Fair Wages and Foreign Sourcing*

Gene M. Grossman
Department of Economics, Princeton University

Elhanan Helpman
Department of Economics, Harvard University

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Abstract

We develop a simple general equilibrium model for studying the impact of workers' relative-wage concerns on resource allocation and the organization of production. We characterize equilibria for the closed economy and for an open economy in which an intermediate input can be produced offshore. In the closed economy, firms that are otherwise identical may have different hiring practices and pay different wages to low-skill workers. In the open economy, some firms perform all production at home while others produce all of the intermediate input offshore. We show that relative-wage concerns add to incentives for offshoring. Offshore production may take place in the presence of relative-wage concerns in situations where it would not be profitable in their absence. And if offshoring takes place with or without such concerns, the extent of offshore production is greater in the former setting than in the latter. We further show that when workers are concerned about relative pay, the equilibrium does not maximize the economy's net output. Nonetheless, the competitive equilibrium with offshoring is constrained Pareto efficient.

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1 Introduction

Most social scientists agree that humans care not only about their own absolute well-being but also about their standing *compared to others*. Relative position affects individuals' self-reporting of their happiness (Easterlin, 2001, Frey and Stutzer, 2002, and Luttmer, 2005) and job satisfaction (Clark and Oswald, 1996, and Hammermesh, 2001). It features prominently in psychologists' theories of internal equity and relative deprivation, in sociologists' theories of social exchange and in economists' theories of reciprocity and internal labor markets. It is accepted wisdom among personnel managers and authors of compensation texts (Bergmann and Carpello, 2000; Milkovich and Newman, 2005). Based on a wealth of evidence of various sorts, it is more than reasonable to take the utility function of "economic man" as having relational variables among its several arguments.

Wage comparisons play an increasingly important role in labor economics. Akerlof (1982) described the work relationship as a "gift exchange" in which workers voluntarily provide effort (in the absence of enforceable contracts) in exchange for "fair" compensation. When a worker perceives his pay to be insufficient, his morale may suffer and his anger flare. Then the worker may withhold his effort, to the detriment of his productivity on the job. In this theory, workers gauge fairness at least in part by what others are being paid. Akerlof and Yellen (1990) and others have applied this notion of "fair wages" to develop an explanation for wage rigidity and unemployment.[1] Firms may be reluctant to alter relative wages in the face of shocks, or to reduce nominal wages when demand falls, for fear that employees would regard these actions as unjust and would work less hard in response. If wages fail to adjust when demand declines, excess supply and involuntary unemployment may result.

The theorizing by Akerlof and others spawned empirical research to investigate its behavioral underpinnings. Researchers have surveyed business managers to question their tendency to preserve pay structure in response to increases in the minimum wage (Grossman, 1983) and their reluctance to pare wages in the face of flagging demand (Blinder and Choi, 1990, Campbell and Kamiani, 1997, and Bewley, 1999). They find that managers regard morale to be an important consideration in setting wages. Experimentalists have established a role for reciprocity in a variety of laboratory games (see the survey by Gächter and Fehr, 2001). Field studies too find a link between relative wages and perceptions of fairness. For example, in a recent case study of the freight-handling industry, Verhoogen, Burks and Carpenter (forthcoming) find a positive correlation between workers' views on the fairness of their pay and the gap between their wage and the (predicted) outside wage they would earn based on their demographics and labor market conditions (see, also, Martin, 1981, Lincoln and Kalleberg, 1990, and Levine, 1993).

If workers' job satisfaction depends upon comparison to others, an immediate question that arises is, who are the "others" in the relevant reference group? Workers might compare themselves to others elsewhere in the economy who have similar backgrounds and perform relatively similar

[1] See also, for example, Agell and Lundborg (1992, 1995), Kreickemeier and Nelson (2006), and Kreickemeier and Schoenwald (2006).

jobs. Or they may compare themselves to others in the same office, plant, or firm within a somewhat broader occupational grouping. Psychologists emphasize the frequency of interaction and the ease of comparison as crucial in defining reference groups (Patchen, 1961, and Goodman, 1977). Their arguments suggest that comparisons within the workplace may be especially important. The available survey evidence supports this view. For example, the managers interviewed by Bewley (1999) point to internal wage structure as an important determinant of company morale, whereas external pay differentials rarely are mentioned, except in highly unionized industries. The managers indicated that employees often know little about pay rates at other firms, even for those in similar occupations and jobs. Levine (1993) reports similarly that internal equity concerns take precedence over external considerations in determining the compensation of corporate executives.

When internal wage comparisons are important to job satisfaction and employee morale, they might affect firms' organizational choices. Baron and Kreps (1999) have suggested that considerations of internal pay structure could motivate firms to outsource certain low-skill activities to independent contractors, in order to avoid the dissatisfaction and jealousy that can develop among these workers when they are permanent employees of the firm. In this paper we explore a related idea: Firms may choose to *offshore* certain activities in order to separate the workers who perform them from those in the firm who are higher paid. This strategy might improve morale if individuals have better information about co-workers employed in the same (or nearby) office or plant than they do about those toiling in a different country, and use only the more salient co-workers in forming their views of the fair wage.

Why might a firm profit by segmenting its labor force geographically, above and beyond any gains that may come from cross-country wage differentials? The fair wage-effort hypothesis offers one possible answer. When workers feel they are being treated unjustly, they may express their displeasure by shaving effort. Then separating those who receive below-average pay from the targets of their potential envy may raise labor productivity. We do not deny the plausibility of this mechanism, but note that variable effort is not necessary for our argument. Relative-wage considerations can play a role in organizational choices even if they do not affect worker performance, so long as they influence job satisfaction. After all, firms must offer a competitive level of utility in order to attract and hold workers. The survey findings suggest that personnel managers are aware of this channel; Blinder and Choi (1990), Campbell and Kamiani (1997) and Bewley (1999) all report that firms preserve internal wage equity, among other reasons, in order to alleviate labor turnover and enhance prospects for recruitment of new workers.

This is an exploratory paper in which we begin to examine how fair-wage considerations affect organizational choices and offshoring decisions in general equilibrium. We assume that a worker's job satisfaction (or, equivalently, his utility from employment) depends upon his real income and his pay rate relative to a reference wage. We take the reference wage to be the average pay in the office or plant in which the worker is employed. By assumption, the worker does not compare himself to others who may be located in an offshore facility, because it is difficult for him to obtain information about the pay of these foreign workers and perhaps difficult to interpret what the pay rates mean in real terms. In other words, the foreign labor force of a multinational firm is less salient to an employee than those who work nearby. Note too our assumption that the *average* wage matters. In much of the literature on fair wages, the worker is assumed to suffer equally when he is relatively poorly paid compared to some other class of workers, no matter how many workers are members of that class. We find this assumption to be implausible. But our alternative implies that firms must take account of fair-wage concerns in deciding the *composition* of their workforce inasmuch as the proportions of employees of different types affect the firm's average wage.

In the next section we develop a very simple model with relative-wage concerns. The model has one good and two types of labor. Each worker derives utility from real income, but suffers a loss in utility if his wage is lower than the average in his firm. Firms behave competitively. The only departure from the standard competitive model is in the utility function of the worker. Firms must take workers' jealousies into account in setting wages and choosing the composition of employment, in order that they can attract and retain the workers they demand.

In Section 3 we illustrate how relative-wage concerns can affect the organization of production, with a simple example akin to that in Akerlof and Yellen (1990). We posit a linearly-separable production function that relates output to the inputs of the two types of labor. High-skill workers are assumed to be more productive than their low-skill counterparts. But this generates a wage gap and incipient jealousies on the part of the lower-paid employees. In a competitive equilibrium, the two types of workers are separated in different firms. In this setting, there is no efficiency cost to such separation and all firms avoid employee dissatisfaction by hiring homogeneous labor forces.

Section 4 introduces a non-linear production function in which the two types of labor are complementary. Firms choose the wage for low-skill workers and the composition of employment in their company to minimize unit cost, taking the wage of the high-skill workers and the utility level for low-skill workers as given by the market. In making their choices, firms are constrained by the requirement that their work environment be sufficiently attractive to allow them to hire low-skill workers. We show that the closed-economy general equilibrium has full employment and characterize the equilibrium choices by firms. Interestingly, when workers' relative-wage concerns are intense, the equilibrium may be characterized by heterogeneity in the behavior of otherwise identical firms. Some will choose to pay a relatively low wage to low-skill workers and employ relatively many of them, while others will pay a higher wage and employ relatively fewer of them.

In Section 5, we introduce the possibility of offshoring. A firm can conduct some of its production activities offshore and thereby isolate a subset of workers from others in the firm. The isolated workers do not compare themselves to higher-paid co-workers in a distant, foreign plant. A key finding is that firms will either employ all of their low-skill workers in a foreign subsidiary, or else all such workers are employed in the domestic plant. In equilibrium, although all firms are ex ante identical, some offshore the production of one intermediate input, while others do not. Offshoring occurs even when the foreign production cost for the activities performed abroad exceeds what it would cost to perform those activities domestically at the equilibrium wage. Moreover, for any given cost of foreign production, more offshoring takes place when relative-wage concerns are present than when they are absent. We show as well that the domestic industrial structure can be very sensitive to changes in foreign production costs when relative-wage concerns are intense.

A final section addresses the efficiency properties of our model. We show that the market equilibrium with offshoring does not maximize the net output of the domestic economy. Nonetheless, a social planner who can choose the wage rates for the two types of workers, the allocation of resources to domestic firms, and the volume of inputs imported from foreign subsidiaries could not achieve a Pareto improvement over the free-market outcome.

2 A Simple Model with Relative-Wage Concerns

We study an economy with one sector and two types of labor. The single final good serves as numeraire. The model is "standard" in every respect except for the manner in which individuals assess their own well-being. We assume as usual that individuals derive additional utility from higher real incomes, but add that a sub-standard wage causes dissatisfaction, the more so the lower is the worker's wage relative to the reference wage w_r. We take the reference wage to be the average wage among employees in the individual's place of employment.

Let $u(w, w/w_r)$ be the utility function of every individual, where w is the individual's real wage and w_r is the reference wage, equal to the average wage in the individual's workplace. We make the following assumption about the properties of this utility function:

Assumption 1 $u(x, y)$ is continuous, differentiable at all (x, y) except, perhaps, at $y = 1$ (i.e., at $w = w_r$), and satisfies (i) $\partial u(x, y)/\partial x > 0$, (ii) $\partial u(x, y)/\partial y > 0$ for $y < 1$, and (iii) $\partial u(x, y)/\partial y = 0$ for $y \geq 1$.

That is, an individual's utility rises with his own real income and rises with his relative pay when his wage is below average. We take utility to be independent of the relative wage when a worker receives more than the average to capture our sense that the unhappiness caused by a perceived slight is not matched by symmetric delight from receiving ones "just dessert."[2]

An unemployed individual receives no pay, but suffers no disutility from unflattering comparisons. We normalize the utility of such an individual to equal zero and adopt

Assumption 2 $u(0, y) = 0$ and $u(x, y) > 0$ for all $x > 0$.

In other words, every individual prefers employment at a positive wage to unemployment, regardless of the structure of his employer's wages.

It will prove useful in what follows to define the reduced-form utility function,

$$v(w, w_r) \equiv u\left(w, \frac{w}{w_r}\right). \tag{1}$$

[2] Akerlof and Yellen (1990) note the ambiguous results that have been found in psychological experiments that look for *increased* effort on the part of those who are *overpaid*. They assume in their modeling that effort does not respond to relative wage once a worker's pay exceeds the reference wage. This is in the same spirit as our assumption that workers do not derive extra utility from an above-average wage.

The properties of $v(w, w_r)$ are characterized in

Lemma 1 Assumptions 1 and 2 imply that $v(w, w_r)$ is continuous; differentiable at all (w, w_r) except, perhaps, at $w = w_r$; $v(0, w_r) = 0$; $\partial v(w, w_r)/\partial w > 0$; $\partial v(w, w_r)/\partial w_r < 0$ for $0 < w \leq w_r$; $\partial v(w, w_r)/\partial w_r = 0$ for $w > w_r$; and $v(\lambda w, \lambda w_r) > v(w, w_r)$ for $w > 0$ and $\lambda > 1$.

The economy is populated by two types of individuals, high-skill workers with human capital of h_H per capita and low-skill workers with human capital h_L per capita, $h_H > h_L$. There are fixed numbers N_H and N_L (respectively) of each type. All workers regardless of type hold the preferences represented by (1). Perfect competition prevails in the product market and both labor markets. In the latter, firms take as given the utility levels they must offer in order to attract employees. A firm sets its own pay rates w_H and w_L, and hires ℓ_H and ℓ_L high-skill and low-skill workers, respectively, subject to the constraint that the employees must be willing to accept the jobs with the prescribed wage and employment conditions. Each worker opts for employment at the firm that offers the highest utility, or at any one of such firms in the event of ties. In equilibrium, firms provide competitive levels of utility and workers are indifferent as to the identity of their employers.

3 An Illustration of Effects on Organization

Our goal is to understand how jealousies within the workplace can influence the organization of production, especially when firms have opportunities to move some production processes offshore. Before turning to this problem, we will show with a simple and somewhat obvious example how relative-wage concerns can affect organizational choices.

Consider a closed economy in which the two types of labor produce final output according to the linear production function,

$$q = h_H \ell_H + h_L \ell_L. \tag{2}$$

With this technology, high-skill and low-skill workers substitute perfectly for one another albeit with different levels of productivity. A competitive firm that produces with constant returns to scale seeks to minimize its per-unit cost. It takes as given the utility levels v_i that workers of type $i \in \{H, L\}$ can obtain from their best alternative employment opportunities. The problem facing a typical firm is to find

$$\min_{\ell_H, \ell_L, w_H, w_L} \frac{w_H \ell_H + w_L \ell_L}{q}$$

subject to

$$h_H \ell_H + h_L \ell_L \geq q$$

and

$$v(w_i, w_r) \geq v_i \quad \text{for } i = H, L,$$

where

$$w_r \equiv \frac{w_H \ell_H + w_L \ell_L}{\ell_H + \ell_L}.$$

The minimand in this problem is the firm's per-unit cost. The first constraint dictates that the composition of employment suffices to generate q units of output. The remaining conditions describe the participation constraints for workers of each type and define the average wage w_r. The firm must pay sufficiently given the composition of its employment to attract the workers that it wishes to hire. Of course, a firm can choose not to produce at all or to employ workers of only one type.

In every solution to this problem, the first constraint is satisfied with equality. Therefore we can simplify the statement of the problem by defining the fraction of low-skill workers,

$$\mu \equiv \frac{\ell_L}{\ell_L + \ell_H} \ ,$$

and imposing the first constraint as an equality, to rewrite the minimand as

$$\min_{\mu, w_H, w_L} \frac{\mu w_L + (1-\mu) w_H}{\mu h_L + (1-\mu) h_H} \tag{3}$$

and the remaining constraints as

$$v[w_i, \mu w_L + (1-\mu) w_H] \geq v_i \ , \text{ for } i = H, L,$$

and

$$0 \leq \mu \leq 1.$$

In this formulation, the average wage is $w_r = \mu w_L + (1-\mu) w_H$. As the problem is now stated, the firm minimizes unit cost subject to the participation constraints for workers of each type and the feasibility constraint on the fraction μ.

The effect of fair-wage concerns on the organization of production can be seen in

Lemma 2 In an economy with the linear technology described by (2), every active firm employs only one type of worker. Firms that employ workers of type i pay wages of $w_i = h_i$ for $i = H$ or $i = L$.

In the equilibrium, every worker receives the average wage of the firm. Therefore, no worker suffers from unpleasant comparisons and all workers regard their wages as "fair."

To prove this result, suppose to the contrary that there exists an equilibrium in which some firm f employs positive numbers of both types of workers. Let the fraction of low-skill workers in this firm be μ, which lies strictly between zero and one. The firm must satisfy the participation constraint for each type of worker, of course. Assumption 1 implies that

$$v(w_i, w_i) \geq v[w_i, \mu w_L + (1-\mu) w_H] \geq v_i,$$

and that the first inequality is strict for workers of type i if $w_i < w_j$ for $i, \in \{L, H\}$ and $i \neq j$.

That is, if an (actual or hypothetical) firm were to hire only workers of type i, it could meet the participation constraint by paying its workforce the same as what the similarly-skilled workers are paid by firm f, and it could do so with slack if workers of type i are the (strictly) lowest paid workers in firm f.

Now note that the unit cost of production for firm f satisfies

$$\frac{\mu w_L + (1-\mu) w_H}{\mu h_L + (1-\mu) h_H} \geq \min\left\{\frac{w_H}{h_H}, \frac{w_L}{h_L}\right\},$$

whereas the unit cost in an (actual or hypothetical) firm that employs only workers of type i and pays them the same as does firm f is w_i/h_i. It follows that the latter firm can achieve a strictly lower unit cost than firm f. It can do so by employing only workers with the lowest w_i/h_i ratio, if $w_L/h_L \neq w_H/h_H$. And if $w_L/h_L = w_H/h_H$, it can do so by employing only low-skill workers and paying them slightly less than what firm f pays its low-skill workers. In the latter case, the competing firm can attract workers despite the slightly lower wage due to the slack in its participation constraint that would be present if it paid the same wage as firm f. It follows that either firm f suffers losses or a potential entrant could make positive profits. This contradicts the supposition that firm f produces positive output in the competitive equilibrium.

In an economy with linear technologies, a firms can avoid internal jealousies by hiring a homogeneous workforce. But the firm is bound to confront such jealousies if it mixes workers of different types. The absence of any technological benefit from mixing workers dictates the equilibrium organizational structure.

Our example shows that relative-wage concerns can affect organizational choices even when workers cannot vary their exertion of effort. In what follows, we enrich the firms' employment problem by introducing a technology that provides incentive for each firm to diversify its workforce. In such an environment, firms face a nontrivial choice of employment composition and wage structure.

4 Closed Economy with Complementary Labor

A firm always can avoid invidious wage comparisons by hiring a homogeneous workforce and paying all of its employees the same wage. When the technology is such that all potential employees are perfect substitutes, such homogeneity comes at no cost to the firm. But when workers bring potentially complementary skills, homogeneity may not be the best option even if diversity begets jealousy. To introduce a trade-off in a firm's choice of workforce composition, we henceforth assume imperfect substitutability between low-skill and high-skill labor.

More specifically, we assume that production requires two intermediate inputs, X_1 and X_2. The two inputs combine to produce final output according to the concave and linearly homogeneous production function,

$$q = F(X_1, X_2).$$

The maintained properties of $F(\cdot)$ are summarized in

Assumption 3 (i) $F(0, X_2) = F(X_1, 0) = 0$ and (ii) $\partial F(X_1, X_2)/\partial X_i > 0$ and $\partial^2 F(X_1, X_2)/\partial X_i^2 < 0$ when $X_j > 0$ for $j = 1, 2$.

We think of the production of X_1 as a manual activity that can be performed with equal productivity by either type of labor.[3] By choice of units, we suppose that $1/h_L$ workers of any skill level are needed to produce one unit of X_1. In contrast, the production of X_2 is a cognitive activity in which the high-skill workers enjoy a comparative advantage. For simplicity (and to avoid a taxonomy), we take this to the extreme by assuming that only high-skill workers can perform this activity. Units are such that $1/h_H$ high-skill workers generate one unit of input X_2.

In this paper, we shall not address decisions about internalization, but rather will simply assume that firms must provide for themselves both of the inputs needed for production of the final output. Later, we will allow the firm to move the production of X_1 offshore and thereby separate the workers engaged in this activity from those who produce input X_2. But for now we assume that both inputs must be produced in the same place. This means that every firm either produces entirely with high-skill labor or else it hires a mix of workers and deploys low-skill workers to perform the manual activities and high-skill workers to perform the cognitive tasks.

The option that a firm has to produce input X_1 with high-skill labor implies that the equilibrium wage paid to these workers must be at least as high as what any firm pays to low-skill workers. Moreover, all firms pay high-skill workers the same wage. To see this, consider a firm that pays $w_H < w_L$ and that successfully hires both types of labor. Such a firm could replace all of its low-skill workers with high-skill workers, pay the latter the same wage as before, and meet the participation constraint for high-skill workers with slack. Since the high-skill workers are as productive as low-skill workers in producing X_1, this would reduce the firm's cost. Now, if all firms pay high-skill workers at least as much as low-skill workers, the former suffer no disutility from internal wage comparisons. It follows that no firm can attract a high-skill worker unless it offers at least what other firms are paying to these workers. In equilibrium, all firms pay $w_H \geq w_L$ and $v_H = v(w_H, w_H)$.

The productivity of high-skill labor in producing input X_1 also puts a lower bound on the equilibrium wage of these workers. A firm could hire only high-skill workers and devote a fraction λ of them to producing X_1 and the remaining fraction $1 - \lambda$ to producing X_2. Let $\lambda^* = \arg\max_\lambda F[\lambda h_L, (1-\lambda) h_H]$ be the fraction that maximizes output per worker under this employment strategy. Were a firm to follow this strategy, it would achieve a unit cost of $w_H / F[\lambda^* h_L, (1-\lambda^*) h_H]$, which can be no less than the price (of unity) of the final good in equilibrium. It follows that high-skill labor must earn at least $w_{\min} = F[\lambda^* h_L, (1-\lambda^*) h_H]$ in equilibrium, which proves

Lemma 3 All firms pay high-skill workers the same wage w_H in equilibrium, with $w_H \geq \max\{w_{\min}, w_L\}$. These workers attain utility of $v_H = v(w_H, w_H) > 0$.

[3] Alternatively, we could allow the high-skill workers to have an absolute advantage but a comparative disadvantage in producing X_1. Then, for a range of productivities of the high-skill workers in this activity, it would not be profitable for firms to use these workers for this purpose, as in the equilibria we study below.

The last part of Lemma 3 implies that high-skill workers are fully employed.

Next we show that low-skill workers also are fully employed in equilibrium.[4] Suppose to the contrary that there are unemployed low-skill workers in equilibrium and that some firm f employs low-skill workers at a positive wage w_L. Firm f earns zero profits in a competitive equilibrium. But then a potential entrant f' could offer w_H to high-skill workers and w'_L to low-skill workers, where $w_L > w'_L > 0$, and hire the two types in the same proportions as firm f. Firm f' meets the participation constraint for high-skill workers, because it offers these workers the same utility as firm f (which, by supposition, operates in equilibrium). And firm f' offers a better option to the low-skill workers than unemployment (by Assumption 2). It follows that firm f' can attract workers and that it can achieve a lower unit cost than does firm f. The potential entrant earns positive profits, which contradicts the supposition of an equilibrium in which firm f is active and low-skill workers are unemployed. Finally, we consider the possibility that all low-skilled workers are unemployed, because active firms hire only high-skill workers to produce both inputs. In such a situation, a potential entrant could earn positive profits by producing the two inputs in the same proportions as an active firm, but using low-skill workers paid $w_L < w_H$ in place of high-skill workers for the production of X_1.

We proceed now to characterize several different wage structures that can prevail in equilibrium and discuss when each arises. We begin with the case in which all workers receive the same pay. To this end, suppose that all firms pay their workers a common wage of $w_H = w_L = w$. In the event, every firm is indifferent between using high-skill workers or low-skill workers (or a mix of the two) for the production of X_1. A firm that chooses to use only high-skill workers to produce X_1 (and, of course, X_2) minimizes cost by inputting X_1 and X_2 in the proportions λ^* and $1-\lambda^*$, where $\lambda^* = \arg\max_\lambda F[\lambda h_L, (1-\lambda) h_H]$ as before, thereby achieving a minimal unit cost of $w_H / F[\lambda^* h_L, (1-\lambda^*) h_H]$. Other firms must achieve the same unit cost, which means that they use the two inputs in the same proportions. These firms employ the same number of total workers to produce a unit of X_1 as the firm that hires only high-skill workers for this purpose, and also the same number of high-skill workers to produce a unit of X_2 as this firm. It follows that, in every firm, at most a fraction λ^* of employees are low-skill workers. An equilibrium with equal wages exists if the fraction of low-skill workers in the economy is no greater than λ^*; i.e., if $N_L/(N_L + N_H) \leq \lambda^*$. In such an equilibrium, all firms break even, which means that all have a unit cost of one. Then the common wage must be $w = w_{\min}$ inasmuch as $w_{\min}$ is the wage for

[4] This property of the model contrasts with results that are commonly found in the literature on fair wages; see, for example, Akerlof and Yellen (1990), Agell and Lundberg (1995) and Kreickemeier and Nelson (2006). It might seem that the different finding reflects the different assumptions about the observability of effort. In the earlier papers, workers efforts are variable and firms pay efficiency wages to promote high productivity. The optimal wage is above the market-clearing wage, which results in unemployment. However, our model would yield an equilibrium with full employment even if workers' efforts were variable. The key difference instead is that we take the reference wage to be the *average* in the firm, whereas previous authors either take the reference wage to be w_H no matter how many employees are hired at that rate or else they take the reference wage to be determined outside the firm. When the reference wage is the average wage, firms can hire many low-skill workers when their wage is sufficiently low without losing their ability to attract workers or to induce positive effort. Firms' willingness to hire many low-skill workers at a sufficiently low wage, together with our assumption that workers always prefer to be employed at a positive wage than to be unemployed, is what eliminates the possibility of unemployment in our model.

high-skill workers that generates a unit cost of one for a firm that employs only high-skill workers.

To verify that an equilibrium like this exists when $N_L/(N_L+N_H) \leq \lambda^*$, note that no firm could attract workers of a type i if it were to offer these workers a wage $w_i < w_{\min}$. And no firm has an incentive to offer workers of type i a higher wage then $w_{\min}$, because doing so can only raise its unit cost. Finally, no firm has an incentive to use the inputs in a different proportion than $\lambda^*/(1-\lambda^*)$, no firm can use low-skill workers to produce X_2 and all firms are indifferent as to how they produce X_1. We note as well that when $N_L/(N_L+N_H) \leq \lambda^*$, there exists no equilibrium with unequal wages, because if firms pay low-skill workers $w_L < w_H$ they prefer to hire only these workers to produce X_1 and to use a greater share of X_1 in total inputs than the fraction λ^*. This means that low-skill workers will comprise more than the fraction λ^* of the workforce in every firm, which is not possible when they comprise at most the fraction λ^* in the population of workers.[5]

We summarize the arguments to this point in

Proposition 1 *Let Assumptions 1-3 be satisfied and let* $N_L/(N_L+N_H) \leq \lambda^*$. *Then, in all firms,* $w_L = w_H = w_{\min}$ *and* $X_1/X_2 = \lambda^*/(1-\lambda^*)$. *Each firm is indifferent as to the employment mix used to produce* X_1, *but, in the aggregate, firms fully employ both types of workers.*

We next consider environments in which low-skill workers are in relatively abundant supply; i.e., $N_L/(N_L+N_H) > \lambda^*$. As should be clear from the previous discussion, the two types of workers cannot be paid the same wages in such circumstances, and, in fact, the high-skill workers will enjoy greater utility than their lesser skilled counterparts. A typical firm seeks to minimize its unit cost by choosing the employment mix μ and the wage of low-skill workers w_L to solve

$$\min_{\mu, w_L} \frac{\mu w_L + (1-\mu) w_H}{F[\mu h_L, (1-\mu) h_H]} \tag{4}$$

subject to the participation constraint for low-skill workers,

$$v[w_L, \mu w_L + (1-\mu) w_H] \geq v_L$$

and the feasibility constraint

$$0 \leq \mu \leq 1 \ .$$

In solving this problem, each firm takes the market wage for high-skill workers w_H and the reservation utility level for low-skill workers v_L as given. It employs only low-skill workers to produce X_1, inasmuch as these workers are as productive as their high-skilled counterparts in this activity and they command a lower wage.

Every firm chooses a combination of μ and w_L such that it meets the participation constraint for low-skill workers as an equality. Failure to do so would mean that the firm could reduce

[5] Note that if $w_L < w_H$ in some firm, then $w_H > w_{\min}$, because if w_H were to equal $w_{\min}$ then the firm with $w_L < w_H$ were to have a unit cost below one, which is not possible in equilibrium. It therefore follows that if a firm pays $w_L < w_H$ in equilibrium, then all firms pay the low-skill workers less then the high-skill workers and $w_H > w_{\min}$. Under the circumstance every firm seeks to employ a fraction of the unskilled in excess of λ^*, which is not possible when $N_L/(N_L+N_H) \leq \lambda^*$.

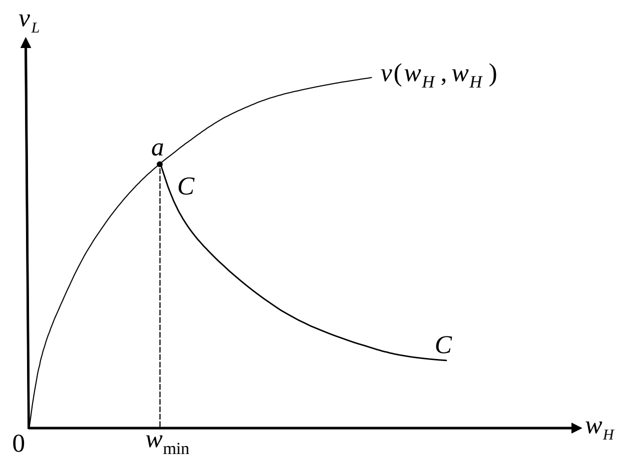

Figure 1: Unit cost

the wage paid to low-skill workers while maintaining the same composition of its workforce, still attract its desired employees, and thereby reduce its unit cost.[6] It follows that the minimum unit cost, which we denote by $c_n(w_H, v_L)$, is continuous and increasing in both arguments for all $v_L < v_H = v(w_H, w_H)$.[7]

The downward sloping curve CC in Figure 1 depicts the combinations of w_H and v_L that satisfy

$$c_n(w_H, v_L) = 1 \; ; \tag{5}$$

i.e., combinations that yield a minimum unit cost equal to the price of the final good. The curve emanates from the $v(w_H, w_H)$ curve at the point a at which $w_H = w_{\min}$. The location of the equilibrium along CC depends on the relative abundance of low-skill workers. Two types of equilibria are possible, as we shall now illustrate by means of an example.

[6] To see this formally, note that the first-order condition with respect to w_L is

$$\frac{\mu}{F} - \zeta(v_1 + v_2\mu) = 0,$$

where $\zeta \geq 0$ is the Lagrangian multiplier of the participation constraint, v_1 is the partial derivative of $v(\cdot)$ with respect to its first argument and v_2 is the partial derivative with respect to its second argument. The last part of Lemma 1, i.e., $v(\lambda w, \lambda w_r) > v(w, w_r)$ for $w > 0$ and $\lambda > 1$, implies that $v_1 w_L + v_2[\mu w_L + (1-\mu) w_H] > 0$, which implies in turn that $v_1 + v_2\mu > 0$, because $v_2 < 0$. As a result, the first-order condition for $w_L > 0$ can be satisfied only if $\zeta > 0$, or the participation constraint is satisfied with equality.

[7] Using the envelope theorem we obtain

$$c_{n1} = \left(\frac{1}{F} - \zeta v_2\right)(1-\mu) > 0,$$

$$c_{n2} = \zeta > 0,$$

where c_{n1} is the partial derivative of $c_n(\cdot)$ with respect to its first argument and c_{n2} is the partial derivative with respect to its second argument. The inequalities result from the fact that the multiplier ζ is strictly positive, as explained in the previous footnote, and the fact that $v_2 < 0$.

To this end, consider an economy with a Cobb-Douglas production function

$$F\left(X_1, X_2\right) = X_1^{\alpha} X_2^{1-\alpha}, \quad 0 < \alpha < 1 \ ,$$

and the utility function

$$u\left(w, \frac{w}{w_r}\right) = \begin{cases} w\left(\frac{w}{w_r}\right)^{1/\eta} & \text{for } \ w < w_r \\ w & \text{for } \ w \geq w_r \end{cases} \ , \quad \eta > 0.$$

The parameter η measures (inversely) a worker's concern about his relative wage. The standard setting in which workers care only about their own pay is represented by the limiting case in which $\eta \to \infty$. This utility function yields an associated indirect utility function of the form

$$v\left(w, w_r\right) = w^{1+1/\eta} w_r^{-1/\eta} \ ,$$

which implies that the $v(w_H, w_H)$ curve in Figure 1 is a ray through the origin.

With these functional forms, a firm's cost-minimization problem for $w_L < w_H$ can be written as

$$\min_{\mu, w_L} \frac{\mu w_L + \left(1-\mu\right) w_H}{h_L^{\alpha} h_H^{1-\alpha} \mu^{\alpha} \left(1-\mu\right)^{1-\alpha}}$$

subject to

$$\frac{w_L^{1+\eta}}{\mu w_L + \left(1-\mu\right) w_H} \geq v_L^{\eta},$$

and

$$0 \leq \mu \leq 1.$$

To characterize the solution to this problem, recall that for equilibrium values of w_H and v_L the participation constraint is satisfied with equality. We can therefore solve from this constraint the fraction μ as a function of the other variables to obtain

$$\mu = \frac{1 - w_\ell^{1+\eta} / v_\ell^{\eta}}{1 - w_\ell}, \tag{6}$$

where $w_\ell = w_L / w_H$ is the relative wage of the unskilled and $v_\ell = v_L / w_H$ is their relative utility, and both must lie between zero and one. The constraint that μ falls between zero and one implies that

$$v_\ell \leq w_\ell \leq v_\ell^{\eta/(1+\eta)}.$$

Next substitute the solution for μ into the firm's objective function to obtain an equivalent

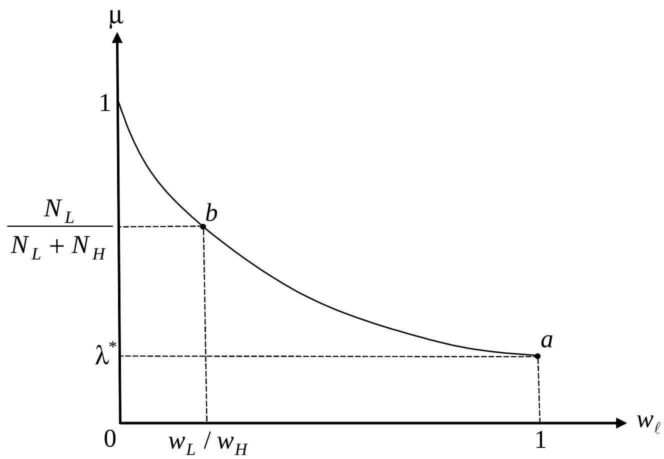

Figure 2: Relative wages and composition of employment for large η

cost-minimization problem,

$$\min_{w_\ell \in \left[v_\ell, v_\ell^{\eta/(1+\eta)}\right]} \frac{k w_\ell^{\eta+\alpha}(1-w_\ell)}{\left(1-\frac{w_\ell^{1+\eta}}{v_\ell^{\eta}}\right)^{\alpha}\left(\frac{w_\ell^{\eta}}{v_\ell^{\eta}}-1\right)^{1-\alpha}}, \tag{7}$$

where

$$k = \frac{w_H}{v_\ell^{\eta} h_L^{\alpha} h_H^{1-\alpha}} \ .$$

The firm takes k as given in solving this problem.

The minimand in (7) is continuous for permissible values of w_ℓ and all $v_\ell < 1$. Therefore, there exists a solution to the minimization problem for every value of $v_\ell < 1$. Moreover, the solution does not depend on k, but only on v_ℓ and the parameters α and η. As w_ℓ approaches v_ℓ from above or $v_\ell^{\eta/(1+\eta)}$ from below, the unit cost tends to infinity. It follows that the cost-minimizing choice of w_ℓ lies strictly in the interior of the permissible range. This implies from (6) that the fraction of low-skill employees lies strictly between zero and one. The remaining question is whether the solution to the firm's cost-minimization problem is unique.

To answer this question, we resorted to numerical simulation. We found a unique solution to the minimization problem for all values of v_ℓ when η is large. Moreover, in these cases, we found w_ℓ to be increasing in v_ℓ and to co-vary inversely with μ. In other words, when workers are mostly concerned about their own real wages and less worried about their relative standing within the firm, an increase in the reservation level of utility for low-skill workers causes firms to pay these workers higher wages and to employ relatively fewer of them as a share of total employment.

In Figure 2 we show the relationship between μ and w_ℓ implied by (6) and the solution to (7), when η is large. Each point on the curve corresponds to a different value of v_ℓ; the higher is v_ℓ, the higher is w_ℓ and the smaller is μ. In the limit, as the utility of the low-skill workers approaches

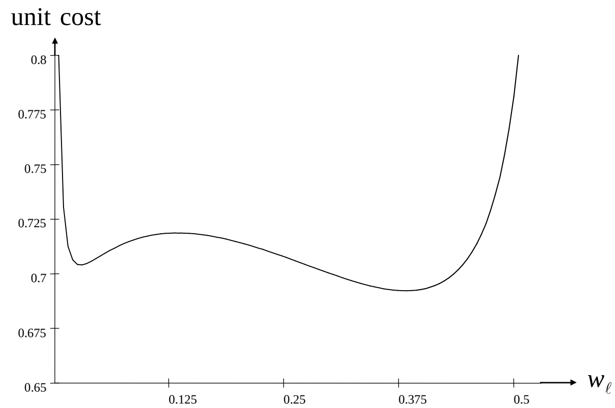

Figure 3: Unit cost with two local minima: $k = 1$, $\alpha = 0.2$, $\eta = 0.1$, $v_\ell = 0.001$

that of the high-skill workers, the wage rates converge (i.e., $w_\ell \to 1$) and the fraction of low-skill workers in every firm approaches λ^*.

When the solution to the firm's problem is unique and can be depicted as in Figure 2, the general equilibrium also is unique. In the equilibrium, all firms choose the same composition of employment, which must of course match the economy's relative supplies of the two types of workers. Therefore, $\mu = N_L/(N_L + N_H)$. Using this value of μ, we can find the corresponding relative wage at point b in the figure. There is a unique value v_ℓ associated with point b, which we can take to Figure 1 to find the corresponding point on the CC curve. This, finally, yields the equilibrium values of v_L and w_H.

The unique equilibrium that emerges when $N_L/(N_L + N_H) > \lambda^*$ and η is large has standard properties. For example, an increase in the relative supply of low-skill workers generates a shift in the composition of employment in all firms toward these workers, an increase in the wage and utility of high-skill workers, and a fall in the wage and utility of those with lesser skills.

A different type of equilibrium can emerge when low-skill workers are in relatively abundant supply and workers place great weight on their relative pay (i.e. η is small). In such circumstances, there may exist values of v_ℓ for which the solution to the cost minimization problem (7) is not unique. Consider Figure 3, which plots a firm's unit cost against its choice of relative wage for a particular set of parameter values that includes a small value of η. As is clear, the function relating unit cost to w_ℓ has two local minima. For the parameters that underlie this figure, the global minimum is attained at the right-most critical point. However, a similar diagram drawn for the same parameter values but a lower value of v_ℓ would show the global minimum at the left-most critical point. And for a particular, intermediate value of v_ℓ that we denote by v_b, the same unit cost is achieved at both local minima; i.e., a firm's optimization problem has multiple solutions.

When $v_\ell = v_b$, a given firm can minimize costs by choosing either of two alternative strategies. It can pay low-skilled workers a low wage and employ relatively many of them, by using a great input of

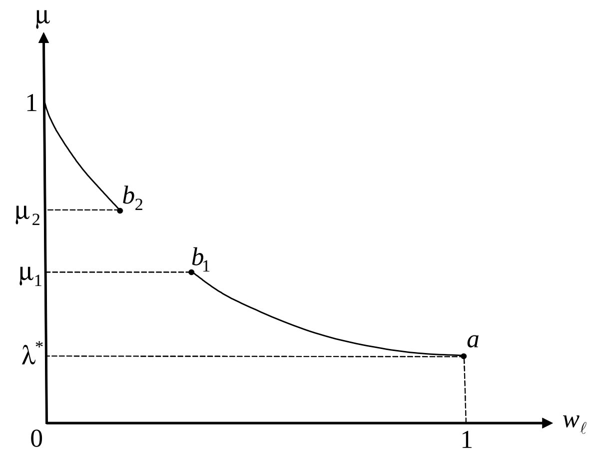

Figure 4: Relative wages and composition of employment for small η

X_1 and a smaller input of X_2, or it can pay the low-skill workers a higher wage but employ relatively fewer of them, substituting more of X_2 for less of X_1. Under the former strategy, the firm attracts low-skill workers despite paying a relatively unattractive wage by providing a work environment with relatively little jealousy. The heavy use of low-skill workers means that the average wage is low, and the typical low-skill worker does not suffer too much from unflattering comparisons. Under the latter strategy with a higher w_L, the low-skill workers derive greater utility from their own pay, but suffer greater disutility when comparing themselves to the average employee in the workplace. In other words, the different compositions of employment imply different comparator groups and therefore different perceptions of fairness.

For low values of η that imply a non-monotonic relationship between a firm's unit cost and the relative wage it offers, the equilibrium relationship between μ and w_ℓ is as depicted in Figure 4. Again, the points along the (discontinuous) downward sloping curve correspond to different values of v_ℓ, which each firm takes as given. For high values of $v_\ell > v_b$, each firm perceives a unique cost-minimizing choice of w_ℓ, which is a relatively high value that achieves the right-most local minimum in a figure like Figure 3.[8] For $v_\ell > v_b$, the relationship between μ and w_ℓ is continuous, and variations in v_ℓ in this range trace out the continuous curve between points b_1 and a in Figure 4. Similarly for low values of $v_\ell < v_b$, each firm perceives a unique cost-minimizing choice of w_ℓ, but now it is is a relatively low value that achieves the left-most local minimum in a figure like Figure 3. Again, the relationship between μ and w_ℓ is continuous and downward sloping, and variation in v_ℓ in the range $v_\ell < v_b$ generates the curve between points b_2 and 1 in Figure 4. Finally, for $v_\ell = v_b$, each firm is indifferent between choosing a relatively high value of w_ℓ and the corresponding composition of employment μ_1 or a lower value of w_ℓ and the fraction of low-skill workers μ_2. The alternative solutions to a firm's cost minimization problem for $v_\ell = v_b$ are represented by points b_1

[8]For v_ℓ large enough, the left-most local minimum may disappear entirely, leaving the higher value of w_ℓ as the unique critical point.

and b_2 in the figure.

We are now ready to describe the equilibrium, the nature of which depends upon the relative supplies of the two types of workers. In equilibrium, the (average) composition of employment within firms must match the relative supplies of the two types of workers in the population. Suppose $\lambda^* < N_L/(N_L + N_H) < \mu_1$. Then the factor markets can clear only if all firms hire a fraction $\mu = N_L/(N_L + N_H)$ of low-skill workers. In the event, the equilibrium relative wage can be read off Figure 4 at the corresponding point along the curve between b_1 and a. The equilibrium relative utility of low-skill workers is the value of v_ℓ associated with the equilibrium μ and w_ℓ. Similarly, if $N_L/(N_L + N_H) > \mu_2$, all firms choose the same cost-minimizing mix of workers, and the equilibrium falls along the curve between b_2 and 1 in Figure 4. But consider how markets can clear when $\mu_1 < N_L/(N_L + N_H) < \mu_2$. On the one hand, there is no single firm that minimizes cost by hiring workers in the precise proportions that they are represented in the labor force, no matter what is the value of v_ℓ. On the other hand, if $v_\ell = v_b$, all firms are indifferent between hiring a fraction μ_1 of low-skill workers and paying the relative wage associated with point b_1 and hiring a fraction μ_2 of low-skill workers and paying the relative wage associated with point b_2. The labor markets can clear only if in equilibrium $v_\ell = v_b$ and if some firms use the employment mix μ_1 and others use the employment mix μ_2 such that on average the two types of workers are employed in the proportions that they populate the labor force.[9]

To summarize, we have[10]

Proposition 2 *Let Assumptions 1-3 be satisfied and let $N_L/(N_L + N_H) > \lambda^*$. Then $w_H > w_L$. For some parameter values, firms that are ex ante identical will differ in their employment mixes. An equilibrium with heterogeneous hiring behavior can arise only when $\partial u(w, y)/\partial y$ is large relative to $\partial u(w, y)/\partial w$, where $y = w/w_r$.*

We see that fair-wage concerns can change the nature of equilibrium when workers are sufficiently sensitive to their relative position in the pay structure. In such circumstances, there may be no equilibrium in which otherwise similar firms pay the same wages and make the same hiring decisions. The explanation for this lies in a positive feedback mechanism: paying a high wage to low-skill workers induces a firm to substitute away from these workers, which changes the composition of employment and necessitates an even higher wage so that workers are attracted to the firm despite the jealousies that are aroused.

5 Foreign Sourcing

In our model of fair wages, firms have an incentive to separate employees in order to reduce or eliminate jealousies among those who are lower paid. We have seen in Section 3 that when firms

[9] More formally, let a fraction s_1 of final producers employ low-skill workers as a fraction μ_1 of their workforce, and let the remaining fraction $s_2 = 1 - s_1$ of firms employ low-skill workers as a fraction μ_2 of the their workforce. Then, in equilibrium, the proportions of each type of firm are determined by $s_1\mu_1 + s_2\mu_2 = N_L/(N_L + N_H)$.

[10] The last part of the proposition follows from the fact that for $\partial u(w, y)/\partial y \equiv 0$ there is a unique standard equilibrium with one type of firms.

can hire a homogeneous workforce without any adverse effects on productivity, the profit incentive will drive them to do so. By separating workers, a firm can avoid compensating low-paid workers for the disutility they suffer from unflattering comparisons with salient co-workers.

Firms may attempt to manage jealousies in the workplace via their decisions about internal organization. For example, the mitigation of internal wage comparisons has been suggested as a reason for firms to outsource certain low-skill activities, such as janitorial services, to specialized suppliers (see Baron and Kreps, 1999). Here we are interested in a similar motivation for offshoring. If individuals assess the fairness of their wages by comparing themselves to others who work with them in close proximity, then firms might consider moving certain activities offshore to alleviate wage jealousies. In this section we study how the decision to offshore is affected by relative-wage concerns.

To keep matters simple, we assume that firms can produce input X_1 in a foreign plant at a constant cost p_1. Implicitly, we are assuming that by producing the input X_1 offshore, the firm creates a foreign facility with a homogeneous workforce and that foreign low-skill workers are paid a wage that is independent of the equilibrium in the home country. Domestic workers have the utility function $u\left(w, w/w_r\right)$, where the comparator group in assessing the average wage w_r comprises all workers and only workers in the home facility. We focus henceforth on the case in which low-skill workers are relatively abundant; i.e., we impose

Assumption 4 $N_L/\left(N_L+N_H\right) > \lambda^*$.

With this assumption, the wage of high-skill workers would be strictly greater than that of low-skill workers in the absence of any offshoring. We denote by w_H^n and v_L^n the (unique) equilibrium values of the wage of high-skill workers and the utility of the low-skill workers in the equilibrium without offshoring, which we described in the Section 4.

The problem now facing the typical firm is to choose the wage of low-skill workers, the composition of domestic employment, and the sourcing of input X_1 so as to minimize unit cost. We let m_1 denote the ratio of the firm's foreign production of X_1 to the size of its domestic labor force. Then the new problem facing the firm can be written as

$$\min_{\mu, w_L, m_1} \frac{p_1 m_1 + \mu w_L + (1-\mu)\, w_H}{F\left[m_1 + \mu h_L, (1-\mu)\, h_H\right]} \tag{8}$$

subject to

$$v\left[w_L, \mu w_L + (1-\mu)\, w_H\right] \geq v_L,$$

and

$$0 \leq \mu \leq 1.$$

To characterize the equilibrium, we will first argue that no firm produces the input X_1 both at home and abroad. To see that this is so, suppose to the contrary that there exists an equilibrium in which some firm f has $m_1 > 0$ and $\mu > 0$. First note that a firm that chooses to manufacture some of input X_1 in a foreign country chooses the quantity m_1 that maximizes the objective function in (8) without constraints, because the imports of this input do not directly affect the participation constraint for low-skill workers. The first-order condition for the choice of m_1 by firm f, together with the equilibrium requirement that its unit cost equals one, implies

$$F_1\left[m_1 + \mu h_L, (1-\mu)\, h_H\right] = p_1 \tag{9}$$

and

$$F\left[m_1 + \mu h_L, (1-\mu)\, h_H\right] = p_1 m_1 + \mu w_L + (1-\mu)\, w_H \ , \tag{10}$$

where $F_1 = \partial F / \partial X_1$. That is, the value marginal product of the imported inputs equals their marginal cost p_1 and the unit cost of the final good equals one. It also follows that if $\{m_1, \mu\}$ minimizes the firm's unit cost with $\mu > 0$, then the firm would realize a unit cost at least as great were it to offshore all of its production of X_1. In particular, consider the alternative strategy available to firm f to set $\mu = 0$ and choose imports of X_1 per domestic employee so as to minimize $(p_1 m_1 + w_H) / F(m_1, h_H)$. Let $\tilde{m}_1$ be the cost-minimizing imports per employee with μ constrained to be zero. It is defined implicitly by the first-order condition,

$$F_1\left(\tilde{m}_1, h_H\right) = p_1 \ . \tag{11}$$

Since this strategy must yield a per-unit cost of producing the final good at least as high as the optimal choice $\{m_1, \mu\}$, and since the latter achieves a minimal cost of one in the hypothesized equilibrium, it follows that

$$w_H + p_1 \tilde{m}_1 \geq F\left(\tilde{m}_1, h_H\right).$$

The linear homogeneity of the production function $F(\cdot)$ then implies that

$$w_H \geq F_2\left(\tilde{m}_1, h_H\right) h_H.$$

Also note that (9) and (11), together with the linear homogeneity of the production function, imply that the marginal products F_1 and $F_2 = \partial F / \partial X_2$ are the same under the alternative strategies open to firm f, because $\tilde{m}_1 = (m_1 + \mu h_L) / (1-\mu)$. Therefore

$$F_1 \mu h_L + F_2 (1-\mu)\, h_H = \mu w_L + (1-\mu)\, w_H \tag{12}$$

and

$$w_H \geq F_2 h_H, \tag{13}$$

where F_1 and F_2 are the common marginal products.

Next, consider a firm f' that chooses to produce all of X_1 at home and employs $(\mu + m_1/h_L) / (1-\mu)$ low-skill workers for every high-skill worker. In this firm the fraction of low skill workers is μ', which satisfies $\mu' / (1-\mu') = (\mu + m_1/h_L) / (1-\mu)$. Suppose that firm f' were to set the same wage w_L as that paid by firm f. By doing so, it would offer strictly higher utility to low-skill workers than firm f, because the fraction of low-skill workers in firm f' would exceed that in firm f, i.e., $\mu' > \mu$.[11] Therefore, firm f' could attract low skill workers with $w_L' < w_L$. Then firm f' would achieve a unit cost of

$$\begin{aligned}
c' &= \frac{\mu' w_L' + (1-\mu')\, w_H}{F\left[\mu' h_L, (1-\mu')\, h_H\right]} < \frac{\mu' w_L + (1-\mu')\, w_H}{F\left[\mu' h_L, (1-\mu')\, h_H\right]} \\
&= \frac{(\mu + m_1/h_L)\, w_L + (1-\mu)\, w_H}{F\left[\mu h_L + m_1, (1-\mu)\, h_H\right]} \\
&= 1 + \frac{m_1\, (w_L/h_L - p_1)}{F\left[\mu h_L + m_1, (1-\mu)\, h_H\right]}.
\end{aligned}$$

The last equality follows from (10). Note that $p_1 \geq w_L/h_L$, because $p_1 = F_1$, F is linearly homogeneous, and $w_H \geq F_2 h_H$ by (13). But this implies that $c' < 1$ or that firm f' could make a positive profit. Evidently, the assumption that firm f is active in equilibrium leads to a contradiction.

Why is offshoring attractive only as an all-or-nothing proposition? Again, the answer reflects a positive feedback mechanism that operates in the presence of relative-wage concerns. A firm that finds it profitable to produce a unit of X_1 abroad at a cost p_1 will find that by doing so, it alters the mix of employment at home in such a way as to reduce the attractiveness of employment for low-skill workers. To retain its remaining low-skill workers in its home operation, it must pay these workers more. But this increases the attractiveness of moving offshore the production of the next unit of X_1, and so on.

To further characterize the equilibrium that arises when offshoring is possible, consider the unit cost function defined by

$$c_m\,(p_1, w_H) \equiv \min_{m_1} \frac{p_1 m_1 + w_H}{F\,(m_1, h_H)}. \tag{14}$$

This is the minimum unit cost that can be achieved by a firm that imports all of its input of X_1 at a cost of p_1 per unit, and that faces a market wage for high-skill workers of w_H. If $c_m\,(p_1, w_H^n) > 1$, then no firm takes up the opportunity to offshore and the equilibrium with potential offshoring is the same as in Section 4. Not surprisingly, offshoring is unattractive when the cost of manufacturing X_1 abroad is sufficiently high. But when the cost of manufacturing X_1 abroad is less than the critical value p_1^n defined implicitly by $c_m\,(p_1^n, w_H^n) = 1$, then some firms will offshore their production of X_1 in equilibrium. Since these firms will produce all of their input of X_1 abroad, and since they must break even, the equilibrium wage of high-skill workers must satisfy

$$c_m\,(p_1, w_H) = 1\ . \tag{15}$$

Firms that produce their input X_1 at home also must break even, which means that their unit

[11] In firm f', the ratio of low-skill to high skill workers is $(\mu + m_1/h_L)\,/\,(1-\mu)$, while in firm f this ratio is $\mu/\,(1-\mu)$. With a greater fraction of low-skill workers and similar wages, firm f' offers low-skill workers a higher relative wage than firm f.

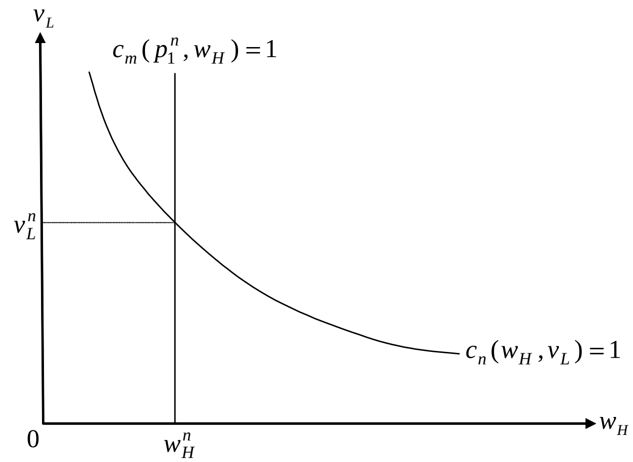

Figure 5: Equilibrium wage and welfare with foreign sourcing

cost equals one, or that

$$c_n(w_H, v_L) = 1. \tag{16}$$

In Figure 5 we plot the two equilibrium conditions, (15) and (16), for the case in which $p_1 = p_1^n$. These conditions jointly determined w_H and v_L, which of course turn out to be the same as in the equilibrium without an offshoring option when, as here, the cost of foreign inputs is equal to the critical value. For a lower foreign manufacturing cost, the $c_m = 1$ curve is further to the right. Then the wage of high-skill workers exceeds that in the equilibrium without offshoring, and the low-skill workers fare worse in utility terms than they do when offshoring is not a possibility. We summarize in

Proposition 3 *Let Assumptions 1-4 be satisfied. If $p_1 \geq p_1^n$, all firms produce X_1 at home and the equilibrium is the same as that described in Section 4. If $p_1 < p_1^n$ then some firms produce X_1 entirely at home while others produce the input entirely abroad. In such an equilibrium, $w_H > w_H^n$ and $v_L < v_L^n$.*

Note that relative-wage concerns strengthen the incentive to offshore in the following sense. When a firms elects to produce X_1 abroad it pays more to do so than it would pay to manufacture the same quantity of the input at home. To see this, consider an equilibrium in which some firms produce X_1 offshore and others produce it at home. The former pay p_1 per unit of the input. The latter pay a wage w_L and require $1/h_L$ workers per unit of output, so their cost per unit is w_L/h_L. Suppose it were the case that $p_1 = w_L/h_L$. Then a firm that produces X_1 at home could earn the same profits by importing X_1 and maintaining its original composition of inputs X_1 and X_2 in producing the final good. But then it could increase profits by re-optimizing its choice of X_1/X_2. The firm would strictly benefit from re-optimization, because it would no longer face a binding participation constraint for low-skill workers. So, equality between the per-unit cost of manufacturing the input X_1 at home and abroad would mean that all firms have an incentive to shift production abroad. In equilibrium, no such incentive can exist, so it must be the case that $p_1 > w_L/h_L$.

We can see that relative-wage concerns strengthen the incentive to offshore in another way. Suppose we compare two economies that are otherwise identical, but job satisfaction depends on relative pay in one economy but not the other. Let a superscript A denote an economy in which workers care only about their own incomes; i.e., $v(w, w_r) = v^A(w)$. A superscript B denotes an economy in which workers care about their relative standing, as described by Assumption 1. Then there exists a range of foreign production costs (p_1^{nA}, p_1^{nB}) such that for p_1 in this range, offshore production takes place if relative-wage concerns are present but not if they are absent. And, for $p_1 < p_1^{nA}$, the volume of offshore production is greater when such concerns are present than when they are absent.

To prove this assertion, let's start with a comparison of the critical cost p_1^n at which firms are indifferent between producing X_1 at home and producing it abroad. The critical cost p_1^{nJ} in economy J is defined by $c_m\left(p_1^{nJ}, w_H^{nJ}\right) = 1$, where w_H^{nJ} is the equilibrium wage of a high-skill worker in setting J when offshoring is not an option. The unit cost function $c_m(\cdot)$ is the same in both settings, because the technologies are the same and firms that offshore minimize their unit cost without constraints. But the closed-economy wage of high-skill workers is higher when relative-concerns are absent; i.e., $w_H^{nA} > w_H^{nB}$.[12] It follows that $p_1^{nB} > p_1^{nA}$.

Now suppose that $p_1 < p_1^{nA}$, so that offshoring takes place whether workers care about their relative standing or not. In both settings, the equilibrium wage of high-skill workers is determined by the zero-profit condition for firms that offshore production of input X_1, namely $c_m(p_1, w_H) = 1$. Therefore, the wage of high-skill workers is the same in either setting. In the economy without relative-wage concerns, the wage equals the marginal product of high-skill labor in firms that produce entirely at home, so $w_H = F_2^A\left[\mu^A h_L, \left(1 - \mu^A\right)\right] h_H$, where μ^A is the fraction of low-skill workers employed by a firm that produces X_1 at home. For simplicity assume that a firm either produces all of X_1 domestically or it produces all of it abroad.[13] Then $\mu^A > \bar{\mu}$ and the extent of offshoring increases with μ^A.

[12] In the economy with no relative-wage concerns, every firm employs a proportion $\bar{\mu}$ of low-skill workers and $w_L^{nA} = F_1^A h_L$ and $w_H^{nA} = F_2^A h_H$, where F_i^A is F_i evaluated at $X_1 = \bar{\mu} h_L$ and $X_2 = (1 - \bar{\mu})\, h_H$ for $i = L, H$. In the economy with relative-wage concerns, the first-order conditions of the cost minimization problem (4) for a firm of type j imply $F_2^{Bj} h_H - F_1^{Bj} h_L > w_H^{nB} - w_L^{nBj}$ and $w_H^{nB} < F_2^{Bj} h_H$, as we show in the next section, where F_i^{Bj} is F_i evaluated at $X_1 = \mu^{Bj} h_L$ and $X_2 = \left(1 - \mu^{Bj}\right) h_H$ for $i = L, H$, and μ^{Bj} is the proportion of low-skill workers employed by a firm of type j. If all firms are symmetric then $\mu^{Bj} = \bar{\mu}$, but we have seen that the equilibrium may have heterogeneous firm behavior such that different firms employ different fractions of low-skill workers. In such circumstances, full employment ensures that a weighted average of the μ^{Bj}s equals $\bar{\mu}$. Note that in both types of equilibrium, the wage of the high-skill workers, w_H^{nB}, is the same in all firms. Since F_2^{Bj} is homogeneous of degree zero in $\mu^{Bj} h_L$ and $\left(1 - \mu^{Bj}\right) h_H$ and the production function is concave, F_2^{Bj} is increasing in μ^{Bj}. Therefore, $F_2^{Bj} h_H \leq F_2^A h_H$ for some j, because a weighted average of the μ^{Bj}s must equal $\bar{\mu}$. It follows that $w_H^{nB} < F_2^A h_H = w_H^{nA}$.

[13] In the absence of relative-wage concerns, every firm is indifferent in equilibrium between producing X_1 at home or abroad. Firms also are indifferent between producing all of X_1 in one location, or producing some in both locations. The discussion in the text assumes that no firm mixes the two forms of acquisition of X_1, but this is done for expositional purposes only; the result does not depend on this assumption.

In the economy with relative-wage concerns, by contrast, the marginal product of high-skill workers exceeds their wage in firms that produce X_1 domestically, because they hire extra low-skill workers to alleviate the participation constraint. In any firm j that produces X_1 at home, $w_H < F_2^{Bj}\left[\mu^{Bj}h_L, \left(1-\mu^{Bj}\right)\right] h_H$, where μ^{Bj} is the fraction of low-skill workers employed by firm j.[14] Since the wage of the high-skill workers is the same in the two economies, $F_2^{Bj} > F_2^A$ for all j and therefore $\mu^{Bj} > \mu^A$ for all j. In other words, every firm that manufactures X_1 domestically uses a larger fraction of low-skill workers when relative-wage concerns are present than when these concerns are absent. It follows that more high-skill workers are employed by firms that offshore production of X_1 in the economy with relative-wage concerns. The quantity of X_1 produced abroad must be larger as well. We have thus established the central result in this section:

Proposition 4 *Suppose firms can produce X_1 abroad at a constant and common unit cost, $p_1 < p_1^n$. Let Assumptions 1-4 be satisfied. Then the quantity of offshore production is greater than it would be in an otherwise similar economy in which workers' utility does not depend on w_r.*

When workers are quite sensitive to relative-wage concerns, there can be a sharp and dramatic responses of industrial structure to small changes in the opportunities for offshoring. Consider, for example, an economy with p_1 slightly above p_1^n. Suppose $N_L/\left(N_L+N_H\right)$ lies between the values μ_1 and μ_2 depicted in Figure 4, and other parameter values are the same as those that underlie this figure. As we have seen, the initial equilibrium is characterized by heterogeneity in firm hiring strategies, with some firms offering the low-skill wage associated with point b_1 and hiring the mix of workers represented by μ_1, and others paying the low-skill wage associated with b_2 and hiring a fraction μ_2 of low-skill workers. Both types of firms pay high-skill workers the market wage w_H^n and both offer low-skill workers a common utility level v_L^n.

Now let the cost of offshoring fall slightly to a level just below p_1^n, so that offshore production becomes marginally profitable. Then, as can be seen from Figure 5, the wage of high-skill labor will rise to a new equilibrium rate $w_H^o > w_H^n$, and the equilibrium utility level for low-skill workers will fall to $v_L^o < v_L^n$ (where the superscript ^{o} denotes the equilibrium with offshoring). These changes are small, since the c_n curve in Figure 5 is continuous. However, the implied changes in industrial structure are large. With $v_L^o < v_b$ and $w_H^o > w_H^n$, the firms that produce X_1 domestically are no longer indifferent between the alternative employment mixes and pay structures represented by points b_1 and b_2 in Figure 4. Rather, they strictly prefer to employ a fraction of low-skill workers μ^o that is greater than μ_2 and to pay a relative wage w_ℓ^o that is smaller than w_ℓ^n. Note that for p_1 close to p_1^n, μ^o will be close to μ_2. Nonetheless, the implications for industrial structure are dramatic. With p_1 slightly above p_1^n, a share s_1 of the domestic population works for firms in which low-skill workers comprise a fraction μ_1 of the workforce, while the remaining fraction of the population works for firms in which low-skill workers comprise a fraction μ_2 of the workforce, $s_1\mu_1 + (1-s_1)\mu_2 = N_L/\left(N_L+N_H\right)$. After offshoring becomes just marginally viable, a strictly positive share s^o of domestic workers is employed by firms that produce the input X_1 abroad. This

[14] The argument is the same as in footnote 12.

fraction is determined by the requirement that the employment mix among firms that produce both inputs locally must match the residual supplies of the two types of workers after accounting for the high-skill types that work for firms that source X_1 abroad. That is, if $s^o(N_L + N_H)$ workers are employed by firms that source X_1 abroad, and all are high-skill types, there are $N_H - s^o(N_L + N_H)$ high-skill workers left to be hired by firms that produce X_1 at home. In equilibrium, each such firm hires a fraction μ^o of low-skill workers, so s^o is given implicitly by

$$\mu^o = \frac{N_L}{N_L + N_H - s^o(N_L + N_H)} \ .$$

It bears emphasizing that the discontinuous change in industrial structure is not an endemic feature of our model, inasmuch as it cannot happen when fair-wage concerns are absent or small. Take, for example, the case where η is very large, so that with p_1 slightly above p_1^n the equilibrium relationship between μ and w_ℓ is as depicted in Figure 2. When offshoring becomes marginally viable due to a small decline in p_1, the wage of the high-skill workers rises slightly and the utility of the low-skill workers falls slightly, due to the small rightward shift of c_m in Figure 5. These changes are associated with a small reduction in v_ℓ, and therefore a small increase in the cost-minimizing fraction of low-skill workers employed by the firms that produce their inputs X_1 locally. With μ^o now slightly above $N_L/(N_L + N_H)$ in these firms, there is a small residual supply of high-skill workers who are employed instead by firms that offshore production of input X_1. In short, a small reduction in p_1 from just above to just below p_1^n induces a small and continuous change in industrial structure, with a few domestic high-skill workers taking employment with firms that engage in offshoring, and the remainder working for firms that continue to produce their inputs locally, albeit with a slightly increased ratio of X_1 to X_2.

6 Efficiency Properties of the Equilibrium with Offshoring

In this section, we explore the efficiency properties of the equilibrium with offshoring. To this end, we consider further the equilibrium in which some firms offshore all of their production of X_1 and others produce the input entirely at home. The firms that produce X_1 abroad import m_1^o units of the input per domestic employee. In firms that produce the input at home, low-skill workers comprise a fraction μ^o of the workforce.

We observe first that the equilibrium outcome does *not* maximize net output. To establish this point, we will show that the marginal product of high-skill workers is greater in firms that produce X_1 domestically than in firms that import the input from abroad. In a firm that produces the input domestically,

$$F_2[\mu^o h_L, (1-\mu^o)\, h_H]h_H - F_1[\mu^o h_L, (1-\mu^o)\, h_H]h_L = (w_H^o - w_L^o)\left(1 - \frac{\mu^o v_2}{v_1 + \mu v_2}\right) \qquad (17)$$

where $v_1 = \partial v(w_L, w_r)/\partial w_L$ and $v_2 = \partial v(w_L, w_r)/\partial w_r$, with both evaluated at $w_L = w_L^o$, $w_H =$

w_H^o and $\mu = \mu^o$.[15] The fact that $v_2 < 0$ and $v_1 + \mu v_2 > 0$ implies $F_2[\mu^o h_L, (1-\mu^o)\, h_H]h_H - F_1[\mu^o h_L, (1-\mu^o)\, h_H]h_L > (w_H^o - w_L^o)$. But $F[\mu^o h_L, (1-\mu^o)\, h_H]$ is homogeneous of degree one and firms make zero profits, which together imply that $F_2[\mu^o h_L, (1-\mu^o)\, h_H]h_H > w_H^o$. In contrast, firms that produce X_1 offshore minimize cost be setting

$$F_2\left(m_1^o, h_H\right) h_H = w_H^o.$$

So, value added can be increased by shifting the marginal high-skill worker from a firm that produces X_1 offshore to one that does not. The reason is simple: Firms that produce domestically use "extra" low-skill workers in order to mitigate the jealousy factor, which leaves the marginal product of skilled workers higher there than in firms that separate their employees.

However, the fact that the equilibrium allocation fails to maximize the economy's net output is not proof of market inefficiency. Allocations that yield greater value added may leave low-skill workers with less utility, if they cause these individuals to suffer greater wage jealousy. We therefore pose a different question: Could a social planner choose a wage for low-skill workers and a wage for high-skill workers, and assign workers to firms, so as to achieve a Pareto improvement relative to the equilibrium outcome?

We consider the following planner's problem:

$$\max_{w_L, w_H, m_1, \mu, s} w_H$$

subject to

$$v\left[w_L, \mu w_L + (1-\mu)\, w_H\right] \geq v_L^o,$$

$$\left[F\left(m_1, h_H\right) - p_1 m_1\right] s + F\left[\mu h_L, (1-\mu)\, h_H\right](1-s) \geq \frac{w_L N_L + w_H N_H,}{N_L + N_H}$$

$$\mu = \frac{N_L}{(1-s)\left(N_L + N_H\right)},$$

and

$$0 \leq \mu \leq 1\ ,$$

where s again is the share of the domestic workforce employed by firms that engage in offshoring. In this problem, the planner seeks to maximize the wage paid to high-skill workers subject to the constraint that the low-skill workers fare at least as well as in the equilibrium with offshoring, that per capita net output suffices to pay the average wage in the economy, and that the employment mix of employees in firms that produce X_1 domestically matches the residual supplies after accounting for the high-skill workers employed by firms that produce X_1 abroad. Implicit in this formulation is the assumption that the planner cannot make side-payments to workers independent of their "wages" in a manner that avoids comparison and jealousy.

The planner's optimal choice of m_1 is given implicitly by

[15] Equation (17) is implied by the first-order conditions for maximizing profits subject to the participation constraint $v[w_L, w_r] \geq v_L$ and the feasibility constraint $\mu \in [0,1]$.

$$F_1(m_1, h_H) = p_1 \ . \tag{18}$$

A similar condition characterizes a firm's choice of imports in the market equilibrium, so $m_1 = m_1^o$. Now we solve $s = (\mu - \bar{\mu})/\mu$ from the third constraint, where $\bar{\mu} \equiv N_L/(N_L + N_H)$, and substitute for s in the second constraint. Then the remaining first-order conditions imply[16]

$$\begin{aligned} F_2 \left[\mu h_L, (1-\mu) h_H\right] h_H - F_1 \left[\mu h_L, (1-\mu) h_H\right] h_L \\ = (w_H - w_L) \left(1 - \frac{\mu v_2}{v_1 + \mu v_2}\right) + (w_H^o - w_H) \frac{1}{\bar{\mu}} \ , \end{aligned} \tag{19}$$

$$F\left[\mu h_L, (1-\mu) h_H\right] = \mu w_L + (1-\mu) w_H + (w_H - w_H^o) \left(\frac{\mu - \bar{\mu}}{\bar{\mu}}\right) \ , \tag{20}$$

and

$$v\left[w_L, \mu w_L + (1-\mu) w_H\right] = v_L^o, \tag{21}$$

where v_1 and v_2 are evaluated at $w = w_L$ and $w_r = \mu w_L + (1-\mu) w_H$.

Observe that $\mu = \mu^o$, $w_H = w_H^o$ and $w_L = w_L^o$ satisfy these first-order conditions.[17] Moreover, we can show that there exists no other solution to (19)-(21) with $w_H > w_H^o$ and $\mu \in [0,1]$. It follows that the planner cannot improve on the market outcome.

To see that there is no solution to (19)-(21) with $w_H > w_H^o$, suppose to the contrary that such a solution exists with $\mu = \mu^*$, $w_L = w_L^*$, and $w_H = w_H^* > w_H^o$. Then (20) implies that $F\left[\mu^* h_L, (1-\mu^*) h_H\right] > \mu^* w_L^* + (1-\mu^*) w_H^*$. But then, in the equilibrium setting of Section 4, a firm f' could offer low-skill workers a wage w_L^* and seek to hire a fraction μ^* of low-skill employees to produce the input X_1. Firm f' could attract workers on these terms, because[18]

$$v\left[w_L^*, \mu^* w_L^* + (1-\mu^*) w_H^*\right] > v\left[w_L^*, \mu^* w_L^* + (1-\mu^*) w_H^o\right] = v_L^o \ .$$

And, by doing so, it would earn positive profits, because[19]

$$F\left[\mu^* h_L, (1-\mu^*) h_H\right] - \mu^* w_L^* - (1-\mu^*) w_H^o > F\left[\mu^* h_L, (1-\mu^*) h_H\right] - \mu^* w_L^* - (1-\mu^*) w_H^* \geq 0 \ .$$

Of course, the fact that a firm f' could make positive profits when facing the market opportunities contradicts the assumption that $\{w_H^o, v_L^o\}$ characterizes a competitive equilibrium. Thus, no solution to (19)-(21) with $w_H > w_H^o$ exists.

We conclude that the social planner cannot improve on the market equilibrium with offshoring.

[16] In writing (19) and (20), we make use of the fact that $m_1 = m_1^o$ and $F(m_1^o, h_H) - p_1 m_1^o = w_H^o$.

[17] With $\mu = \mu^o$, $w_H = w_H^o$ and $w_L = w_L^o$, (19) is satisfied by (17), (20) is satisfied because firms in the market equilibrium make zero profits, and (21) is satisfied because firms in the market equilibrium satisfy the participation constraint for low-skill workers.

[18] The first inequality follows from the hypothesis that $w_H^* > w_H^o$. The second inequality follows from (21).

[19] Again, the first inequality follows from the hypothesis that $w_H^* > w_H^o$. The second inequality follows from (20), $w_H^* > w_H^o$, and $\mu^* \geq \bar{\mu}$.

Although firms' incentives to separate employees induce offshoring beyond the level that maximizes net output, the psychological gain to domestic workers who suffer less from unfavorable wage comparisons justifies the loss of material well-being.

7 Concluding Comments

When low-paid workers suffer disutility from earning less than the average in their office or plant, they will be attracted to firms that offer more equitable pay structures. In such an environment, firms face a trade-off between the wages they pay to low-skill workers and the mix of workers they employ. This trade-off, which exists even if job satisfaction has no effect on effort or productivity, has implications for resource allocation and the organization of firms.

In this paper, we have developed a simple general equilibrium model of an economy in which individuals compare their own wage to the average pay of their fellow workers. The concerns over relative wage impact firms' decisions about pay structure, employment mix, and the organization of production. We study these links for a closed economy and for an open economy in which firms can produce an intermediate input abroad. General equilibrium interactions play an important role in our analysis, because firms must structure jobs so that they can hire workers, which means that the optimal organization of production depends on workers' outside options. In our model, the outside options are endogenous and vary with the opportunities firms have to move part of their operation abroad. If workers compare themselves only to co-workers in the same location, then relative-wage concerns enhance the incentives for offshoring.

Our analysis has focused on economies that produce a single final good. It would be desirable to extend the model to include additional sectors. Such an extension is essential, for example, if one wishes to understand the links between relative-wage concerns and comparative advantage. We have not conducted such an analysis as yet, but offer some tentative observations.

Consider an economy similar to the one described here, but with two industries that produce different final goods. Each sector uses two intermediate inputs, one produced primarily by high-skill labor, the other produced primarily by low-skill labor. Let the industries differ in their relative use of the two inputs. Suppose there are two countries that share identical technologies, identical homothetic preferences over the two final goods, and identical labor endowments. The countries differ, however, in their workers' sensitivity to below-average wages. We might ask, Does the country with individuals who care more about their relative wage have a comparative advantage in producing skill-intensive products? The answer appears to be "not necessarily."

The source of ambiguity lies in the fact that relative-wage concerns cause relatively severe problems for firms that use an even mix of employees, but less severe problems for those that employ a relatively homogeneous work force. Wage jealousies have relatively little adverse effect on cost in firms that hire mostly low-skill workers, but also in firms that hire mostly high-skill workers. So a country whose workers are more sensitive to wage comparisons may gain a comparative advantage in either sector, if the factor intensity in that sector is extreme. The trade pattern will depend on structural features, such as the nature of the technologies, and on the general equilibrium interactions between sectors. In such an environment, the opportunities for offshoring affect the industrial structure in a complex way that we do not yet fully understand. The complexity of these interactions raises interesting questions for future research.

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