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Monopoly and Economic Efficiency: Perspective from an Efficiency Wage Model

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Abstract

The objective of this paper is to analyze the efficiency consequences of monopoly from the perspective of an efficiency-wage model based on Shapiro and Stiglitz (1984). An important innovation of our model is that a firm can raise the probability that a shirking worker is detected by increasing its effort or investment in the monitoring of workers. By comparing with the competitive equilibrium we find that monopoly is associated with higher unemployment rate and less monitoring. Surprisingly, however, monopoly is not necessarily dominated by perfect competition in terms of economic efficiency.

Keywords: Monopoly, Economic Efficiency, Unemployment, Efficiency Wage

1. Introduction

It is well-known that monopoly causes inefficient allocation of resources. Traditionally, deadweight losses, productive inefficiencies and rent seeking activities are cited as reasons for efficiency losses of monopoly. However, there is one area of potential efficiency losses of monopoly that so far has rarely been explored in microeconomic theory, that is, the effects of monopoly on unemployment. Given that output is an increasing function of labor, reduction in output by a monopoly will normally cause a reduction in labor employed. Therefore, it seems plausible that monopoly cause higher rate of unemployment.

On the other hand, however, the effect of monopoly on economic efficiency, if taking unemployment into consideration, is not that clear and has not been studied deeply in microeconomic theory. Therefore, the main objective of this paper is to analyze the efficiency consequences of monopoly from the perspective of an efficiency wage model of unemployment based on Shapiro and Stiglitz [1]. In this model a monopolist has to offer a wage high enough to induce workers to expend efforts on the job. An important feature of our model is that a monopolist can raise the probability of shirking detection by increasing its effort or investment in the monitoring of workers[1]. Using this model we find that monopoly does not necessarily lead to lower welfare level than perfect competition. This result is surprising in light of the common belief about the welfare losses of monopoly.

The rest of this paper is organized as follows. Section 2 presents the model and compares the monopoly equilibrium with the competitive equilibrium. Section 3 analyzes the welfare consequence of monopoly and presents the main results from simulations. And conclusions are in section 4.

2. The Model

Consider an industry served by a monopolist[2], whose objective is to maximize profits. The demand for the good produced by the monopolist is represented by $p = \alpha P(Q)$, where p is the price and Q is the output with $P'(Q) < 0$ and $2P'(Q) + P''(Q) \cdot Q < 0$ (to ensure the monopolist's marginal revenue is decreasing in output), and $\alpha > 0$ measures the market size. The monopolist produces the good according to the production function $Y = sF(eL)$ with $F'(\cdot) > 0$ and $F''(\cdot) < 0$, where Y is the output, L is the number of workers employed, e is the effort level expended by the representative worker (hence, eL represents the effective amount of labor em-

[1]Shapiro and Stiglitz [1] discuss informally the case of endogenous monitoring. They indicate that in general it is impossible to ascertain whether the competitive equilibrium entails too much or too little employment.

[2]Thus, we do not distinguish the firm's wage and the economy-wide wage. Alternatively, we may assume that there are many monopolized industries in the economy and it can be shown that this assumption does not shatter our major results in this paper.

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ployed by the firm), and s is an exogenous technology parameter.

To incorporate unemployment into the model, we use the efficiency wage model of Shapiro and Stiglitz [1]. Specifically, we assume that workers may shirk (*i.e.* exerting no effort) on the job. The firm, however, cannot perfectly observe workers' effort. In other words, if a worker shirks, there is some probability, denoted by q, that the worker will be caught and fired. In the standard Shapiro-Stiglitz efficiency wage model, the detection probability q is taken as exogenous. In our model, we endogenize q by assuming that q is a function of the effort and/or investment by the firm in monitoring the workers, $q = q(m)$ with $q'(m) > 0$ and $q''(m) < 0$, where m denotes the monitoring level.

To discourage workers from shirking, the firm has to pay a wage high enough (*i.e.* the efficiency wage or non-shirking wage):

$$w^* = \overline{w} + e + \frac{e}{q(m)}(a+b+r) \tag{1}$$

where, $\overline{w} > 0$ is the unemployment benefit received by an unemployed worker; a denotes the job acquisition rate, b is the natural separation rate and r represents the intertemporal discount rate.

Taking the efficiency wage into consideration, the monopolist's optimization problem is written as:

$$\max_{\{m,L\}} \pi = \alpha P\big(sF(eL)\big)\cdot sF(eL) - \left[\overline{w} + e + \frac{e}{q(m)}(a+b+r)\right]L - H(m) \tag{2}$$

where $H(m)$ is the cost of monitoring workers with $H'(\cdot) > 0$ and $H''(\cdot) > 0$[3].

Note that in the steady state of the labor market, the flow into and the flow out of the unemployment pool per unit time are equal. That is,

$$bL = a(N-L) \quad \text{or} \quad a = bL/(N-L) \tag{3}$$

Then the first order conditions for Equation (2) can be rewritten as:

$$\frac{eL\cdot q'(m)}{[q(m)]^2}\left(\frac{bN}{N-L}+r\right) - H'(m) = 0 \tag{4}$$

$$\alpha s^2 e\cdot P'\big(sF(eL)\big)F'(eL)F(eL) + \alpha se\cdot P\big(sF(eL)\big)F'(eL) - \left[\overline{w} + e + \frac{e}{q(m)}\left(\frac{bN}{N-L}+r\right)\right] = 0 \tag{5}$$

Let $L = A_m(m)$ and $L = B_m(m)$ denote the functional relationships implied by Equations (4) and (5), respectively. Thus, graphically, the intersection of these two curves in the (m, L) space is the monopoly equilibrium (m_m^*, L_m^*).

Proposition 1. *Both curves, $L = A_m(m)$ and $L = B_m(m)$, are strictly upward sloping in the (m, L) space. Moreover, at the equilibrium point, the slope of $L = A_m(m)$ is greater than the slope of $L = B_m(m)$. As a result, there is a unique monopoly equilibrium*[4].

Now consider a perfectly competitive industry, where all firms are price-takers. The representative firm's optimization problem is:

$$\max_{\{m,L\}} \left\{\overline{p}\cdot sF(eL) - \left[\overline{w} + e + \frac{e}{q(m)}(a+b+r)\right]L - H(m)\right\} \tag{6}$$

Equilibriums in the product and the labor markets require that $\overline{p} = \alpha\cdot P\big(sF(eL)\big)$ and $bL = a(N-L)$ or $a = bL/(N-L)$. Then the first order conditions for Equation (6) can be rewritten as:

$$eL\cdot\frac{q'(m)}{[q(m)]^2}\cdot\left[\frac{bN}{N-L}+r\right] - H'(m) = 0 \tag{7}$$

$$\alpha se\cdot P\big(sF(eL)\big)\cdot F'(eL) - \left\{\overline{w} + e + \frac{e}{q(m)}\left[\frac{bN}{N-L}+r\right]\right\} = 0 \tag{8}$$

Let $L = A_c(m)$ and $L = B_c(m)$ be the curves implied by Equations (7) and (8), respectively. Then the intersection of these two curves (m_c^*, L_c^*) represents the levels of monitoring and employment in the competitive equilibrium.

Proposition 2. *Both curves, $L = A_c(m)$ and $L = B_c(m)$, are strictly upward sloping in the (m, L) space. Moreover, at the equilibrium point, the slope of $L = A_c(m)$ is greater than the slope of $L = B_c(m)$. Therefore, there is a unique competitive equilibrium.*

Note that the comparison of Equations (4) and (7) indicates that $L = A_m(m)$ and $L = A_c(m)$ are exactly the same curve in the $(m$-$L)$ space. To determine the efficiency consequences of monopoly, compare the monopoly equilibrium with that under perfect competition (as shown in **Figure 1**) to obtain:

Proposition 3. *Relative to a perfectly competitive market, a monopolist employs fewer workers and invests less in the monitoring of workers. That is, $m_m^* < m_c^*$ and $L_m^* < L_c^*$.*

Since the quantity produced is an increasing function of employment, Proposition 3 in turn implies that the

[3]It should be noted that the monitoring cost here is assumed to be independent of the number of workers. Alternatively, for future research, it may take the form of $h(m)L$.

[4]Based on the assumptions made above, it can be shown that the second order conditions are satisfied. This ensures the existence of the equilibrium.

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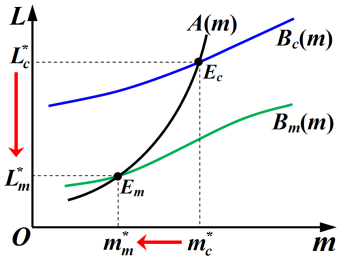

Figure 1. Monopoly equilibrium vs. competitive equilibrium.

monopolist produces a smaller output and accordingly sets a higher price than a competitive firm. On the surface, these effects of monopoly appear to be the same as in the standard monopoly case. However, there are more factors at play in this model. Intuitively, a monopolist has a tendency to restrict output because it faces a downward sloping demand curve. As a result of this tendency, employment level falls, which tends to push down the non-shirking wage. In our model this has an additional effect because it induces the monopolist to reduce the level of monitoring, causing a further fall in employment.

3. Welfare Effects of Monopoly

Given that this is a partial equilibrium model, we use the total surplus as the measure of welfare. Note that compared with the standard textbook model of monopoly, we have an additional group of agents in our model, the workers. In principle, the measure of total welfare should also take into consideration the utility of workers. This raises an additional issue of how to treat the unemployment benefits:

1) If the unemployment benefits are financed by lump sum taxes on consumers, they are merely a wealth transfer and as such should not be included in the total surplus;

2) Alternatively, if there are no government transfer payments and the unemployment benefits merely represent the value that an unemployed worker obtain from home production, the unemployment benefits should be included in the total surplus;

3) In addition, the conventional measure of total surplus that takes into consideration the welfare of consumers and the firms only (*i.e.* excluding the workers).

Our welfare analysis in what follows uses the first type of total surplus[5]:

$$TS \equiv \int_0^{Q^*} P(Q)\mathrm{d}Q - eL^* - H(m^*) \tag{9}$$

It is easy to obtain $\int_0^{Q_c^*} P(Q)\mathrm{d}Q > \int_0^{Q_m^*} P(Q)\mathrm{d}Q$, $eL_c^* > eL_m^*$, $H(m_c^*) > H(m_m^*)$ since $L_c^* > L_m^*$ and $m_c^* > m_m^*$. Thus, monopoly may lead to a higher social welfare than perfect competition does. Specifically, $TS_m > TS_c$ if and only if

$$\underbrace{\left[e\cdot\left(L_c^* - L_m^*\right)\right]}_{\Delta E} + \underbrace{\left[H(m_c^*) - H(m_m^*)\right]}_{\Delta H} > \underbrace{\int_{Q_m^*}^{Q_c^*} P(Q)\mathrm{d}Q}_{\Delta CS_g} \tag{10}$$

The left hand side of Equation (10) is the sum of the difference of worker's efforts put into production (ΔE) and the difference of monitoring cost (ΔH). And the right hand side is the difference of gross consumer surplus (ΔCS_g).

In what follows we conduct numerical simulations using a version of our model with specific functional forms. The objectives of these simulations are to provide concrete examples for the welfare effects of monopoly, in comparison with the competitive benchmark**.**

Our simulation results, based on the specific functional forms and parameter values presented in **Table 1**, show that the total surplus under monopoly is not necessarily lower than that under perfect competition. As we can see from **Figures 2** and **3**, monopoly improves welfare if, *ceteris paribus*, market size (α) is relatively large or unemployment benefit ($\bar{w}$) is relatively small[6].

These numerical simulations, together with the general analysis demonstrate that

Proposition 4. *Monopoly is not always dominated by perfect competition in terms of economic efficiency if an efficiency wage is offered and unemployment is taken into consideration.*

4. Conclusions

In this paper, by constructing an efficiency-wage model that takes into account the firm's choice of monitoring,

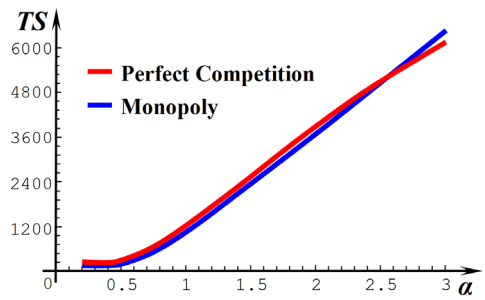

Figure 2. Comparison of welfare: monopoly vs. competition (varying market size).

[5]It can be demonstrated that the similar results will be obtained if the other two measures are used.

[6]Indeed, we also find examples that when separation rate is relatively high (say $b > 0.24$) or technology shock is relatively low (say $0.3 \le s \le 0.8$), the total surplus under monopoly is larger than that under perfect competition. To avoid verbosity, we do not present them here.

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Table 1. Functional forms and parameter values.

Functional Forms	Inverse Demand Function: $P(Q)=100-0.1Q^{1.5}$				Production Function: $F(L)=s\cdot L^{0.65}$	
	Monitoring Technology: $q(m)=0.8m/(m+15)$				Monitoring Cost: $H(m)=6m^3$	
Basic Parameter Values	Separation Rate (*b*)	Discount Rate (*r*)	Technology Shocks (*s*)	Market Size (*α*)	Unemployment Benefit ($\bar{w}$)	Labors Force (*N*)
	0.05	0.05	0.35	2.75	0.5	1000

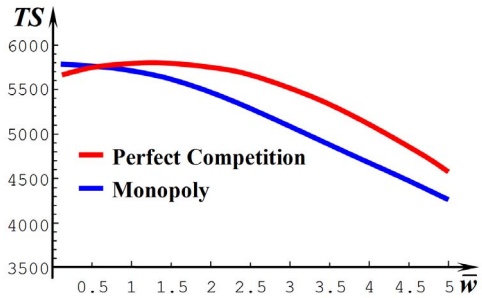

Figure 3. Comparison of welfare: monopoly vs. competition (varying unemployment benefit).

we have analyzed the efficiency and employment con- that takes into account the firm's choice of monitoring, we have analyzed the efficiency and employment consequences of monopoly in the presence of unemployment caused by efficiency wage considerations. We have shown that in addition to a smaller output and a higher price, monopoly also leads to higher unemployment rate than the competitive equilibrium.

It is worth noting that the effect of monopoly on total welfare, however, is ambiguous. Numerical simulations of the model indicate that under certain range of parameter values, monopoly generates higher total surplus than perfect competition. Therefore, by introducing an additional distortion (*i.e.* unemployment) into the model, it is no longer the case that monopoly is always dominated by perfect competition in terms of economic efficiency.

5. References

[1] C. Shapiro and J. Stiglitz, "Equilibrium Unemployment as a Worker Discipline Device," *American Economic Review*, Vol. 74, No.3, 1984, pp. 433-444.