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メタデータ	言語: eng 出版者: 公開日: 2014-01-09 キーワード (Ja): キーワード (En): 作成者: Watanabe, Shigeru, Maeda, Miki メールアドレス: 所属:
URL	https://doi.org/10.24729/00000844

On Law and Economics
—Wage Rate Leadership, NPO and Product Liability*—

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Abstract: The first purpose of this paper is to analyze the product liability taking N.P.O. into consideration. The firm which maximizes the expected profit is assumed to sell the product to the NPO which sells that product to consumers. A part of the products produced by the firm may be defective. It is assumed that not only the efficiency of the workers but also the rate of the defective products will depend on the wage rate. Further, the defective products will not always be detected by the firm before they are sold to the NPO. The rate of the detection is also assumed to depend on the wage rate of the laborers who work at the firm. Hence, some parts of the defective goods may be sold to the NPO. The defective goods may be detected by the NPO before they sell the products to the consumers. The rate at which the defective goods are detected by the NPO is also assumed to depend on the wage rate of the NPO. The following results have been derived. The higher the penalty due to the product liability, the lower the price at which the products are sold to the NPO. The effect of an increase in the wage rate of the workers at the firm on the wage rate of the workers at the NPO cannot be determined in general. However, when an increase in the wage rate of the firm increases only the production efficiency, an increase in that wage rate will decrease the price at which the products are sold from firm to NPO but will increase the wage rate of NPO. On the other hand, when an increase in the wage rate of the firm does not have effect on the production efficiency, if the increase in that wage rate increases the rate at which the products are not defective then an increase in that wage rate will increase the price at which the products are sold from firm to NPO but will decrease the wage rate of NPO. The second purpose of this paper is to analyze the

* We thank Professor A. Sawai for helpful comments and recommending beneficial references for the product liability. We also thank T. Fujiwara : the President of Osaka Prefecture University College of Technology for academic relationship between Osaka Prefecture University and Osaka Prefecture University College of Technology.

relationship between the efficiency wages and the wage rate leadership instead of price leadership. We get a result that in the absence of defective products the elasticity of the efficiency of labor with respect to the wage rate becomes less than 1, hence, the ordinal Sollow's condition does not hold in this model of the wage rate leadership. In the presence of the defective product, when they are not detected before they are sold to the consumers and the profit is positive, the sum of the elasticity of the efficiency of the labor with respect to the wage rate and that with respect to the labor employment is larger than the elasticity of the production level with respect to the wage rate. Hence, if the sum of the elasticity of the efficiency of the labor with respect to the wage rate and that with respect to the employed labor is not larger than the elasticity of the output level with respect to the wage rate, then wage rate determined by the wage rate leadership and the employment level are not determined at the optimal levels.

Keywords: Product Liability, NPO, Efficiency Wages, Wage Rate Leadership, Law and Economics.

1. Introduction

The first purpose of this paper is to analyze the product liability[1] taking NPO[2] into consideration. The firm which maximizes the expected profit is assumed to sell the product to the NPO which sells that product to consumers. A part of the products produced by the firm may be defective. It is assumed that not only the efficiency[3] of the workers but also the rate of the defective products[4] will depend on the wage rate. Further, the defective products will not always be detected by the firm before they are sold to the NPO. The rate of the detection is also assumed to depend on the wage rate of the laborers who work at the firm. Hence, some parts of the defective goods may be sold to the NPO. The defective goods may be detected by the NPO before they sell the products to the consumers. The rate at which the defective goods are detected by the NPO is also assumed to depend on the wage rate of the NPO.

From the analysis of this paper the following results have been derived. The higher the penalty due to the product liability, the lower the price at which the products are sold to the NPO. The effect of an increase in the wage rate of

the workers at the firm on the wage rate of the workers at the NPO cannot be determined in general.

However, when an increase in the wage rate of the firm increases only the production efficiency, an increase in that wage rate will decrease the price at which the products are sold from firm to NPO but will increase the wage rate of NPO.

On the other hand, when an increase in the wage rate of the firm does not have effect on the production efficiency, if the increase in that wage rate increases the rate at which the products are not defective then an increase in that wage rate will increase the price at which the products are sold from firm to NPO but will decrease the wage rate of NPO.

The second purpose of this paper is to analyze the relationship between the efficiency wages and wage rate leadership instead of price leadership. As a result of this analysis, we get a result that in the absence of defective products the elasticity of the efficiency of labor with respect to the wage rate becomes less than 1, hence, the ordinal Sollow's condition[5] does not hold in this model of the wage rate leadership. On the other hand in the presence of the defective product, when they are not detected before they are sold to the consumers and the profit is positive we get the following result that the sum of the elasticity of the efficiency of the labor with respect to the wage rate and that with respect to the labor employment is larger than the elasticity of the production level with respect to the wage rate. Hence, if the sum of the elasticity of the efficiency of the labor with respect to the wage rate and that with respect to the employed labor is not larger than the elasticity of the output level with respect to the wage rate, then wage rate determined by the wage rate leadership and the employment level are not determined at the optimal levels.

In the next section a simple model of the product liability is shown considering NPO. The wage rate leadership instead of price leadership will be examined in section 3. Concluding remarks will be given in the last section.

2. A Simple Model of Product Liability and NPO

Some of the products produced by the firm may be defective. In the following the rate of the defective product, $1-\alpha$, depends on the wage rate of the firm. The defective products are not always detected by the firm before

they are sold to NPO.

The rate of being detected by the firm, β, is also assumed to depend on the wage rate of the firm. It will be plausible to assume that the higher the wage rate the higher the incentive for decreasing the defective products and that for detecting the detective products. Before the resale to consumers, NPO may detect the defective products. However, the defective products are not always detected by NPO before they are sold to the consumers. The rate at which the defective products are detected by NPO, γ, will depend, in turn, on the wage rate of NPO. Hence, in the same way the higher the wage rate of NPO the higher the rate at which the defective products are detected before the resale to the consumers. In the following it is assumed that only the firm which produced the defective products is responsible for the damage or injuries caused by the defective products. Therefore, the detection of the defective products by NPO before the resale is a matter of importance especially for the firm which produced the products under the product liability law.

The profit, π, of the firm under the product liability law is denoted by the following equation (1).

$$\pi = P\alpha(w)X(e(w)\ell) - w\ell - F(1-\gamma(v))(1-\beta(w))(1-\alpha(w))X(e(w)\ell), \quad (1)$$

where P is the price at which the products are sold to NPO, α is the rate at which the products are not defective, w is the wage rate of the firm, X is the output level, e is the efficiency of the worker, ℓ is the number of the workers employed by the firm, F denotes the degree of the damage or injuries caused by the defective products, γ is the rate at which the defective products are detected by NPO, v is the wage rate of the NPO, β is the rate at which the defective products are detected by the firm.

On the other hand, the budget of NPO is denoted by the following equation (2).

$$(P_M - P)\alpha(w)X(e(w)\ell) = vm, \quad (2)$$

where P_M is the market price of the product at which the NPO sells the products to the consumers m is the number of the workers employed by the NPO.

In the following to focus on the relationship between the firm and NPO the variables other than the price P at which the products are sold from the firm to NPO and v which is determined from the budget balance of the NPO are assumed to be given.

Maximizing the equation (1) with respect to P under the condition of (2) yields the following first order condition (3).

$$d\pi/dP = A - \frac{1}{2}\beta\gamma_0 v^{-\frac{1}{2}}\frac{\alpha(w)}{m}X(e(w)\ell) = 0, \tag{3}$$

where $A = \alpha(w)X(e(w)\ell)$,

$$B = F(1-\beta(w))(1-\alpha(w))X(e(w)\ell)$$

and $\gamma(v)$ is specified such that $\gamma(v) = \gamma_0 v^{\frac{1}{2}}$.

Second order condition is satisfied in the following manner.

$$\frac{d^2\pi}{dP^2} = -\frac{1}{4}\beta\gamma_0\frac{\alpha(w)}{m^2}X^2(e(w)\ell)v^{-\frac{3}{2}} < 0. \tag{4}$$

Hence, from the first order condition the optimal price P^* can be derived in the following manner.

$$P^* = P_M - \frac{\gamma_0^2 F^2(1-\beta(w))^2(1-\alpha(w))^2 X(e(w)\ell)}{4m\alpha(w)}. \tag{5}$$

Then from the equation (2) the optimal v^* can also be obtained straightforwardly.

$$v^* = \frac{1}{m}(P_M - P^*)X(e(w)\ell). \tag{6}$$

Therefore from (5) and (6) the following results can also be obtained straightforwardly.

$$\partial P^{*} / \partial P_{M} > 0, \tag{7}$$

$$\partial P^{*} / \partial \gamma_{0} < 0, \tag{8}$$

$$\partial P^{*} / \partial F < 0, \tag{9}$$

$$\partial P^{*} / \partial m > 0, \tag{10}$$

$$\partial v^{*} / \partial P_{M} < 0, \tag{11}$$

$$\partial v^{*} / \partial \gamma_{0} > 0, \tag{12}$$

$$\partial v^{*} / \partial F > 0, \tag{13}$$

$$\partial v^{*} / \partial m < 0. \tag{14}$$

Hence, from (9) and (13) we get the following result. (i) An increase in the degree of injuries caused by the defective products will decrease the price at which the products are sold from the firm to NPO but will increase the wage rate of NPO.

On the other hand, from (7) and (11) we also get the following result. (ii) An increase in the market price at which the products are sold from NPO to consumers will increase the price at which the products are sold from the firm to NPO but will decrease the wage rate of NPO. Other results can also be obtained as shown in (8), (10), (12) and (14).

Next, the effects of an increase in the wage rate of the firm on the price at which the products are sold from firm to NPO and on wage rate of NPO can also be shown in the following manner.

When $de/dw>0$, **if** $d\alpha(w)/dw = d\beta(w)/dw = 0$,

$$\text{then } \partial P^{*}/\partial w < 0 \text{ and } \partial v^{*}/\partial w > 0, \tag{15}$$

if $d\alpha(w)/dw>0$, and $d\beta(w)/dw \geqq 0$,
then the effects cannot be determined,

if $d\beta(w)/dw > 0$, and $d\alpha(w)/dw \geqq 0$,
then the effects cannot be determined.

On the other hand, when $de/dw = 0$,

if $d\alpha(w)/dw = d\beta(w)/dw = 0$,

then $\partial P^*/\partial w = \partial v^*/\partial w = 0$, (16)

if $d\alpha(w)/dw > 0$, and $d\beta(w)/dw \geqq 0$,

then $\partial P^*/\partial w > 0$ and $\partial v^*/\partial w < 0$, (17)

if $d\beta(w)/dw > 0$, and $d\alpha(w)/dw \geqq 0$,

then $\partial P^*/\partial w > 0$ and $\partial v^*/\partial w < 0$, (18)

Therefore, from (15) when an increase in the wage rate of the firm increases only the production efficiency, an increase in that wage rate will decrease the price at which the products are sold from firm to NPO but will increase the wage rate of NPO.

On the other hand, from (17) when an increase in the wage rate of the firm does not have effect on the production efficiency, if the increase in that wage rate increases the rate at which the products are not defective and doesn't decrease β then an increase in that wage rate will increase the price at which the products are sold from firm to NPO but will decrease the wage rate of NPO. Similarly from (16) and (18) other results can also be obtained straightforwardly.

3. Wage Rate Leadership and Efficiency Wages

In this section the relationship between the efficiency wages and wage rate leadership instead of price leadership will be analyzed. As a result of this

analysis, we get a result that in the absence of defective products the elasticity of the efficiency with respect to the wage rate becomes less than 1. Hence, the ordinal Sollow's condition does not hold in this model of the wage rate leadership.

In the following instead of the price leadership the wage rate leadership is taken into consideration.

It is assumed that once the wage rate, w, is determined by the wage rate leadership, each small firm determines the quantity of the labor employments then the total quantity of the workers employed by the small firms, $D(w)$, can be determined and the labor supply, $S(w)$, is also determined. The larger firm also determines the quantity of the labor employments, ℓ. Then, the quantity of the unemployed workers, $S(w)-D(w)-\ell$, can be determined. It is assumed in the following that the larger the unemployed workers the higher the efficiency of the workers. Hence, the efficiency of the workers can be simply denoted in the following manner.

$$e(w, \ell)=1+\theta(S(w)-D(w)-\ell), \tag{19}$$

where $\theta>0$ and $S(w)-D(w)-\ell>0$ are assumed.

Hence, in the absence of the defective products, the profit, π, of the large firm can be shown by the equation (20) to make the analysis simple.

$$\pi=Pk\,Log\,e(w, \ell)\ell-w\ell, \tag{20}$$

where $e(w, \ell)=1+\theta(S(w)-D(w)-\ell)$ from (19), $k>0$ and P is the given price of the product.

Maximizing (20) with respect to w and ℓ yields the following first order conditions.

$$\begin{aligned}&\partial\pi/\partial w\\&=Pk\theta(dS(w)/dw-dD(w)/dw)/\{1+\theta(S(w)-D(w)-\ell)\}\\&\quad-\ell\\&=0,\end{aligned} \tag{21}$$

$$\partial\pi/\partial\ell$$

$$= Pk\{-\theta\ell + 1 + \theta(S(w) - D(w) - \ell)\}/\{1 + \theta(S(w) - D(w) - \ell)\}\ell$$

$$- w$$

$$= 0. \tag{22}$$

Second order conditions are assumed to be satisfied.

From the first order conditions (21) and (22) the following result can be obtained straightforwardly.

$$\eta \equiv (w/e)\partial e/\partial w < 1. \tag{23}$$

Hence, from the wage rate leadership model we get the result that in the absence of the defective products the elasticity of efficiency of labor with respect to the wage rate is less than 1, which is different from the ordinal Sollow's condition concerning the efficiency wages.
On the other hand in the presence of the defective products, when they are not detected before they are sold to the consumers the equation (20) is rewritten in the following manner.

$$\pi = P\alpha k Log e(w, \ell)\ell - w\ell - F(1 - \alpha(e(w, \ell)))k Log e(w, \ell)\ell,$$

$$\text{where } 0 < \alpha < 1. \tag{24}$$

Similarly, maximizing (24) with respect to w and ℓ yields the first order conditions. Second order conditions are assumed to be satisfied.

From the first order conditions the following result (25) can straightforwardly be obtained when $\pi > 0$.

$$\eta_w^e + \eta_\ell^e > \eta_w^X, \tag{25}$$

where η_w^e is the elasticity of the efficiency of the labor with respect to the wage rate, η_ℓ^e is the elasticity of the efficiency of the labor with respect to the employed labor and η_w^X is the elasticity of the output level with respect to the wage rate.

Hence, if the sum of the elasticity of the efficiency of the labor with respect to the wage rate and that with respect to the employed labor is not larger than the elasticity of the output level with respect to the wage rate, then wage rate determined by the wage rate leadership and the employment level are not determined at the optimal levels.

4. Concluding Remarks

In this paper it is assumed that not only the efficiency of the workers but also the rate of the defective products will depend on the wage rate. Further, the defective products will not always be detected by the firm before they are sold to the NPO. The rate of the detection is also assumed to depend on the wage rate of the laborers who work at the firm. Hence, some parts of the defective goods may be sold to the NPO. The defective goods may be detected by the NPO before they sell the products to the consumers.

From the analyses of this paper, we get the following results. An increase in the degree of injuries caused by the defective products will decrease the price at which the products are sold from the firm to NPO but will increase the wage rate of NPO. An increase in the market price at which the products are sold from NPO to consumers will increase the price at which the products are sold from the firm to NPO but will decrease the wage rate of NPO. When an increase in the wage rate of the firm increases only the production efficiency, an increase in that wage rate will decrease the price at which the products are sold from firm to NPO but will increase the wage rate of NPO. On the other hand, when an increase in the wage rate of the firm does not have effect on the production efficiency, if the increase in that wage rate increases the rate at which the products are not defective then an increase in that wage rate will increase the price at which the products are sold from firm to NPO but will decrease the wage rate of NPO.

Further, we get the following results from the analysis of wage rate leadership. In the absence of defective products the elasticity of the efficiency of labor with respect to the wage rate becomes less than 1, hence, the ordinal Sollow's condition does not hold in this model of the wage rate leadership. On the other hand in the presence of the defective products, when they are not detected before they are sold to the consumers and the profit is positive,

we get the following result that the sum of the elasticity of the efficiency of the labor with respect to the wage rate and that with respect to the labor employment is larger than the elasticity of the production level with respect to the wage rate. Hence, if the sum of the elasticity of the efficiency of the labor with respect to the wage rate and that with respect to the employed labor is not larger than the elasticity of the output level with respect to the wage rate, then wage rate determined by the wage rate leadership and the employment level are not determined at the optimal levels.

Notes

1. See Matsuoka (2012), Yamada and Sano (2009) for the excellent explanation of the product liability.
2. See Yamauchi (1997) and Yamauchi (2003) for NPO.
3. See Stiglitz (1976), Solow (1979), Yellen (1984), Watanabe (1996 a), Chang and Ching (1996), Watanabe (1996 b) and Laszlo (2004), Watanabe (2013), Watanabe and Maeda (2013 a), and Watanabe and Maeda (2013 b) for the efficiency wages.
4. See Watanabe (1997) for the relationship between tax evasion and product liability.
5. In the ordinal efficiency wages model the efficiency of the labor with respect to the wage rate is equal to 1.

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