a circle of unit circumference as in Salop (1979). The circle is populated with an even number of  $n$  firms, with  $n \geq 2$ . The distance to the next firm on each side is  $1/n$ . The distance on the circle between the location of a firm and the position inhabited by any particular worker can be interpreted as the dis-utility of the job offered by that firm due to its non-wage characteristics. These non-wage characteristics may relate to physical working conditions, working hours, colleagues, customer relationships, or commuting distance. They cannot be ranked generally in that all workers prefer one set of characteristics to another. Instead, different workers have different preferences over these non-wage features of a job, i.e., the model is one of horizontal job differentiation. Locations for firms and working time per worker are fixed.

A worker's utility is linear in the sum of wage income and the utility from social comparisons, to be specified below, and the dis-utility from disadvantageous job characteristics. This dis-utility equals the product  $tx$  of the distance from a firm,  $x$ , and the costs per unit of distance, denoted by  $t$ . A worker will accept the job offered by a firm if the resulting utility level is positive and higher than the utility from a job offered by another firm. All workers have reservation wages of zero.

We assume that workers compare their wage income to a reference income. Analyses of social comparisons often differ with respect to the composition of the reference group and the nature of social preferences. In the context of our model in which all individuals work, other workers constitute the natural reference group. Moreover, status preferences have usually been incorporated into models of labor supply as depending either on the difference between wage or income levels (see, inter alia, Ljungqvist and Uhlig, 2000; Choudhary and Levine, 2006; Pérez-Asenjo, 2011) or as being a function of their ratio (see, e.g., Persson, 1995; Corneo, 2002; Goerke and Hillesheim,

2013). We choose the additive comparison approach (c.f. Clark and Oswald, 1998) because it preserves the linear relationship between wages and labor supply characterizing the model without social comparisons.<sup>2</sup> More specifically, if the wage workers receive is greater (less) than the average wage, workers gain (lose) utility. The strength of such comparison effects depends on the absolute difference of wage levels and is indicated by a parameter  $\gamma$ ,  $\gamma \geq 0$ , where  $\gamma = 0$  captures the absence of such considerations. Formally, the utility of working at firm  $i$  if located at distance  $x$  from that firm is given by:

$$w_i + \gamma \left( w_i - \frac{1}{n-1} \sum_{j \neq i}^n w_j \right) - tx. \quad (1)$$

To generate meaningful wage comparisons and wage and profit distributions, we suppose that there are two types of firms.  $L$ -type firms have lower profits than  $H$ -type firms when facing the same production costs, for example, because of lower productivity. We, finally, assume that firms of different productivities alternate on the circle, such that each  $L$ -firm has an  $H$ -type firm to the left and right, and vice versa. This substantially simplifies the subsequent analysis, without affecting the basic features of the model (c.f. Bhaskar and To, 2003).

### 3.2 Labor supply to a firm

Denote wages paid at the two firms located next to firm  $i$  with  $w_{i+}$  and  $w_{i-}$ . In order to derive labor supply to a firm  $i$  we have to consider workers located between firm  $i$  and its neighbor on one side, firm  $i_+$ , and workers located between  $i$  and the neighbor on the other side, that is, firm  $i_-$ . We focus on a worker who is situated at distance  $x$  from firm  $i$  and at distance  $1/n - x$  from firm  $i_+$ . Such a worker will compare the utility from working

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<sup>2</sup>Mujcic and Frijters (2013) compare both approaches and find that the additive model can explain empirical observations slightly better than the ratio version.

at firm  $i$  or at firm  $i_+$ . Consequently, the worker will select firm  $i$  if

$$w_i + \gamma \left( w_i - \frac{1}{n-1} \sum_{j \neq i}^n w_j \right) - tx > w_{i_+} + \gamma \left( w_{i_+} - \frac{1}{n-1} \sum_{j \neq i_+}^n w_j \right) - t(1/n-x). \quad (2)$$

We may re-write the inequality as

$$\begin{aligned} w_i + \gamma \left( w_i - \frac{1}{n-1} w_{i_+} - \frac{1}{n-1} \sum_{j \neq i, i_+}^n w_j \right) - tx > \\ w_{i_+} + \gamma \left( w_{i_+} - \frac{1}{n-1} w_i - \frac{1}{n-1} \sum_{j \neq i_+, i}^n w_j \right) - t(1/n-x) \end{aligned} \quad (3)$$

to see that, given the symmetric set-up, comparison with average wages at all other firms results in comparing wages of the firms to the two sides of a worker. After canceling common terms one gets

$$\frac{(w_i - w_{i_+}) \left( 1 + \gamma \frac{n}{n-1} \right)}{2t} + \frac{1}{2n} > x. \quad (4)$$

All workers closer to firm  $i$  than distance

$$\tilde{x}_+ = \frac{(w_i - w_{i_+}) \left( 1 + \gamma \frac{n}{n-1} \right)}{2t} + \frac{1}{2n} \quad (5)$$

will work for firm  $i$ . All other workers rather prefer to work for firm  $i_+$ .

Considering also the workers on the other side of firm  $i$ , total labor supply to firm  $i$  becomes

$$L_i = \tilde{x}_+ + \tilde{x}_- = \frac{(w_i - \bar{w}_i) \left( 1 + \gamma \frac{n}{n-1} \right)}{t} + \frac{1}{n} \quad (6)$$

with  $\bar{w}_i = \frac{1}{2} (w_{i_+} + w_{i_-})$ . Labor supply to firm  $i$  increases with the absolute differential between the wage it pays itself and the average wage of its two neighboring firms. Moreover, the slope of the labor supply function to firm  $i$ ,

that is  $\partial L_i / \partial w_i$ , is decreasing in  $t$  and increasing in the degree of social comparisons  $\gamma$ . This implies that as social comparisons become more prevalent the inverse labor supply curve to an individual firm holding all else constant flattens out. The firm acts as if it was placed in a more competitive setting.

The features of the labor supply curve (6) with respect to social comparisons are very general and do not depend on the formulation of preferences as described by equation (1). Alternative specifications include preferences (a) as in Fehr and Schmidt (1999) who assume that workers also derive disutility when earning a higher wage than the reference group, (b) such that workers compare their wage to some (employment-) weighted average of reference wages, (c) which attach different weights to different reference groups, or (d) which ensure that stronger social comparisons reduce the relevance of the own wage (see Appendix). Consequently, the specific characteristics of preferences as captured in equation (1) have no impact on the firms' profit maximizing wage choices derived below.

### 3.3 Profit maximization

As in Bhaskar and To (1999; 2003) we consider a production function which is homogeneous degree of one in labor

$$Y_i = L_i f_i(K_i/L_i), \quad (7)$$

where  $K_i$  is capital input to firm  $i$ , and  $f'_i > 0$  and  $f''_i < 0$ . Firm  $i$ 's profit equation follows as

$$\pi_i = p_i L_i f_i(K_i/L_i) - r K_i - w_i L_i \quad (8)$$

where  $p_i$  is the price which firm  $i$  charges for its product and  $r$  is the capital rental rate. We may reformulate the profit function by using the first-order condition for the firm's optimal capital usage

$$p_i f'_i(k_i^*) - r = 0 \quad (9)$$

as

$$\pi_i = \phi_i(p_i, r)L_i - w_iL_i \quad (10)$$

with  $\phi_i(p_i, r) = p_i (f_i(k_i^*(r/p_i)) - f_i'(k_i^*(r/p_i))k_i^*(r/p_i))$  and  $k_i^*$  being the optimal capital-labor ratio.  $\phi_i$  is firm  $i$ 's net revenue product of labor for which the firm optimally adjusted its capital-labor ratio. The firm's net revenue product of labor increases in the capital-labor ratio,  $k_i$ , and the price,  $p_i$ , because the production function is strictly concave. Moreover, the optimal capital-labor ratio  $k_i^*$  increases with the price (see (9)).

We model firm differences by assuming that  $\phi_H(p_H, r) > \phi_L(p_L, r)$ . As shown below,  $H$ -type and  $L$ -type firms will pay different wages and have different profit levels. Accordingly, the assumption of differences in the net revenue product of labor generates an income distribution. Net revenue products of two firms which compete against each other in the same labor market may diverge because they produce different goods allowing them to set different prices. Alternatively,  $\phi_H(p_H, r) > \phi_L(p_L, r)$  may occur because the  $H$ -type firm has a higher productivity, possibly due to differences in managerial talent or production techniques. To formally capture the idea of differences in the net revenue product of labor we, therefore, assume that  $p_H = a_p p_L$  and  $f_H(k) = a_f f_L(k)$ , where  $a_p, a_f \geq 1$  and  $a_p + a_f > 2$ . In our subsequent exposition we focus on productivity differences as the cause of  $\phi_H(p_H, r) > \phi_L(p_L, r)$ , i.e. a setting in which  $a_f > 1 = a_p$  holds, and refer to  $H$ -type ( $L$ -type) firms as high (low) productivity enterprises.

Each firm maximizes profits with respect to its own wage, taking as given the wages paid at other firms. Using labor supply (6) the first-order condition is given by

$$\frac{\partial \pi_i}{\partial w_i} = - \left( \frac{(w_i - \bar{w}_i) \left(1 + \gamma \frac{n}{n-1}\right)}{t} + \frac{1}{n} \right) + (\phi_i(p_i, r) - w_i) \frac{\left(1 + \gamma \frac{n}{n-1}\right)}{t} = 0. \quad (11)$$

As usual in models of oligopsonistic labor markets, the optimal wage results from the trade-off between higher labor costs and greater labor supply. The

second-order condition for a maximum is fulfilled ( $\partial^2\pi_i/\partial^2w_i < 0$ ). Rearranging (11) gives the optimal wage a firm  $i$  sets as:<sup>3</sup>

$$w_i^* = \frac{1}{2} \left( \phi_i(p_i, r) + \bar{w}_i - \frac{t}{n(1 + \gamma\frac{n}{n-1})} \right). \quad (12)$$

The optimal wage of a firm  $i$  equals the weighted sum of the firm's net revenue product of labor, and the wages paid in neighboring firms, less a measure of the disutility cost  $t$  (as in Bhaskar and To, 1999, 2003; Kaas, 2009; Hirsch, 2009). Own productivity, as captured by  $\phi_i(p_i, r)$ , has a positive wage effect because the gain in profits from increasing labor input becomes larger the more productive the additional worker is. Moreover, higher unit disutility costs  $t/n$  for workers make it less likely that a worker will accept the wage offer by a neighboring firm, because the net gain from doing so, i.e., the difference between the wage paid by that firm less disutility costs, is reduced. Finally, a higher wage in a neighboring firm lowers labor supply to firm  $i$ . To reduce the resulting decline in profits, the wage in firm  $i$  is raised. This strategic complementarity in wage setting has important implications for the effect of social comparisons, because its strength, as measured by the parameter  $\gamma$ , raises the elasticity of labor supply. While disutility costs lower the labor supply elasticity to firms, social comparisons have a counteracting effect on it.

## 4 Results

Having derived optimal wage-setting behavior by an arbitrary firm  $i$ , we now turn to the implications of social comparisons by workers for wage setting, the distribution of wages, employment, output, the functional income distribution, and welfare. To simplify notation, we subsequently omit the arguments of the net revenue product  $\phi_i(p_i, r)$  and denote it by  $\phi_H$  and  $\phi_L$  for the high- and the low productivity firms, respectively.

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<sup>3</sup>We assume that profits are positive and derive the restriction on the net revenue product of labor,  $\phi_i(p_i, r)$ , which guarantees this feature in the Appendix.

## 4.1 Wage effects

For equilibrium wages we get the following results.

**Proposition 1.** *Equilibrium wages for the high (H) and low (L) productivity firms write:*

$$w_H^* = \frac{2}{3}\phi_H + \frac{1}{3}\phi_L - \frac{t}{n(1 + \gamma\frac{n}{n-1})} \quad (13)$$

and

$$w_L^* = \frac{1}{3}\phi_H + \frac{2}{3}\phi_L - \frac{t}{n(1 + \gamma\frac{n}{n-1})}. \quad (14)$$

*A higher prevalence of social comparisons increases wages in both types of firms by the same amount.*

*Proof.* When setting wages, the  $n$  firms play Nash against each other. From (12) we already know each firms' reaction function. Thus, we have to solve for a system of  $n$  equations taking into account that due to the assumption of alternating productivity levels of neighboring firms, a low productivity firm has two high productivity neighbors, and vice versa. After adding up the  $n/2$  reaction functions of the high productivity and of the low productivity firms, the system of  $n$  equation essentially boils down to two equations:<sup>4</sup>

$$w_H = \frac{1}{2} \left( \phi_H - \frac{t}{n(1 + \gamma\frac{n}{n-1})} \right) + \frac{1}{2}w_L \quad (15)$$

$$w_L = \frac{1}{2} \left( \phi_L - \frac{t}{n(1 + \gamma\frac{n}{n-1})} \right) + \frac{1}{2}w_H. \quad (16)$$

Solving for  $w_H^*$  and  $w_L^*$  we obtain (13) and (14). The partial derivatives are:  $\partial w_H^*/\partial\gamma = \partial w_L^*/\partial\gamma > 0$ .  $\square$

Social comparisons partly compensate for the expropriation of workers that typically arises on non-competitive labor markets where firms can exert

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<sup>4</sup>A proof of stability of the Nash equilibrium is provided in the Appendix.



market power due to frictions. In our oligopsonistic setting it is the disutility  $t$  from disadvantageous job characteristics that reduces workers' wages. Social comparisons, however, increase equilibrium wages due to the strategic complementarity in the wage setting of firms in oligopsony. Firms are trying to attract workers by offering higher wages than their competing neighbors. A higher wage set by firm  $i$  has a negative externality on its neighboring firms which have to increase their wage offers in order not to fall short of labor supply. The more pronounced social comparisons are, the stronger the negative externality becomes. Thereby, social comparisons effectively stiffen competition between firms and increase equilibrium wages. Note, that this result is independent of the firm specific productivities  $\phi_H$  and  $\phi_L$ . While firm productivities affect equilibrium wages, the effect of social comparisons of wages is not mediated by the distribution of productivities.

## 4.2 Wage distribution

Social comparisons also have an effect on the wage distribution.

**Proposition 2.** *A higher prevalence of social comparisons decreases the relative wage differential.*

*Proof.* Using our previous results we get for the relative wage differential

$$\frac{w_H^*}{w_L^*} = \frac{\frac{2}{3}\phi_H + \frac{1}{3}\phi_L - \frac{t}{n(1+\gamma\frac{n}{n-1})}}{\frac{1}{3}\phi_H + \frac{2}{3}\phi_L - \frac{t}{n(1+\gamma\frac{n}{n-1})}}. \quad (17)$$

The partial derivative is  $\frac{\partial \frac{w_H^*}{w_L^*}}{\partial \gamma} < 0$ . □

To provide an intuition, remember how each firm sets the wage, cf. (12). It takes as given the wages of the two neighboring firms with which it competes for labor and raises its own wage as long as the net revenue less the wage of the additional worker is larger than the loss from having to pay all workers a higher wage. The fact that all firms take as given the wage of the

neighboring firms when optimizing explains why  $\gamma$  does not enter the absolute wage differential. Since job characteristics are distributed uniformly, changes in the disutility from accepting a job with more disadvantageous features reduce the gain from accepting any job by the same amount. This implies that an increase in wages paid by low and high productivity firms by the same amount owing to more pronounced social comparisons results in a smaller proportional increase of the (high) wage paid by the high productivity firm. Accordingly, the relative wage differential  $w_H^*/w_L^*$  declines with the strength of social comparisons.

### 4.3 Employment and output

Social comparisons change the composition of employment between high and low productivity firms and, therefore, alter aggregate output.

**Proposition 3.** *A higher prevalence of social comparisons shifts employment from low to high productivity firms, thereby increasing total output in the economy.*

*Proof.* Inserting equilibrium wages  $w_H^*$  and  $w_L^*$  into (6) gives

$$L_H^* = \frac{\frac{1}{3}(\phi_H - \phi_L) \left(1 + \gamma \frac{n}{n-1}\right)}{t} + \frac{1}{n} \quad (18)$$

and

$$L_L^* = \frac{\frac{1}{3}(\phi_L - \phi_H) \left(1 + \gamma \frac{n}{n-1}\right)}{t} + \frac{1}{n}. \quad (19)$$

As  $\phi_H > \phi_L$  we get that  $\partial L_H^*/\partial\gamma = -\partial L_L^*/\partial\gamma > 0$ .<sup>5</sup>

The change in aggregate output,  $Y = Y_H + Y_L = L_H^* f_H(k_H^*) + L_L^* f_L(k_L^*)$ , owing to an increase in the parameter  $\gamma$ , taking into account that  $k_i^*(p_i, r)$  is independent of  $\gamma$ , is given by:

$$\frac{\partial Y}{\partial\gamma} = \frac{\partial L_H^*}{\partial\gamma} f_H(k_H^*) + \frac{\partial L_L^*}{\partial\gamma} f_L(k_L^*) = \frac{\partial L_H^*}{\partial\gamma} (f_H(k_H^*) - f_L(k_L^*)). \quad (20)$$

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<sup>5</sup>In the Appendix we derive the condition for  $L_L^* > 0$ .

To establish the increase in aggregate output, utilizing  $\partial L_H^*/\partial\gamma > 0$ , we have to show that  $f_H(k_H^*) - f_L(k_L^*) > 0$  holds. Since  $f_i(k)$  is increasing in  $k$  and  $f_H(k) = a_f f_L(k) \geq f_L(k)$  by assumption,  $f_H(k_H^*) - f_L(k_L^*) > 0$  will surely be true if  $k_H^* > k_L^*$  holds. From the first-order condition (9) we know that  $p_H f_H'(k_H^*) = r = p_L f_L'(k_L^*)$ . Further,  $p_H = a_p p_L$  and  $f_H(k) = a_f f_L(k)$ , where  $a_p, a_f \geq 1$  and  $a_p + a_f > 2$ , implies that  $p_H f_H'(k) = a_p p_L a_f f_L'(k) > p_L f_L'(k)$ . Since  $f(k)$  is strictly concave in  $k$  and  $f'(k)$ , hence, decreasing in the capital-labor ratio,  $p_H f_H'(k) > p_L f_L'(k)$  and  $p_H f_H'(k_H^*) = p_L f_L'(k_L^*)$  together can only hold if  $k_H^*$  exceeds  $k_L^*$ .  $\square$

Labor supply is a positive function of the difference between the wage paid in the firm under consideration and the average wage in neighboring firms. For high productivity firms this average equals the wage paid by low productivity firms, and vice versa. In addition, more pronounced social comparisons amplify the effects of the absolute wage differential on labor supply. In consequence, if individuals compare the wages paid by firms more intensively, labor supply to firms paying higher wages will go up, whereas labor supply to low wage firms will decline. Since  $H$ -type firms use the (marginal) unit of labor input more productively, shifting labor to  $H$ -type firms increases aggregate output.

#### 4.4 Functional income distribution

Social comparisons also have an effect on the functional income distribution.

**Proposition 4.** *A higher prevalence of social comparisons increases the total wage bill and reduces profits of both types of firms and, consequently, in aggregate.*

*Proof.* Let us write the wage bill for two neighboring firms as  $w_H L_H + w_L L_L$ . Since there are  $n/2$  such firm pairs, the total wage bill  $W$  is:

$$W = \frac{n}{2} (w_H L_H + w_L L_L) = \frac{n}{2} (w_H L_H - w_L L_H + w_L L_L + w_L L_H) \quad (21)$$

$$= \frac{n}{2} ((w_H - w_L) L_H + w_L (L_L + L_H)) \quad (22)$$

$$= \frac{n}{2} ((w_H - w_L) L_H + w_L). \quad (23)$$

As we have already shown that (a) the absolute wage differential does not change with more pronounced social comparisons, (b) all wages increase, and (c) employment at high productivity firms goes up, the wage bill rises.

Inserting wages and employment levels into the profit equations, we can calculate maximal profits as:

$$\pi_H^* = \frac{1 + \gamma \frac{n}{n-1}}{t} \left( \frac{1}{3} (\phi_H - \phi_L) + \frac{t}{n(1 + \gamma \frac{n}{n-1})} \right)^2 \quad (24)$$

$$= \frac{1 + \gamma \frac{n}{n-1}}{t} \left( \frac{1}{3} (\phi_L - \phi_H) + \frac{t}{n(1 + \gamma \frac{n}{n-1})} \right)^2 + \frac{4}{3n} (\phi_H - \phi_L) \quad (25)$$

$$= \pi_L^* + \frac{4}{3n} (\phi_H - \phi_L) \quad (26)$$

We know that wages of low-productivity firms increase with  $\gamma$  and employment at low-productivity firms decreases with  $\gamma$ . This implies that profits of low-productivity firms shrink if social comparisons become more pronounced ( $\partial\pi_L/\partial\gamma < 0$ ). Since, moreover,  $\partial\pi_L^*/\partial\gamma = \partial\pi_H^*/\partial\gamma$ , profits in both types of firms and in aggregate decline.  $\square$

In the present setting, total wage payments unambiguously increase for two reasons: First, total employment is constant. Thus, a shift in employment towards high-productivity, high-wage firms increases wage payments of all workers who change firms. Second, wages of workers in high- and in low-productivity firms go up. Consequently, also wage payments to those workers rise who stay in the same firm. The profit effect can be explained as follows: Social comparisons incentivize firms of both types to pay higher wages. This squeezes their profits per worker employed. Moreover, more intense social comparisons shift labor supply towards the high-productivity firms, at the expense of the low-productivity firms. As a consequence, the

low-productivity firms employ fewer workers and each worker generates less revenues. Although the high productivity firms gain in terms of attracting a larger share of the labor force, it does not compensate for the lower net revenue less the wage of a worker. Aggregate profits decline.

#### 4.5 Welfare

In the absence of social comparisons welfare will be maximized by an allocation of workers across firms such that the increase in output by having one additional worker in a high-productivity instead of a low-productivity firm balances the rise in the dis-utility from working at less advantageous conditions. This allocation will not result as market outcome because firms compare the changes in output and wages. Given identical wage payments to all workers within a firm, the firm's marginal costs of attracting an additional worker are higher than the social costs, as measured by the dis-utility incurred by workers. Since high-productivity firms pay higher wages, the distortion is more pronounced for such firms and the market equilibrium in the absence of social comparisons is characterized by too little employment in high-productivity firms.

To ascertain the welfare consequences of social comparisons, we define welfare as the sum of firms' profits and wage payments net of dis-utility costs. In our interpretation, we focus on the indirect effects of a higher prevalence of social comparisons. These repercussions via a reallocation of labor across the different types of firms represent the economically relevant adjustments. More intensive social comparisons also have a direct impact on welfare, simply because the aggregate utility from social comparisons changes. The welfare effect of social comparisons can be summarized as follows.

**Proposition 5.** *A higher prevalence of social comparisons increases welfare.*

*Proof.* Define  $WF$  as the sum of profits of all firms and wage payments net

of dis-utility costs of all workers

$$WF = \frac{n}{2} (\pi_H^* + \pi_L^*) + \frac{n}{2} \left( 2 \int_{x=0}^{\frac{L_H^*}{2}} U_H(\bar{x}) d\bar{x} + 2 \int_{x=0}^{\frac{L_L^*}{2}} U_L(\bar{x}) d\bar{x} \right) \quad (27)$$

with

$$U_i(\bar{x}) = w_i^* + \gamma \left( w_i^* - \frac{1}{n-1} \sum_{j \neq i}^n w_j^* \right) - t\bar{x}$$

and

$$\pi_i^* = (\phi_i - w_i^*) L_i^* \quad (28)$$

for  $i = L, H$ . From the definition of utility and profits it is immediately obvious that welfare  $WF$  is unaffected by the level of wage payments. Simplifying welfare accordingly and formulating the effects of social comparisons and dis-utility explicitly, yields:

$$WF = \frac{n}{2} [\phi_H L_H^* + \phi_L L_L^* + \gamma L_H^* \left( w_H^* - \frac{1}{n-1} \left( \left( \frac{n}{2} - 1 \right) w_H^* + \frac{n}{2} w_L^* \right) \right) \quad (29)$$

$$+ \gamma L_L^* \left( w_L^* - \frac{1}{n-1} \left( \left( \frac{n}{2} - 1 \right) w_L^* + \frac{n}{2} w_H^* \right) \right) - \frac{t}{4} (L_H^{*2} + L_L^{*2})]$$

Collecting terms and inserting equilibrium wages  $w_H^*$ ,  $w_L^*$  in accordance with (13) and (14), welfare can be expressed as:

$$WF = \frac{n}{2} (\phi_H L_H^* + \phi_L L_L^* + \gamma \frac{n}{6(n-1)} (\phi_H - \phi_L) (L_H^* - L_L^*) \quad (30)$$

$$- \frac{t}{4} [L_H^{*2} + L_L^{*2}])$$

The derivative of welfare with respect to  $\gamma$  is given by:

$$\frac{dWF}{d\gamma} = \frac{\partial WF}{\partial \gamma} + \frac{\partial WF}{\partial L_H^*} \frac{\partial L_H^*}{\partial \gamma} + \frac{\partial WF}{\partial L_L^*} \frac{\partial L_L^*}{\partial \gamma} \quad (31)$$

We know that the direct welfare effect of an increase in  $\gamma$ ,  $\frac{\partial WF}{\partial \gamma}$ , is positive since  $\phi_H > \phi_L$  and employment in  $H$ -type firms exceeds employment in  $L$ -type firms. Making use of  $\frac{\partial L_H^*}{\partial \gamma} = -\frac{\partial L_L^*}{\partial \gamma}$ , and collecting common terms, the overall welfare change is found to be:

$$\begin{aligned} \frac{dWF}{d\gamma} &= \frac{\partial WF}{\partial \gamma} + \frac{n}{2} \frac{\partial L_H^*}{\partial \gamma} (\phi_H - \phi_L + \\ &+ \gamma \frac{n}{3(n-1)} (\phi_H - \phi_L) - \frac{t}{2} [L_H^* - L_L^*]) \end{aligned} \quad (32)$$

Substituting for employment levels in accordance with (18) and (19) it can be noted that the increase in revenues dominates the rise in dis-utility.

$$\frac{dWF}{d\gamma} = \underbrace{\frac{\partial WF}{\partial \gamma}}_{(+)} + \underbrace{\frac{n}{3} \frac{\partial L_H^*}{\partial \gamma} (\phi_H - \phi_L)}_{(+)} > 0 \quad (33)$$

□

Since greater prevalence of social comparisons reduces profits, welfare can only increase if the utility gains of the workers more than compensate the losses of the firms. First of all, more social comparisons increase wages of all workers and, moreover, employment shifts to the better paying firms. However, workers also incur greater dis-utility from working at firms with less advantageous characteristics and may suffer from greater losses due to other firms paying higher wages than the firm at which they are employed. In total, however, workers are better off and, additionally, no worker is worse off. Intuitively, this is the case, because all wages rise by the same amount. Therefore, the utility from social comparisons will remain constant for all workers who do not change firms, for a given intensity of social comparisons, that is, ignoring the direct impact of more intensive comparisons. Moreover, higher wages make all workers better off. In consequence, all workers who remain with their employer experience higher utility due to wage adjust-

ments. Now, consider workers who change firms. They will only do so if the increase in wages more than compensates the rise in dis-utility due to having to work at a less favorable location. Accordingly, the workers who move to high-productivity firms owing to a greater prevalence of social comparisons are also better off. Comparing the workers' gains with the firms' losses it can be noted that the welfare consequences of wage changes are zero because the fall in profits is balanced by the increase in workers' income. However, firms will only employ additional workers if the increase in output is larger than the additional wage costs. Therefore, profits fall by less than wages increase and the net effect of more intensive social comparisons is positive because of the reallocation of labor to high-productivity firms.

## 5 Conclusions

We analyzed the consequences of social preferences for labor market outcomes in oligopsony. It turns out that status seeking behavior of workers has important implications for wages, the wage distribution, the structure of employment, output, welfare, as well as the functional income distribution in an imperfectly competitive market setting. Interestingly, social comparisons among workers reduce the market power of firms, compensating for the expropriation of workers typically arising in monopsony and oligopsony. We find that wages paid both in high- and in low-productivity firms increase. Furthermore, we can show that the ratio of wages of high- and low-productivity firms fall. Employment shifts towards the high productivity firms and, therefore, total output and the wage sum become larger, whereas total profits decline. Our calculations clarify that the workers' increase in utility more than compensates the decline in firms' profits so that welfare defined as the sum of profits and aggregate utility increases with social comparisons.

In our model, aggregate employment is constant because all workers are better off working than becoming unemployed. This outcome results because workers have a zero reservation wage. Therefore, the question arises whether our predictions will also hold if workers have a positive reservation wage. In



this case, some workers will be unemployed if their reservation wage exceeds the utility from wages, social comparisons and the dis-utility due to having to work at an unfavorable location. In order to answer this question we assume that workers who are unemployed compare their positive reservation income with the average wage and, hence, incur a utility loss from social comparisons. Solving this model numerically, since it is analytically not tractable, we can show that if employment is not too low the main results summarized in Section 4 continue to hold.<sup>6</sup> The main difference is that profits of both types of firms and, thus, in aggregate increase. The positive profit effect arises because aggregate employment goes up. Therefore, the profit increase resulting from greater output dominates the profit reduction owing to higher wages. In addition, workers who remain unemployed become worse off owing to less advantageous social comparisons. As the predictions summarized in Propositions 1 to 5 can basically also be derived in a setting in which all workers have a positive reservation wage, they are most likely to hold in a world in which workers with zero and positive reservations wages co-exist (cf. Bhaskar and To (1999; 2003)). Hence, our predictions are not due to the assumption of constant employment.

Accordingly, our results, we believe, have important implications for empirical work on estimating the labor supply curve facing a firm (see Manning, 2003, ch. 4). To the extent that social comparisons matter and flatten out the inverse labor supply curves to individual firms in non-competitive settings, estimates may suffer from an omitted variables bias. If it is not taken into account that workers compare their own wages to wages paid at other firms, firm specific labor supply elasticities may understate the actual degree of labor market frictions. It should be interesting to include measures of social comparisons which are becoming more and more available in household survey data into estimates of labor supply elasticities facing a firm.

Policy implications of our analysis are different from the ones of other contributions on social comparisons where tax policy implications are scrutinized (see references in the Introduction). We conjecture that taxing individuals in accordance with the strength of social comparisons could actually

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<sup>6</sup>The detailed findings are available upon request.

be welfare-reducing in our setting. This would be the case because social comparisons can never fully eradicate the distortion due to market power of (profitable) firms. Hence, our contribution suggests that market interventions via taxation in order to internalize externalities due to social comparisons need to be viewed more carefully against the background of labor market imperfections.

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## Appendix

### Alternative specifications for social comparisons

#### Labor supply with inequity aversion

Assume that workers are inequity averse as in Fehr and Schmidt (1999). In this case, a worker compares the utility when working for firm  $i$  or firm  $i_+$  according to

$$w_i - \gamma_h \max[w_i - w_{i_+}, 0] - \gamma_l \max[w_{i_+} - w_i, 0] - tx > \quad (34)$$

$$w_{i_+} - \gamma_h \max[w_{i_+} - w_i, 0] - \gamma_l \max[w_i - w_{i_+}, 0] - t(1/n - x).$$

The worker  $i$  derives dis-utility if he earns more than workers at the other firm, and also derives dis-utility if he earns less than the workers at the other firm  $i_+$ . This is in essence inequity aversion. The same reasoning applies if the worker would be employed at firm  $i_+$ . Arising dis-utility is weighted with  $\gamma_h, \gamma_l > 0$ . For deriving labor supply, we have to distinguish two cases:

- For Case 1 with  $w_i > w_{i_+}$  we get from (34):

$$w_i - \gamma_h(w_i - w_{i_+}) - tx > w_{i_+} - \gamma_l(w_i - w_{i_+}) - t(1/n - x) \quad (35)$$

- For Case 2 with  $w_i < w_{i_+}$  we get:

$$w_i - \gamma_h(w_i - w_{i_+}) - tx > w_{i_+} - \gamma_l(w_i - w_{i_+}) - t(1/n - x) \quad (36)$$

It turns out that the condition which defines a situation in which it is beneficial for the worker to work in firm  $i$  is the same for Cases 1 and 2. Solving for  $x$  gives:

$$\frac{(w_i - w_{i_+})(1 - \gamma_h + \gamma_l)}{2t} + \frac{1}{2n} > x \quad (37)$$

If  $\gamma_l > \gamma_h$ , i.e. if earning less than the comparison group reduces utility by more than earning more, social comparisons counteract the effect of the dis-utility arising from  $t$ , as it is the case in (4).

### Labor supply with encompassing asymmetric social comparisons

Alternatively, consider the following very general utility function for a worker placed between firms  $i$  and  $i_+$  and working in firm  $i$

$$(1 - \alpha)w_i + \alpha_1(w_i - w_{i_+}) + \alpha_2(w_i - \bar{w}_1) + \alpha_3(w_i - \bar{w}_2) - tx, \quad (38)$$

and the utility of the same worker placed between firms  $i$  and  $i_+$  would he work in firm  $i_+$

$$(1 - \alpha)w_{i_+} + \alpha_1(w_{i_+} - w_i) + \alpha_2(w_{i_+} - \bar{w}_1) + \alpha_3(w_{i_+} - \bar{w}_2) - t(1/n - x). \quad (39)$$

This specification assumes that the worker derives (dis-) utility from the comparison of wages in the two firms where he can decide to work. The strength of this comparison effect is indicated by the parameter  $\alpha_1$ ,  $\alpha_1 > 0$ . Moreover, the utility function captures the idea that the intensity of

comparisons, as described by the parameters  $\alpha_2$  and  $\alpha_3$ ,  $\alpha_2, \alpha_3 > 0$ , may vary across reference groups. For simplicity, we have limited their number to two and denoted the respective reference wages, which are exogenous from the worker's perspective by  $\bar{w}_1$  and  $\bar{w}_2$ . These reference wages may, for example, refer to different groups of workers or firms with respect to income or distance on the circle, such that  $\bar{w}_1$  ( $\bar{w}_2$ ) is the average wage paid in low (high) productivity firms. Additionally, the reference wages could be given by employment or distance weighted averages, for example, because workers situated closer to the worker under consideration affect the reference wage more strongly than those situated further away. Finally, the parameter  $1 - \alpha$  allows for the possibility that stronger social comparisons reduce the relevance of the own wage. One way to model such an effect would be to assume that  $\alpha_1 + \alpha_2 + \alpha_3 - \alpha$  is constant.

Given such preferences, a worker will rather work for firm  $i$  if

$$\frac{(1 - \alpha + 2\alpha_1 + \alpha_2 + \alpha_3)(w_i - w_{i+})}{2t} + \frac{1}{2n} > x. \quad (40)$$

Again social comparisons, that is, an increase in  $\alpha_1$ ,  $\alpha_2$ , or  $\alpha_3$  or a concomitant rise in  $\alpha$  by the same amount, counteract the effect of the disutility arising from  $t$ , as it is the case in (4).

### Stability of Nash equilibrium

The Jacobian matrix of the Nash game for  $n = 2$  writes

$$J = \begin{pmatrix} 0 & 1/2 \\ 1/2 & 0 \end{pmatrix} \quad (41)$$

and for  $n \geq 4$  firms writes

$$J = \begin{pmatrix} 0 & 1/4 & 0 & \dots & 1/4 \\ 1/4 & 0 & 1/4 & \dots & 0 \\ 0 & 1/4 & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ 1/4 & 0 & 0 & \dots & 0 \end{pmatrix}. \quad (42)$$

Both matrices are circular and symmetric. Eigenvalues of such a matrix follow from

$$\alpha(l) = a(l) + ib(l) \in \mathbb{C} \quad (43)$$

with

$$a(l) = \sum_{r=1}^n j(r) \cos(2\pi lr/n) \quad (44)$$

and

$$b(l) = -\sum_{r=1}^n j(r) \sin(2\pi lr/n) \quad (45)$$

where  $j(r)$  with  $r = 1, \dots, n$  are the elements of the first row of the matrix  $J$ , and  $l = 0, \dots, n - 1$  is the index for the eigenvalues (c.f. Montaldi, 2012).

For  $n = 2$  we have one nonzero entry  $j(r) = 1/2$  in each row of  $J$ , and for  $n \geq 4$  we have two nonzero entries  $j(r) = 1/4$  in each row of  $J$ . As for circular and symmetric matrices one has  $b(l) = 0$  for all  $l$ , it follows  $\alpha(l) = a(l)$ . As, moreover,  $-1 \leq \cos(x) \leq 1$  all eigenvalues will lie in the interval

$$-\frac{1}{2} \leq \alpha(l) \leq \frac{1}{2}, \quad (46)$$

i.e. within the unit circle, which proves stability of the Nash equilibrium.

### Condition on positive profits

From the proof of Proposition 4 we already know that profits of higher productivity firms will surely be positive if profits of low productivity firms are non-negative and that  $\pi_L > 0$  will hold if  $\phi_H - \phi_L < \frac{3t}{n(1+\gamma\frac{n}{n-1})}$ . Since the right-hand side of the inequality is decreasing in the number of firms  $n$ , for any  $n \geq 2$ ,  $\pi_L > 0$  will surely hold if  $\phi_H - \phi_L < 3t/(2(1+2\gamma))$ .

### Condition on utility larger than reservation wages

Utility of workers is, see (1),

$$w_i + \gamma \left( w_i - \frac{1}{n-1} \sum_{j \neq i}^n w_j \right) - tx. \quad (47)$$

From the utility function of a worker it is obvious that a high wage worker always has a higher utility than a low wage worker, for a given dis-utility from disadvantageous job characteristics. Therefore, a sufficient condition for all workers wanting to work is that a low wage worker living away at maximum distance from a low productivity firm has utility

$$w_L + \gamma \left( w_L - \frac{1}{n-1} \left( \left( \frac{n}{2} - 1 \right) w_L + \frac{n}{2} w_H \right) \right) - t \frac{1}{n} > 0. \quad (48)$$

Simplifying and inserting wages gives

$$\frac{1}{3} \phi_H + \frac{2}{3} \phi_L - \frac{t}{n(1 + \gamma \frac{n}{n-1})} - \gamma \frac{n}{2(n-1)} \frac{1}{3} (\phi_H - \phi_L) > \frac{t}{n}. \quad (49)$$

Rearranging yields

$$\left( \frac{1}{3} \phi_H + \frac{2}{3} \phi_L \right) \frac{1 + \gamma \frac{n}{n-1}}{2 + \gamma \frac{n}{n-1}} - \gamma \frac{n}{2(n-1)} \frac{1}{3} (\phi_H - \phi_L) \frac{1 + \gamma \frac{n}{n-1}}{2 + \gamma \frac{n}{n-1}} > \frac{t}{n}. \quad (50)$$

The condition on positive profits for firms, as derived about, is

$$\phi_H - \phi_L < \frac{3t}{n(1 + \gamma \frac{n}{n-1})}. \quad (51)$$

Combining both conditions gives by substituting  $t/n$

$$\begin{aligned} \left( \frac{1}{3} \phi_H + \frac{2}{3} \phi_L \right) \frac{1 + \gamma \frac{n}{n-1}}{2 + \gamma \frac{n}{n-1}} - \gamma \frac{n}{2(n-1)} \frac{1}{3} (\phi_H - \phi_L) \frac{1 + \gamma \frac{n}{n-1}}{2 + \gamma \frac{n}{n-1}} > \\ (\phi_H - \phi_L) \frac{(1 + \gamma \frac{n}{n-1})}{3} \end{aligned} \quad (52)$$

and after simplification

$$\frac{-\phi_H + 4\phi_L}{\phi_H - \phi_L} \frac{2(n-1)}{3n} > \gamma. \quad (53)$$

As long as  $\phi_H$  is not too much larger than  $\phi_L$ , a  $\gamma$  exists such that all workers will want to work and firms make positive profits.

## Positive employment

Employment was derived as

$$L_H^* = \frac{\frac{1}{3}(\phi_H - \phi_L)\left(1 + \gamma\frac{n}{n-1}\right)}{t} + \frac{1}{n} \quad (54)$$

and

$$L_L^* = \frac{\frac{1}{3}(\phi_L - \phi_H)\left(1 + \gamma\frac{n}{n-1}\right)}{t} + \frac{1}{n}. \quad (55)$$

As by assumption  $\phi_H > \phi_L$ , employment at all firms will be positive if

$$\phi_H - \phi_L < \frac{3t}{n\left(1 + \gamma\frac{n}{n-1}\right)} \quad (56)$$

which is equivalent to  $\pi_L > 0$ .

## No capturing of neighbor's market

So far derivations of equilibrium wages etc. have been based on the assumption that a firm  $i$  employs workers situated between firms  $i$  and  $i_+$ , and  $i$  and  $i_-$ , respectively. Theoretically, firm  $i$  could attempt to raise its profits above the levels defined in equation (26) by also employing workers situated, for example, between firm  $i_+$  and the next firm on the circle. Here we derive a sufficient condition for a firm to be unwilling to offer a wage such that it captures the neighboring firm's labor. In order to do so and without loss of generality we may consider 3 firms. Firms 1 and 3 are  $H$ -type firms, firm 2 is an  $L$ -type firm. The order on the circle is 1, 2, 3. First, we want to know under which condition it is more attractive for a worker who is indifferent between working in firms 2 or 3 to work in firm 1. Second, we show that a wage which fulfills this condition may result in negative profits and will, hence, not be offered by firm 1.

Suppose this marginal worker is located at distance  $\eta$  from firm 2, such that the costs of traveling to firm 1 are  $t/n + t\eta$ . Further assume that if the worker moves to firm 1 because he is offered a wage sufficiently high, the worker knows that all workers in firm 2 will do the same thing. This would

be the case because all other workers are located closer to firm 1. Therefore, firm 2 would cease to exist. Consequently, the number of firms would go down by one and the comparison wage would only include  $n/2 - 1$   $H$ -type and  $L$ -type firms (instead of  $n/2$   $H$ -type firms and  $n/2 - 1$   $L$ -type firms when working in firm 2). The indifferent worker would rather work for firm 1 if that firm offered a wage  $w_{cap}$  that fulfills

$$\begin{aligned} w_{cap}(1 + \gamma) - \frac{\gamma}{n-2} \left( \left( \frac{n}{2} - 1 \right) w_H^* + \left( \frac{n}{2} - 1 \right) w_L^* \right) - t\eta - \frac{t}{n} \quad (57) \\ > w_L^*(1 + \gamma) - \frac{\gamma}{n-1} \left( \frac{n}{2} w_H^* + \left( \frac{n}{2} - 1 \right) w_L^* \right) - t\eta \end{aligned}$$

where the left hand side of the inequality is the utility accruing to the worker if he worked for firm 1 that would pay a wage  $w_{cap}$ , and the right hand side is the utility of that same worker if he continued to work at the  $L$ -type firm. Rearranging gives

$$w_{cap}(1 + \gamma) - \frac{t}{n} > w_L^* \frac{(1 + \gamma)2(n-1) + \gamma}{2(n-1)} + w_H^* \frac{-\gamma}{2(n-1)} \quad (58)$$

and after inserting equilibrium wages (13), (14) we get

$$\begin{aligned} w_{cap} > \frac{1}{3}\phi_H \left( \frac{2(n-1) + \gamma(2n-3)}{2(n-1)(1+\gamma)} \right) + \frac{1}{3}\phi_L \left( \frac{4(n-1) + \gamma(4n-3)}{2(n-1)(1+\gamma)} \right) \quad (59) \\ + \frac{t}{n} \frac{\gamma}{(1+\gamma)(n-1)(1+\gamma\frac{n}{n-1})}. \end{aligned}$$

For the firm 1 to make positive profits when deviating it needs to be the case that  $\phi_H > w_{cap}$ , so that we may write

$$\begin{aligned} \phi_H > \frac{1}{3}\phi_H \left( \frac{2(n-1) + \gamma(2n-3)}{2(n-1)(1+\gamma)} \right) + \frac{1}{3}\phi_L \left( \frac{4(n-1) + \gamma(4n-3)}{2(n-1)(1+\gamma)} \right) \quad (60) \\ + \frac{t}{n} \frac{\gamma}{(1+\gamma)(n-1)(1+\gamma\frac{n}{n-1})} \end{aligned}$$



which simplifies to

$$\phi_H - \phi_L > \frac{3t}{n} \frac{1}{4(n-1) + \gamma(4n-3)} \frac{2\gamma}{(1 + \gamma \frac{n}{n-1})}. \quad (61)$$

Condition (61) implies that as long as  $\gamma > 0$  we can find a parametrization for which firm  $H$  does not have an incentive to pay a higher wage than in equilibrium because profits would turn negative. For this parametrization also the  $L$ -type firm will not want to offer a wage to capture the neighboring market given that it has lower productivity than the  $H$ -type firm.

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