On Footloose Industries, Asymmetric Information, and Wage Bargaining

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Abstract: If capital becomes internationally mobile but labor does not, is the bargaining outcome for workers worsened? In this paper we show that the answer to this question depends critically on the information structure of the bargaining process. In particular, we demonstrate a hitherto under appreciated information role of capital mobility in determining the distribution of output between workers and employers. In doing so we bring together three strands of literature that are not often seen together — incentive compatible contracting, union-employer bargaining, and the consequences of capital mobility.

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1 Introduction

If capital becomes internationally mobile but labor does not, is the bargaining outcome for workers worsened? In this paper we show that the answer to this question depends critically on the information structure of the bargaining process. In particular, we demonstrate a hitherto under appreciated informational role of capital mobility in determining the distribution of output between workers and employers.

We begin with an intuitive account of the problem and of our approach. Consider the standard union-employer bargaining framework under perfect information where the union makes a "take it or leave it" wage-employment offer. If the employer accepts then the bargain is complete. If the employer does not, neither side gets the benefit of production. The union will thus make an offer just attractive enough to the employer to accept. In such a setting a key determinant of the outcome is the elasticity of the marginal value product of labor with respect to employment (in other words, the wage elasticity of labor demand). The larger is this elasticity, the less favorable will be the outcome for the union. The role of capital mobility can now be seen clearly. Allowing capital to be mobile increases the wage elasticity of labor demand, since production activities can now be relocated in response to higher wages, and this makes the union worse off. Such a line of argument is to be found, for example in Rodrik (1997).[1]

The framework set out above has been criticized in the union bargaining literature because if it is to be believed we would never observe any strikes and less than full employment of union labor. This is an obvious violation of empirical reality.[2] The literature proceeds to model bargaining in the presence of imperfect information, a setting which can indeed generate strikes and less than full employment of the union workforce. Suppose, for example,

[1] Using U.S. data, Slaughter (1997) investigates whether there is indeed a positive relationship between labor demand elasticity and openness, and finds mixed empirical support. Panagariya (1999) examines the theoretical robustness of the labor demand elasticity and openness relationship and argues based in part on the factor price equalization theorem, that the schedule of factor prices with respect to foreign direct investment is perfectly elastic in the diversification cone.

[2] Card (1990) provides theoretical implications and empirical support of a model of union bargaining under asymmetric information. McConnell (1989) provides empirical estimates of the slope of the concession schedule (in wage and strike duration space) as implied by the asymmetric information framework. Also see Abowd and Tracy (1989) and Cramton, Taylor and Tracy (1995) for empirical investigations of strike duration and wage outcomes, taking into account product market characteristics of the firm and labor market regulations.

that the employer is fully informed about the total factor productivity of the firm but the union is not. Then in a closed economy the union fashions an offer schedule for each level of possible productivity. Since information is revealed after the bargain is struck, it is at least theoretically possible for there to be less than full employment of the union workforce-in other words, strikes. Moreover, the union cannot now be as well off as before, since the firm earns an informational rent from the fact that the union cannot perfectly tailor its offer to a known marginal value product of labor (MVPL) curve. The greater the spread of MVPL, i.e. the greater the imperfection of information, the worse off will the union be.[3]

But suppose now that investing abroad is an option for the firm after it sees the union offer. Will the union be better off or worse off? There are now two forces in play. First, as before, this openness increases the elasticity of the MVPL curve at each level of productivity, and this tends to have all of the effects discussed in the perfect information setting. But second, it can have an effect on the spread of MVPL's. If it increases this spread, in other words, if it widens the gap in MVPL for any given gap in productivity, it worsens the union's position by increasing the informational rent extractable by the employer. If it decreases the spread then it effectively reduces the asymmetric information and thereby strengthens the union's hand.

The object of this paper is to elaborate upon this informational consequence of capital mobility. We develop a model in which the competing forces affecting the bargaining outcome can be brought into sharp relief, and their relative strengths can be analyzed in detail. In doing so we bring together three strands of literature that are not often seen together-incentive compatible contracting, union-employer bargaining, and the consequences of capital mobility. The plan of the paper is as follows. Section 2 introduces the basic notation and model. Section 3 derives the basic results. Section 4 concludes.

[3]This is also a burgeoning literature on foreign direct investment under asymmetric information. See Bond and Gresik (1996), Calzolari, Diaw and Pouyet (2002), Prusa (1990) for example, that examine investment policy formation with asymmetrically informed government / governments and perfectly informed multinationals. Also see Bagwell and Staiger (2003) for the informational role of the locational choice of multinationals.

2 The Basic Model

A firm and a labor union constitute the two parties of the bargaining process. The employer is endowed with $\bar{K}$ units of capital, and hires laborers from a pool of labor union members to produce an output. Let $R(\sigma, \ell, k) = \sigma k^{\beta} \ell^{\alpha}$ denote the revenue function, with $\alpha + \beta < 1$. σ denotes the productivity of the firm. The range of σ is given by $[\underline{\sigma}, \bar{\sigma}]$.

The labor union is made up of $\mathcal{L}$ members, each with one unit of labor time. A contract between the union and the firm stipulates a wage-employment pair, respectively, w and ℓ, where $w/\mathcal{L}$ denotes wage per union member, and $1 - \ell/\mathcal{L}$ is the amount of labor time spent on strike by each union member. Each union member earns a reservation wage income, to be denoted as $\bar{W}$, in the event of strike induced unemployment. The preferences of the labor union are represented by a utility function that embodies the interests of all $\mathcal{L}$ number of union members, $U(W, L) = w + \bar{W}(\mathcal{L} - \ell)$.

Let demand for capital in the rest of the world be perfectly elastic, offering unit returns $r^*_\sigma = r^* \sigma^{\delta}$, with $r^* > 0$, for capital originating from firms with productivity σ in the home country.[4] δ denotes the location specificity of the firm's capital.[5] More specifically, define

Definition 1 *The productivity of capital exhibits home-bias if and only if*

$$1 = \frac{\partial \log R(\sigma, k, \ell)}{\partial \log \sigma} > \frac{\partial \log r^*_\sigma K}{\partial \log \sigma} = \delta.$$

Thus, when the productivity of capital is subject to home-bias ($1 > \delta$), raising the productivity of the firm σ leads to higher (proportionate) revenue gains at home than abroad.

The decision problem of the firm involves allocating capital between the home country (k) and the rest of the world ($\bar{K} - k$), taking union employment ℓ, and wage proposal w as given. The restricted home profit (π) function is given by

[4] We model foreign demand for capital as perfectly elastic for two reasons. First, we are interested in investment behavior by the individual firm, and hence the lack of market power in world market for capital would seem to be a reasonable assumption. Second, while the absence of investment opportunities (a perfectly inelastic foreign demand for capital at zero capital flow) represents one extreme, the case of perfectly elastic demand represents the other, wherein union's ability to command high wages is likely to be affected the most.

[5] We shall also assume throughout that parameters $\bar{W}$, $\bar{K}$ and r^* take on values that permit outward foreign investment, with $R_K(\sigma, L, \bar{K}) \leq r^*_\sigma$, when employment level in the home country equates the marginal value product of labor with the opportunity cost of labor $\bar{W}$. This requires that $r^*_\sigma \bar{K} \geq \beta \left[\left(\frac{\alpha}{\bar{W}} \right) \left(\sigma \bar{K}^{\beta} \right)^{\alpha} \right]^{\frac{1}{1-\alpha}}$.

$$\begin{aligned}\pi(\sigma,\ell) &\equiv \max_k \{R(\sigma,k,\ell) - r_\sigma^* k\}, \\ &= (1-\beta)\left(\sigma(\frac{\beta}{r_\sigma^*})^\beta \ell^\alpha\right)^{\frac{1}{1-\beta}} \end{aligned} \tag{1}$$

By standard arguments, the restricted home profit function is increasing and quasi-convex in σ. Meanwhile, π is decreasing and quasi-concave in $r_\sigma^* = r^*\sigma^\delta$. With both of these effects depending critically on δ, we rearrange the restricted home profit function to yield:

$$\pi(\sigma,\ell) = (1-\beta)\left(\sigma^{1-\delta\beta}(\frac{\beta}{r^*})^\beta \ell^\alpha\right)^{\frac{1}{1-\beta}} \equiv \phi \ell^{\frac{\alpha}{1-\beta}} \tag{2}$$

where $\phi = \phi(\sigma) = (1-\beta)(\sigma^{1-\delta\beta}(\frac{\beta}{r^*})^\beta)^{\frac{1}{1-\beta}}$ will henceforth be referred to as the mobility-adjusted productivity of the firm in the home country. As may be expected, ϕ rises with σ if and only if productivity improvements lead to proportionate revenue gains abroad that are not too much higher than that attainable in the home country. This requires $\delta < 1/\beta$.

The mobility adjusted productivity of the firm determines the profit of the firm at home, and the value of marginal product of labor in the home country in much the same way as σ does in the absence of capital mobility. To see this, note that at given ℓ, restricted profit $\pi(\cdot)$ at home rises proportionately with $\phi > 0$. Likewise, the marginal value product of the labor $v(\cdot)$ in the home country with capital mobility is proportional to ϕ, with

$$\begin{aligned} v(\phi,\ell) &= R_\ell(\sigma,k^*,\ell) + R_K(\sigma,k^*,\ell)\frac{\partial k^*}{\partial \ell} \\ &= v_o(\sigma,k^*,\ell) + R_K(\sigma,k^*,\ell)\frac{\partial k^*}{\partial \ell} \\ &= \frac{\alpha}{1-\beta}\phi \ell^{\frac{\alpha}{1-\beta}-1} \end{aligned} \tag{3}$$

where

$$v_o(\sigma,k^*,\ell) = \alpha\sigma\ell^{\alpha-1}(k^*)^\beta \tag{4}$$

denotes the marginal value product of labor when capital is immobile at k^*, while k^* solves the maximization problem of the firm, with

$$k^*(\sigma,\ell) = argmax_k \{R(\sigma,k,\ell) - r_\sigma^* k\} = \left(\frac{\beta\sigma\ell^\alpha}{r_\sigma^*}\right)^{\frac{1}{1-\beta}}. \tag{5}$$

have

$$L(\sigma) = L_0(\sigma)\left(1 - \frac{1}{\epsilon^f(\sigma)}\right)^{\frac{1}{1-\alpha}} \leq L_0(\sigma). \tag{16}$$

To recall, $L_0(\sigma)$ is simply union employment when both information asymmetry and capital mobility are absent (Equation (6)). We have the following result:

Proposition 1 *The change in union employment subsequent to openness when information is asymmetric is given by:*

$$\begin{aligned}\log \ell^*(\sigma) - \log L(\sigma) &= \log \ell_0^*(\sigma) - \log L_0(\sigma) \\ &+ \left(\frac{1-\beta}{1-\alpha-\beta} - \frac{1}{1-\alpha}\right)\log(1 - \frac{1}{\epsilon^f(\sigma)}) \\ &+ \frac{1-\beta}{1-\beta-\alpha}\left(\log(1 - \frac{1-\delta\beta}{1-\beta}\frac{1}{\epsilon^f(\sigma)}) - \log(1 - \frac{1}{\epsilon^f(\sigma)})\right). \end{aligned} \tag{17}$$

Thus, the change in union employment once the option of capital mobility opens depends on the interaction of three effects. First, $\log \ell_0^*(\sigma) - \log L_0(\sigma)$ represents the change in union employment when information asymmetry is not an issue. The size of this difference depends on whether there is excess supply of capital $\bar{K}$ in the home country, given r^* and $\bar{W}$. Second, since information asymmetry in effect drives a wedge between the reservation union wage and the marginal product of labor, the more elastic is the demand for labor, the larger will be the corresponding impact on employment. Now, as the elasticity of demand for labor from $1/(1-\alpha)$ to $(1-\beta)/(1-\alpha-\beta)$ when capital market opens up, this second effect has an unambiguous negative effect on the right hand side of equation (17), since $1 - \frac{1-\delta\beta}{1-\beta}\frac{1}{\epsilon^f(\sigma)} < 1$. Finally, openness can nevertheless imply a net positive impact on union employment, if the third term on the right hand side of equation (17), which represents the *informational* role of capital mobility, is sufficiently large.

In particular, if $\delta < 1$, and hence $\epsilon^g(\phi(\sigma)) > \epsilon^f(\sigma)$ (Lemma 1), the productivity of capital exhibits home bias. In turn, capital mobility strengthens the informational advantage of the firm, and union employment is necessarily falls at given σ. If $\delta \geq 1$, however, the third term of the right hand side of equation (17) is strictly positive. Clearly, the larger δ is, the more likely it is that employment can in fact increase with openness. The question, however, is whether there is a clearly identifiable range of δ's that can accomplish this in equilibrium. To this end,

Proposition 2 *There exists* $\delta^* \in (1, 1/\beta)$ *such that*

$$\frac{\ell^*(\sigma) - L(\sigma)}{L(\sigma)} > \frac{\ell_0^*(\sigma) - L_0(\sigma)}{L_0(\sigma)}.$$

for all $\delta > \delta^*$*, and* $\sigma < \bar{\sigma}$*. In addition,*

$$\frac{\ell^*(\bar{\sigma}) - L(\bar{\sigma})}{L(\bar{\sigma})} = \frac{\ell_0^*(\bar{\sigma}) - L_0(\bar{\sigma})}{L_0(\bar{\sigma})}.$$

Proof: Making use of equations (7) and (15), it can be readily confirmed that $(\ell^*(\sigma) - L(\sigma))/L(\sigma)$ is strictly increasing in δ. Note, in addition, evaluated at $\delta = 1/\beta$,

$$\frac{\ell^*(\sigma) - L(\sigma)}{L(\sigma)} - \frac{\ell_0^*(\sigma) - L_0(\sigma)}{L_0(\sigma)} = \frac{\ell_0^*(\sigma)}{L_0(\sigma)} \left[\frac{1}{\left(1 - \frac{1}{\epsilon^f(\sigma)}\right)^{\frac{1}{1-\alpha}}} - 1 \right] > 0.$$

Evaluated at $\delta = 1$,

$$\frac{\ell^*(\sigma) - L(\sigma)}{L(\sigma)} - \frac{\ell_0^*(\sigma) - L_0(\sigma)}{L_0(\sigma)} = \frac{\ell_0^*(\sigma)}{L_0(\sigma)} \left[\frac{\left(1 - \frac{1}{\epsilon^f(\sigma)}\right)^{\frac{1-\beta}{1-\alpha-\beta}}}{\left(1 - \frac{1}{\epsilon^f(\sigma)}\right)^{\frac{1}{1-\alpha}}} - 1 \right] < 0.$$

The first part of the proposition thus follows from the intermediate value theorem. The second part of the proposition follows directly from equation (15).

Intuitively, Proposition 1 states that as long as δ is sufficiently close to $1/\beta$, the fraction of employment losses once the option of capital mobility opens up is strictly less than the perfect information benchmark. The following observations are immediate.

Corollary 1 *If the productivity of capital exhibit home-bias, openness can never increase union employment in the presence of information asymmetry.*

Corollary 2 *If* $\ell_0^*(\sigma) = L_0(\sigma)$ *when information imperfection is not an issue, then openness gives rise to*

1. *strictly higher union employment when information is asymmetric*

$$\ell^*(\sigma) - L(\sigma) > 0$$

for all $\sigma < \bar{\sigma}$ *and* $\delta > \delta^*$*, despite the fact that*

2. equilibrium capital outflow is strictly positive, $k(\sigma, \ell^*(\sigma)) < \bar{K}$ for $\sigma < \bar{\sigma}$.

We have thus the following employment ranking in the two capital mobility and the two information regimes

$$L(\sigma) < \ell^*(\sigma) < \ell_0^*(\sigma) = L_0(\sigma).$$

Since information asymmetry leads to a reduction in employment given any one of the two capital mobility regimes, $L(\sigma) < L_0(\sigma)$ and $\ell^*(\sigma) < \ell_0^*(\sigma)$. However, since $\delta > \delta^*$, capital mobility reduces the degree of information asymmetry confronting the union. Indeed, the conditions of Corollary 2 guarantee that $L(\sigma) < \ell^*(\sigma)$.

The second observation in the proposition follows upon substituting the expression for $\ell^*(\sigma)$ into $k(\sigma, \ell)$. Since under-employment ($\ell^*(\sigma) < \ell_0^*(\sigma)$) decreases the returns to capital in the home country, there is thus strictly positive capital outflow even when none exists in the absence of asymmetric information.

3.3 Openness, Profits and Wages

Turning now to the welfare and the wage earning of the union, constraint (II), equation (15), and the definition of $y(\phi)$ jointly imply that

$$y(\phi(\sigma)) \equiv y^*(\sigma) = \int_{\underline{\sigma}}^{\sigma} \frac{1-\delta\beta}{1-\beta} \ell^*(t)^{\frac{\alpha}{1-\beta}} \frac{\phi(t)}{t} dt \tag{18}$$

$$w^*(\sigma) = \phi(\sigma)\ell^*(\sigma)^{\frac{\alpha}{1-\beta}} - y^*(\sigma). \tag{19}$$

As should be apparent, the informational rent of the firm is directly related to the location specificity of capital. In particular, as δ tends to $1/\beta$, informational asymmetry effectively vanishes, and $y(\phi(\sigma))$ accordingly tends to zero, for any firm type σ.

Thus, the wage bill that the union can maximally extract from the firm is likewise intimately linked to the location specificity of capital. Indeed, union welfare may rise or fall when capital markets open up, depending on the interplay between savings on informational rent, and the loss of employment opportunities as outward capital flow takes place. For the same reasons, the profits of the firm may similarly rise or fall when the option to export capital abroad opens up. In particular,

Proposition 3 *In the absence of productivity reversal, the change in union wage income subsequent to openness is given by:*

$$\begin{aligned}\log w^*(\sigma) - \log W(\sigma) &= \log w_0^*(\sigma) - \log W_0(\sigma) \\ &+ \left(\frac{\alpha}{1-\alpha-\beta} - \frac{1}{1-\alpha}\right)\log(1 - \frac{1}{\epsilon^f(\sigma)}) \\ &+ \frac{\alpha}{1-\beta-\alpha}\left(\log(1 - \frac{1-\delta\beta}{1-\beta}\frac{1}{\epsilon^f(\sigma)}) - \log(1 - \frac{1}{\epsilon^f(\sigma)})\right) \\ &+ \log\left(1 - \frac{1-\delta\beta}{1-\beta}\int_{\underline{\sigma}}^{\sigma}\left(\frac{t}{\sigma}\right)^{\frac{1-\delta\beta}{1-\alpha-\beta}}\frac{1}{t}\Omega^g(t)dt\right) \\ &- \log\left(1 - \int_{\underline{\sigma}}^{\sigma}\left(\frac{t}{\sigma}\right)^{\frac{1}{1-\alpha}}\frac{1}{t}\Omega^f(t)dt\right) \qquad (20)\end{aligned}$$

$$\Omega^g(t) = \left((1 - \frac{1-\delta\beta}{1-\beta}\frac{1}{\epsilon^f(t)})/(1 - \frac{1-\delta\beta}{1-\beta}\frac{1}{\epsilon^f(\sigma)}\right)^{\alpha/(1-\alpha-\beta)} < 1$$

and

$$\Omega^f(t)) = \left((1 - \frac{1}{\epsilon^f(t)})/(1 - \frac{1}{\epsilon^f(\sigma)}\right)^{\alpha/(1-\alpha)} < 1.$$

Thus, the change in union wage earnings once the option of capital mobility opens depends on the interaction of four effects. The first three of these effects are analogous to the factors governing the corresponding change in union employment displayed in Proposition 2. In particular, $\log w_0^*(\sigma) - \log W_0(\sigma)$ represents the change in wage earnings in the absence of information asymmetry. As discussed, this is unambiguously negative as soon as the option of capital mobility opens up. The second effect is likewise strictly negative, as higher labor demand elasticity in the presence of capital mobility exacerbates the negative output impact of the proportionate wage gap $1 - 1/\epsilon^f(\sigma)$. The third effect concerns the size of the wage gap required to elicit truth-telling, and is strictly negative (positive) whenever the productivity of capital exhibits (does not exhibit) home bias.

A final effect concerns the informational rent of the firm, $y^*(\sigma)$ and $Y(\sigma)$. In particular, if $\delta = 1/\beta$, capital mobility deprives the firm completely of its informational advantage, and difference displayed in the last two terms of equation (20) is strictly positive. We have the following:

Proposition 4 *As δ tends to $1/\beta$,*

1. *total profits of the firm approaches* $r^*_\sigma \bar{K}$ *for all* $\sigma \in [\underline{\sigma}, \bar{\sigma}]$,

2. *the welfare of union members approaches the perfect information benchmark with capital mobility,* $w^*_0(\sigma) + \bar{W}(\mathcal{L} - \ell^*_0(\sigma))$,

Turning now to the welfare of the union, respectively denote $U(\sigma)$ and $u(\sigma)$ as the welfare of the union with and without capital mobility, we have

$$\begin{aligned} U(\sigma) - u(\sigma) &= \bar{W}\left[L(\sigma) - \ell^*(\sigma)\right]\left(\frac{1-\Omega^f(\sigma)}{\alpha(1-1/\epsilon^f(\sigma))} - 1\right) \\ &\quad + \bar{W}\left[\frac{1-\Omega^f(\sigma)}{\alpha(1-1/\epsilon^f(\sigma))} - \frac{(1-\beta)(1-\Omega^g(\sigma))}{\alpha(1-(1-\delta\beta)/((1-\beta)\epsilon^f(\sigma))}\right]\ell^*(\sigma). \end{aligned}$$

The first term in square brackets reflects the employment impact of foreign direct investment in the presence of information asymmetry. From Corollary 2, $L(\sigma) < \ell^*(\sigma)$ as δ is sufficiently close to $1/\beta$. The second term in square brackets reflects the combined impact of (i) the information rent ($\Omega^g(\sigma)$ and $\Omega^f(\sigma)$), and (ii) the size of the wage gap required to elicit truth telling ($1/\epsilon^f(\sigma)$ and $(1-\delta\beta)/((1-\beta)(\epsilon^f(\sigma)))$ on union welfare. In both cases, the closer δ is to $1/\beta$, the more likely it is that the welfare of the union $u(\sigma)$ exceeds $U(\sigma)$.

4 Conclusion

It has long been recognized that greater openness in foreign investment regimes is likely to disadvantage workers in their bargaining with employers because it increases the elasticity of the marginal value product of labor (MVPL) curve. This paper has highlighted a hitherto underappreciated informational role of openness in affecting the bargaining outcome in a world of asymmetric information. Openness can reduce or increase the variability of the marginal value product of labor curve, and hence the informational rent that the firm can extract from the union. Whether it does so or not depends crucially on how foreign returns vary with domestic productivity.

If foreign returns increase very fast as domestic productivity of capital increases, openness will lead more productive firms to invest abroad disproportionately, leaving disproportionately less capital at home. This reduces the domestic MVPL disproportionately, relative to the increase expected by the simple increase in domestic productivity. In this case, therefore,

openness to foreign investment will reduce the spread of MVPL and hence improve the outcome for workers in a world of bargaining with asymmetric information. This effect will counteract the conventional negative effect on workers of an increase in the elasticity of the MVPL curve as a result of greater openness. However, if foreign returns to capital increase sufficiently slowly as domestic productivity of capital increases, then the spread of MVPL increases and workers are disadvantaged all round by greater openness.

Apart from bringing together capital mobility, incentive compatibility and bargaining together in a way that they are not usually brought together, our analysis thus highlights a key feature that needs to be explored – the precise empirical relationship between domestic returns and foreign returns in a cross section of firms. This is an interesting area for further research.

Appendix

In this Appendix, we briefly describe the solution to the optimal control problem of the union when capital is immobile. We seek a wage bill and an employment schedule, respectively $W(\sigma)$ and $L(\sigma)$, that jointly maximize expected union welfare while satisfying incentive compatibility, and individual rationality. Since the profit function is given by $Y(\sigma,\widehat{\sigma})\sigma\bar{K}^{\beta}L(\widehat{\sigma})^{\alpha} - W(\widehat{\sigma})$, with $Y(\sigma,\sigma) = Y(\sigma)$. It can be readily verified that incentive compatibility requires that $(\sigma - \widehat{\sigma})\bar{K}^{\beta}L(\sigma)^{\alpha} \geq Y(\sigma) - Y(\widehat{\sigma}) \geq (\sigma - \widehat{\sigma})\bar{K}^{\beta}L(\widehat{\sigma})^{\alpha}$. In addition, $Y(\sigma)$ is convex, and differentiable almost everywhere, with

$$\dot{Y}(\sigma) \equiv \frac{dY(\sigma)}{d\sigma} = p\bar{K}^{\beta}L(\sigma)^{\alpha}.$$

If the contract yields non-negative profits for a firm with $\sigma = \underline{\sigma}$,

$$0 \leq Y(\underline{\sigma}) \leq Y(\sigma,\underline{\sigma}) \leq Y(\sigma,\sigma), \quad \sigma > \underline{\sigma}$$

where the inequalities follow respectively since $Y(\sigma,\widehat{\sigma})$ is monotonically increasing in σ and since incentive compatibility is satisfied.

Thus, the decision problem of the union is subject to four constraints: (i) $Y(\underline{\sigma})$ is non-negative; (ii) $\dot{Y}(\sigma) = p\bar{K}^{\beta}L(\sigma)^{\alpha}$; (iii) $L(\sigma)$ is non-decreasing with respect to σ and finally, (iv) $L(\sigma) \leq \mathcal{L}$. Setting up the Hamiltonian as in equation (13), the union welfare maximizing

contract requires that

$$V(\sigma, L(\sigma), p)\left(1 - \frac{1}{\epsilon^f(\sigma)}\right) = \bar{W}. \tag{21}$$

Rearranging terms, we obtain,

$$L(\sigma) = L_0(\sigma)\left(1 - \frac{1}{\epsilon^f(\sigma)}\right)^{\frac{1}{1-\alpha}} < L_0(\sigma). \tag{22}$$

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