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Efficient Bargaining with Underutilization of Labor

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The standard efficient contract involving a monopolistic firm and a union has always been derived under the assumption that the firm operates efficiently, i.e., it fully uses its labor force. However, nothing constrains the firm to do so and production with underutilization of labor may occur. The implications of ignoring that possibility and the conditions under which underutilization effectively occurs are studied in this paper.

Keywords: union, monopoly, bargaining, efficient contract, employment.

JEL classification: D43, J50.

1 Introduction

Underutilization of labor, or overmanning, seems to be a frequent practice in the real world. Conditions of work including an inordinately high number of workers per machine (like a high number of crew members in aircrafts) are often contracted. A typical example of overmanning can be found in the General Motors dispute at the Dayton, Ohio brake plant that caused a shutdown of GM's North American operations and eventually led to an agreement with hiring assurances: in the past GM had reneged on promises to produce products at the plant that would have maintained or added jobs; the final deal on March 22, 1996, between unions and the automaker allowed GM to continue outsourcing (i.e., the practice of giving parts contracts to outside vendors), but GM had guaranteed to honor its promise to keep and add jobs at two Dayton plants. Another example could be the supplementary unemployment benefit programs that are common at GM and other US automakers – essentially forcing the firm to subsidize (but not pay full wages) the workers it lays off.

The literature which studies the interaction of monopolistic price-setting and union–firm efficient bargaining (Svejnar, 1986; Veugelers, 1989; Layard and Nickell, 1990; Mezzetti and Dinopoulos, 1991; Nickell and Wadhwani, 1991; Bughin, 1993) always presupposes that the firm fully uses its labor force. In the present paper, we derive the conditions under which it is actually optimal for the firm to use less labor in the production process than is possible given the number of enrolled workers. This results from the combination of three conditions. First, on the product market, the marginal revenue is decreasing. Second, the union and the firm bargain over wages and employment (efficient contract). Third, the union is strongly interested in the level of employment. Given these features, the union can obtain a high level of employment. If the corresponding potential output entails a negative marginal profit, the firm will decide to underutilize its labor force, still preferring this contract to others providing less jobs, full utilization, but higher wages.[1]

De la Croix and Toulemonde (1995) show in an example that the usual efficient-bargaining outcome with full utilization of labor is not necessarily bilaterally optimal. Indeed, starting from the standard outcome, a benevolent planner can relax the requirement of being on the production frontier and this can improve the union's welfare, keeping profits constant. The question was whether such an outcome can arise naturally from a bargaining process.[2] In this paper, we show that this is indeed the case and we derive sufficient conditions on technology and preferences to obtain overmanning as a chosen outcome.

The resolution of a bargaining procedure in our context follows two steps. In the first step, union and firm determine wages and employment. We formalize this negotiation by the Nash bargaining process. In the second step, given employment and wages, the firm sets its price, buys its other inputs if necessary, and produces. It is free to underutilize its labor force and to determine the number of workers it will effectively use for production. This sequential framework is a convenient way to take into account the fact that the firm is always free to choose its optimal output level.[3]

1 In their seminal paper, McDonald and Solow (1981) discuss a case where a fix-price firm faces a sales constraint. Voluntarily ignoring labor hoarding, they conclude that this case may generate countercyclical wage variations. Here, the firm may face a sales constraint but its price is no longer exogenous and it is shown that labor hoarding is induced by the bargaining procedure itself.

2 The answer to this question is not straightforward and the difficulty is that the iso-profit curves are no longer concave. Indeed, the contract curve becomes the locus of tangency points between convex iso-profit curves and convex iso-utility curves.

The paper is organized as follows. In Sect. 2, we analyze the production decision of the firm and we set up the negotiation problem. In Sect. 3, we show that it can be optimal for the firm to produce below its production frontier and we derive a sufficient condition for it. We next provide an example where this case arises if the weight of employment in the union's objective function is high enough. In Sect. 4, we discuss the robustness of our result with the introduction of additional factors of production. Section 5 draws the main implications for the literature of the possibility of efficient underutilization of labor.

2 The Model

We consider a firm producing a single commodity with labor as input. Its technology is described by a production function $y = f(z)$ where y is the quantity produced and z is the "effective employment." The production function is strictly increasing in its argument and concave for all $z \geq 0$. It satisfies $f(0) = 0$ and is continuously differentiable.

The firm is a monopolist in its product market and faces a demand function $p = d(y)$ where p denotes the selling price. The revenue function expressed in terms of z is defined by

$$r(z) = f(z)p(f(z)) ,$$

where $p(.)$ is the inverse of the demand function. We make the following assumptions on the revenue function.

Assumption 1: r is continuous for all $z \geq 0$. It is strictly concave and continuously differentiable for all $z > 0$, and it has a maximum at z_0.

The point z_0 where r achieves its maximum is therefore unique and positive. It is the point where the marginal revenue is equal to zero. We define $r_0 = r(z_0)$.

The firm is a monopsonist in the labor market and faces a union whose preferences concerning wage and employment are represented by a utility function $u(w, l)$ defined on the set $U = \{ (w, l) \in \mathbf{R}^2 \mid w \geq \bar{w},\ l \geq \bar{l} \}$. It satisfies the following assumptions.

3 Overmanning could also be studied in a one-stage game and its existence does not depend on the two-step nature of the game. However two-stage games seem more natural in our context, leaving the firm the right to choose effective employment. Moreover, it leads to a simpler condition for the occurrence of underutilization of labor.

Assumption 2: u is continuous, strictly increasing, and strictly quasi-concave on U. It is twice continuously differentiable on the interior of the set U.

Without loss of generality, we set $u(\bar{w}, \bar{l}) = 0$. Hence, u is positive-valued on U.

The minimum acceptable wage and employment $\bar{w}$ and $\bar{l}$ are assumed positive[4] and compatible with z_0 and $r(z_0)$:

Assumption 3: $\bar{w} > 0, 0 < \bar{l} < z_0$, and $\bar{w}z_0 < r(z_0)$.

In particular it is profitable to employ z_0 workers at the minimum wage. A further assumption, strengthening the quasi-concavity requirement, will be introduced later. The marginal utilities of wage and employment are denoted by $u_w(w, l)$ and $u_l(w, l)$ respectively. u_w is assumed to satisfy the following condition.

Assumption 4: $\lim_{w \to \bar{w}} u_w(w, l) = +\infty$ for all $l > \bar{l}$.

Wage and employment are the result of a negotiation between the firm and the union. If (w, l) is the wage–employment pair agreed upon within the negotiation, the wage bill wl is a fixed cost and the employment level is a constraint for the firm which has still to decide on how much to produce. Its objective is then to maximize its revenue r and this may naturally lead the firm to underutilize its labor force. This is a matter of comparing the employment level agreed upon with the optimal labor input z_0. The effective employment is simply given by $z = \min(z_0, l)$ and the associated level of profit is defined by $\pi(w, l) = r(\min(z_0, l)) - wl$.

The bargaining is modelled as a symmetric Nash bargaining whose solution is given by the maximization of the product of the union's utility and the firm's profit:[5]

$$\varphi(w, l) = u(w, l)\pi(w, l) .$$

The maximization of $\varphi(w, l)$ is restricted to the set U. We assume that

4 The positivity of $\bar{w}$ and $\bar{l}$ is there to ensure the existence of a solution. As it is clear from the examples, this is not a necessary condition. $\bar{l}$ can be seen as the minimum employment level that is required to organize a union in the firm.

5 The generalization to the asymmetric Nash product is straightforward.

there is a solution (w^*, l^*), which is unique and interior, i.e., $w^* > \bar{w}$ and $l^* > \bar{l}$. The question concerns the conditions under which underutilization of labor occurs, i.e., $z_0 < l^*$.

The following decomposition of the function φ will be useful:

$$\varphi(w,l) = \begin{cases} \varphi_1(w,l) & \text{if } w \geq \bar{w} \text{ and } \bar{l} \leq l \leq z_0, \\ \varphi_2(w,l) & \text{if } w \geq \bar{w} \text{ and } l \geq z_0, \end{cases}$$

where

$$\varphi_1(w,l) = u(w,l)(r(l) - wl), \quad \varphi_2(w,l) = u(w,l)(r_0 - wl)\,.$$

These functions satisfy the inequality

$$\varphi_1(w,l) \leq \varphi_2(w,l) \tag{1}$$

for all $(w,l) \in U$, with equality whenever $l = z_0$.[6] Notice that the maximization of φ_1 on U corresponds to the standard bargaining problem.

3 Underutilization of Labor

Let us consider the bargaining problem whose solution is given by the maximization of φ_2 on U. The existence of a solution follows from the fact that $\varphi_2(w,l)$ is nonpositive outside $\bar{U}$, where $\bar{U} = \{(w,l) \in U \mid wl \leq r_0\}$ is a nonempty and compact subset of U as a consequence of Assumption 3.

Let us consider the indifference curves associated with $u(w,l)$ and the iso-profit curves associated with $(r_0 - wl)$. The contract curve related to the bargaining problem φ_2 is well defined as the locus of tangency points between the indifference curves and the iso-profit curves if the curvature of union's indifference curves exceeds the curvature of the rectangular hyperbola which are tangent to them. That is, the union's indifference curves should be more convex than the indifference curves of a union caring only for the wage bill wl. We prove in the appendix that this is equivalent to the following assumption:

Assumption 5: The elasticity of the indifference curves, defined by:

$$\sigma(w,l) = \frac{w u_w(w,l)}{l u_l(w,l)}$$

6 At these points, the first derivatives of φ_1 and φ_2 also coincide.

is decreasing in w (or equivalently increasing in l) along any indifference curve.

The equation defining the contract curve related to φ_2 is given by $\sigma(w, l) = 1$. Under Assumption 5, φ_2 has a unique maximum (w_2, l_2) located somewhere on the contract curve. As a consequence of the inequality (1), $\varphi_2(w_2, l_2)$ is larger than or equal to $\varphi(w, l)$ for all (w, l) on U. By definition, when $l_2 > z_0$, $\varphi_2(w_2, l_2) = \varphi(w_2, l_2)$, i.e., the maximum of φ must take place at l_2 and $l^* = l_2 > z_0$. On the other hand, if $l^* > z_0$, $\varphi(w^*, l^*) = \varphi_2(w^*, l^*)$ and l^* must coincide with l_2. This establishes the following key equivalence:

$$l^* > z_0 \quad \text{if and only if} \quad l_2 > z_0 \, . \tag{2}$$

This means that we only need to study the function φ_2 in order to find conditions under which underutilization of labor occurs.

Let us consider the following auxiliary maximization problem:

$$\max \varphi_2(w, l) \quad \text{subject to } w \geq \bar{w} \text{ and } l \geq z_0 \, .$$

Assumption 4 ensures that the constraint on w is not binding. The first-order conditions are then given by:

$$(r_0 - wl)u_w(w, l) = lu(w, l) \, , \tag{3}$$

$$(r_0 - wl)u_l(w, l) = wu(w, l) - \lambda \, , \tag{4}$$

$$\lambda \geq 0, \, l \geq z_0, \text{ and } \lambda(l - z_0) = 0 \, , \tag{5}$$

where λ is the Lagrange multiplier associated with the constraint $l \geq z_0$.

Let w_0 denote the solution of Eq. (3) evaluated at $l = z_0$. It is uniquely defined and positive as the solution to the following equation:

$$w + \frac{u(w, z_0)}{u_w(w, z_0)} = \frac{r_0}{z_0} \, . \tag{6}$$

Existence and uniqueness of w_0 follow from the fact that the left-hand side of Eq. (6), denoted by $g(w)$, is a continuous and increasing function which satisfies $\lim_{w \to \bar{w}} g(w) = \bar{w}$ and $\lim_{w \to \infty} g(w) = +\infty$, and from Assumption 3 which requires that $r_0/z_0 > \bar{w}$.

If $l_2 \leq z_0$ the constraint is satisfied with equality: $l = z_0$, $w = w_0$, and $\lambda \geq 0$. Combining (3) and (4) we then obtain $\sigma(w_0, z_0) \geq 1$. Hence, $l_2 \leq z_0$ implies $\sigma(w_0, z_0) \geq 1$. Together with (2), this establishes the following proposition.

Proposition 1: Under Assumptions 1 to 5, $\sigma(w_0, z_0) < 1$ is a sufficient condition for underutilization of labor to occur.

This could be understood intuitively as follows: If at the point (w_0, l_0) the union is ready to accept an increase in employment in exchange for a more important decrease in the wage, it is then bilaterally optimal to employ more workers than necessary for production. This possibility is consistent with Pencavel's (1991) finding that "not only do the assumptions of rent and wage bill maximization usually conflict with the data, but so does the proposition that unions care about wages only and not about employment. On the contrary most studies find a greater weight attached to employment, greater, that is, compared with what rent maximization would imply."

Example 1: We assume a linear demand function $d(y) = \max(0, 2 - y)$ and a production function $f(z) = \sqrt{z}$. That implies that $z_0 = r_0 = 1$. The union's preferences are assumed to be represented by the following utility function:

$$u(w, l) = (w - \bar{w})^{\alpha}(l - \bar{l})^{1-\alpha} ,$$

where $0 < \alpha < 1$. The restrictions on the minimum acceptable wage and employment are given by $0 < \bar{w} < 1$ and $0 < \bar{l} < 1$. The elasticity of the indifference curves is given by

$$\sigma(w, l) = \frac{\alpha(l - \bar{l})w}{(1 - \alpha)(w - \bar{w})l} .$$

Assumptions 1 to 5 are all satisfied. The value of w_0 is $(\alpha + \bar{w})/(1 + \alpha)$, and the elasticity evaluated at (w_0, z_0) is given by

$$\sigma(w_0, z_0) = \frac{(\alpha + \bar{w})(1 - \bar{l})}{(1 - \alpha)(1 - \bar{w})} .$$

Notice that $\sigma(w_0, z_0)$ increases with $\bar{w}$ and decreases with $\bar{l}$. The condition specified in the proposition is satisfied whenever $\alpha < (1 - 2\bar{w} + \bar{w}\bar{l})/(2 - \bar{w} - \bar{l})$. When $\bar{w}$ and $\bar{l}$ are close to zero, $\sigma(w_0, z_0)$ is approximately equal to $\alpha/(1 - \alpha)$: underutilization of labor then occurs when $\alpha < 1/2$, i.e, when the union cares more about employment than about wage. This example illustrates that if the weight of employment in the union's objective function is high enough, then the standard solution with full utilization of labor is no longer valid and should be replaced by a solution allowing for

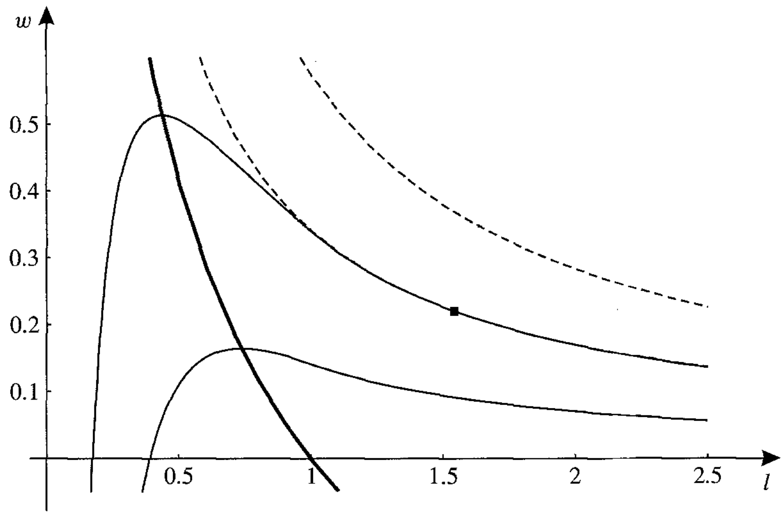

Fig. 1. Baseline example. The thick line represents marginal revenue, the two thin lines represent iso-profit curves and the dashed lines two indifference curves. The efficient outcome is represented by the square. It lies at the right of the point where the marginal revenue is zero

labor underutilization. It also shows that producing below the production frontier in the presence of efficient bargaining may arise with very simple functional forms.

Taking $\alpha = 0.4$, $\bar{w} = 0.01$, $\bar{l} = 0.01$, computation of the solution to the modified bargaining problem yields $w = 0.22$ and $l = 1.54$. The solution is presented in Fig. 1.

4 Generalization to a Multi-Input Firm

Overmanning occurs if the marginal revenue is negative. Otherwise the firm would fully utilize its labor force. The existence of a maximum of the revenue function is therefore a necessary condition (Assumption 1). It is interesting to notice that once other inputs which can be substituted for labor are explicitly introduced, that condition cannot be satisfied.

To see this let us consider a firm producing a single commodity using labor and another good as input. We assume that the decision on the purchase of this input is taken simultaneously with the decision on output and effective employment, i.e., after the bargaining. Its technology is described by a production function $y = f(z, x)$, where y is the quantity produced, z is the "effective employment," i.e., the labor force effectively used, and x the quantity of the other input. The production function is strictly increasing in its arguments and concave for all $z, x \geq 0$. It satisfies $f(0, x) = 0$ for all $x \geq 0$ and is continuously differentiable. The net revenue, as a function of employment, is now defined by

$$r(z) = \max_{x \geq 0}[p(f(z, x))f(z, x) - qx] ,$$

where q is the price of the input x. The first-order condition at a positive solution corresponding to that maximization problem is given by

$$f_x(z, x)[p'(y)y + p(y)] = q . \tag{7}$$

By the Envelope theorem, the marginal net revenue is given by $r'(z) = f_z(z, x)[p'(y)y + p(y)]$. Using (7), it can be written as $r'(z) = q[f_z(z, x)/f_x(z, x)]$. With usual assumptions on the production function, it is well defined and $r'(z) > 0$ for all $z > 0$. Hence, the optimal level of effective employment is always equal to the number of enrolled workers.

It must be stressed that this argument does not save the literature mentioned in the introduction as the models used in that literature fail to include explicitly nonlabor inputs. Furthermore, there is a very simple way to extend our overmanning result to the multi-input case. For this purpose we assume that in addition to the other input, the firm has a running cost associated with "effective worker," defined by $c(z)$, where c is a continuously differentiable, increasing, and convex function.[7] Hence it is more costly to pay the workers and to effectively use them than to pay them and lay them idle. The net revenue function expressed in terms of z is now defined by

$$r(z) = \max_{x \geq 0}[f(z, x)p(f(z, x)) - qx] - c(z) .$$

In that case, $r'(z) = q[f_z(z, x)/f_x(z, x)] - c'(z)$, and we can impose Assumption 1 on the net revenue function. The point z_0 where r achieves its maximum is the point where the marginal revenue is equal to the running costs per effective worker. Under Assumption 1, the arguments developed in Sect. 3 are valid and underutilization of labor may occur as an optimal outcome. Notice finally that the inclusion of running costs makes the condition under which underutilization occurs more appealing: in the case of

7 Notice that a linear running-cost function would be equivalent to the introduction of another input in the production function which would be perfectly complementary with effective labor.

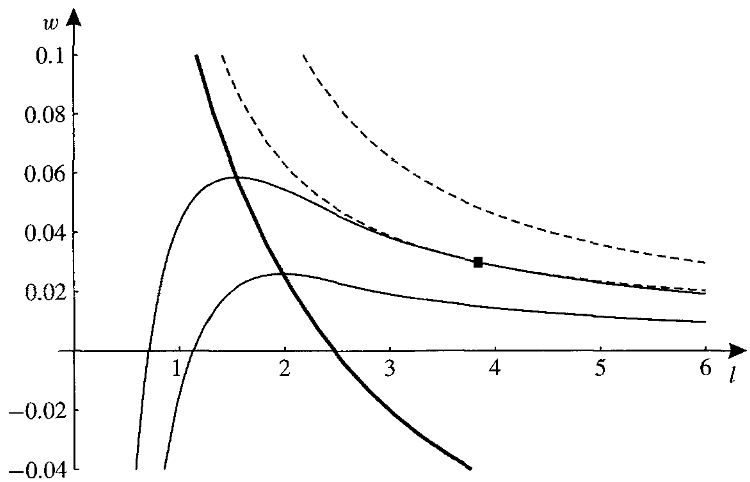

Fig. 2. Example with running costs. The thick line represents marginal revenue net of running costs, the two thin lines represent iso-profit curves, and the dashed lines two indifference curves. The efficient outcome is represented by the square. It lies at the right of the point where the net marginal revenue is zero. At this point the marginal revenue (not represented) is still positive

underutilization, output is determined by the condition that the net marginal revenue be equal to the marginal running costs (instead of by the condition that the marginal revenue be equal to zero).

Example 2: We assume a linear demand function $d(y) = \max(0, 2 - y)$ and a production function $f(z) = \sqrt{zx}$. That implies that $z_0 = r_0 = 1$. The preferences of the union are the same as in Example 1. Taking $c(z) = 0.1z$, $q = 2$, $\alpha = 0.49$, $\bar{w} = 0.01$, $\bar{l} = 0.01$, computation of the solution to the modified bargaining problem yields $z_0 = 2.47$, $w = 0.03$, and $l = 3.84$. The solution is presented in Fig. 2.

5 Implications for the Literature

The feature of overmanning is largely ignored in the literature. According to Proposition 1, underutilization of labor may be optimal in a number of bargaining models like those of Svejnar (1986), Veugelers (1989), Layard and Nickell (1990), Nickell and Wadwhani (1991). This could be the case as well with oligopolistic market structures like those of Mezzetti and Dinopoulos (1991), Bughin (1993), but also in Dowrick (1989), assuming a general demand function. In these papers, the standard solution may be incorrect because the possibility of underutilizing the labor force has not been taken into account at the time of the bargaining. Ignoring this fact gives rise to misleading conclusions.

In case of underutilization, prices and output are independent of unions' preferences: output is determined by the condition that the marginal revenue be equal to the running costs per effective worker. This reduces the scope of Dowrick's proposition (1989, p. 1130) stating that "under efficient union-oligopoly bargaining, any change in the bargaining parameters which allows unions to win higher wages leads to higher industry output if unions are risk-averse." For the same reason, the proposition of Mezzetti and Dinopoulos (1991, p. 89) that "an increase in the bargaining power of an employment-oriented union increases ... domestic welfare" is reversed when overmanning is taken into account.

The estimations of union power and union preferences with panel data as in Svejnar (1986), Veugelers (1989), and Bughin (1993) are no longer valid if underutilization of labor occurs. For instance, in eq. (7) of Svejnar (1986), nothing prevents the marginal revenue from becoming negative for some parameter configurations, in which case allowing for underutilization is relevant and would lead to different results.

Another important area where underutilization affects the results is the literature aimed at testing the efficiency of union–firm bargaining. The shape of the contract curve resulting from our framework is different from the standard case. More precisely, our framework implies a regime switching at the point where marginal revenue is equal to the running cost per effective workers. At this point, the slope of the contract curve changes, involving strong nonlinearities. All this affects the empirical analyses based on the estimation of such contract curve, as in Brown and Ashenfelter (1986).

Not taking into account the possibility of underutilization may invalidate empirical studies of production frontiers. In particular, the scenario developed in this paper could also apply to public firms. In this case, the estimation and interpretation of efficiency in publicly owned firms are likely to be affected by the possibility of overmanning.

An extension of the paper could be to relax the assumption that the union cares only about the wage and "nominal" employment. As overmanning generates more leisure (or less effort) for union members and if union preferences are responsive to the preferences of their members, this should be reflected in union preferences too. However, this modification of the model would not invalidate the results of this paper. Rather, they might reinforce the results, as the union now has a preference for overmanning per se.

This paper opens at least the following two possibilities for further research: establishing Proposition 1 in an oligopolistic context and formulating our two-stage game in a dynamic setup à la Espinoza and Rhee (1989).

Appendix

We prove here that the Assumption 5 is equivalent to the statement that the union's indifference curves are more convex than the rectangular hyperbolas. To simplify, let us consider the following change of variables: $x = \ln w$ and $y = \ln l$. The above statement is then equivalent to the strict quasi-concavity of the function $h(x, y) = u(\mathrm{e}^x, \mathrm{e}^y)$. In terms of (w, l), the determinant of the bordered Hessian of h is given by $H_h = w^2 l^2 H_u - wlu_w u_l(wu_w + lu_l)$, where H_u is the determinant of the Hessian of the utility function, which is positive by Assumption 2. The derivative of the elasticity σ with respect to w along an indifference curve is given by

$$\frac{\mathrm{d}\sigma}{\mathrm{d}w} = \frac{\partial\sigma}{\partial w} + \frac{\partial\sigma}{\partial l}\frac{\mathrm{d}l}{\mathrm{d}w},$$

where $\mathrm{d}l/\mathrm{d}w$ is the slope of the indifference curve given by $-u_w/u_l$. Hence,

$$\frac{\mathrm{d}\sigma}{\mathrm{d}w} = \frac{\partial\sigma}{\partial w} - \frac{u_w}{u_l}\frac{\partial\sigma}{\partial l} = \frac{-1}{l^2 u_l^3}[wlH_u - u_w u_l(wu_w + lu_l)].$$

This establishes the equivalence.

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