A Higher Corporate Profit Tax May Lead to a Welfare Improvement in a Fair Rate-of-Return Regulated Monopoly

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Well-known in the literature, a profit tax on an unregulated monopoly will not alter the optimal position of price and output. Given that unregulated monopoly is few and far in between, it has little practical relevance. This paper presents for the first time a paradox: A profit tax can indeed alter the optimal price and output and as such may lead to a welfare improvement in the case of a rate-of-return-regulated monopoly. In addition, it does not require extraneous assumptions of increasing returns to scale and/or very convex demand curve.

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I. Introduction

In the United States one of the major business taxes is the corporate income or profits tax. The impact of such a tax on the decisions of an unregulated monopolist has been known for over 160 years.[1] It is well known that a tax on the profits of an unregulated firm does not change the position of the marginal

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revenue and cost curves. Thus, it does not alter the firm's optimum price and output. This neutrality of the profit tax is a long-established and well-accepted principle in both perfect competition and unregulated monopoly models. While unregulated monopolies are quite rare, regulated monopoly is common. Despite deregulatory efforts, rate-of-return regulation will continue to impact a significant portion of certain industries.[2] Since the seminal work of Averch and Johnson (1962), there has been a vast amount of theoretical and empirical research on regulated firms.[3] Despite these analyses, the research on the effects of a corporate income tax on a regulated firm is rather scanty. The only published analysis of the profit tax is in Bailey (1973) who cited the unpublished work of Dayan (1973). Dayan determined the impact of a profits tax on factor employment and output. The purpose of this paper is to investigate the impact of this tax on welfare. In particular, we show for the first time that imposing a profits tax can lead to an

[1] See for example Cournot (1838), Wicksell (1896), and Edgeworth (1925). An excellent source on the historical development of the profit tax can be found in Musgrave (1959).

[2] For example, in the electric utility industry only the generation of electricity is or will be deregulated. The transmission and distribution of electricity are unlikely to be deregulated as the firm providing these services is usually a natural monopoly. A rough estimate of the fraction of the industry that will remain regulated can be estimated from data for large privately owned electric utilities collected by the Energy Information Administration (1997). This data indicates that in 1996 more than 40% of the utilities' capital stock and 10% of total cost were from transmission and distribution. Rates for small customers are likely to be more affected by continued regulation as transmission and distribution cost are a larger fraction of their cost of service. For example, for one of the authors in California, transmission and distribution cost are approximately half of his monthly residential electric bill.

[3] An excellent summary of the theoretical research can be found in Evans and Garber (1988). The results of empirical tests of the *A-J* hypothesis in the electric utility is mixed: Courville (1974), Peterson (1975), and Hayashi and Trapani (1976) have supported the hypothesis while Moore (1970), Boyes (1976), and Barron and Taggert (1977) have rejected it. One of the best critiques of the *A-J* model can be found in Joskow (1974). Sheshinski (1971) showed that a welfare improvement occurs if the allowed rate of return is reduced from a high level. Crew and Kleindorfer (1981) proved a similar result on peak-load pricing. Yang and Fox (1994a) demonstrate that a property tax can lead to a Pareto improvement. Recent applications of the model include the work by Silverman (1982, 1985), Hsu and Chen (1990), and Yang and Fox (1994b).

improvement in welfare. This is demonstrated by first deriving the comparative static properties of the tax on labor, capital and output. Then the theoretical possibility of the welfare anomaly is derived. This possibility is verified in three numerical examples.

II. The Corporate Profit Tax in the Rate-of-Return Regulated Monopoly Model

In order to determine the necessary conditions for this welfare anomaly, we follow the formulation of the *A-J* model used by Bailey (1973). If a profit tax u is imposed as a fraction of the profit obtained by a profit-maximizing monopolist subject to an after tax rate of return constraint, we obtain the following model:

$$\text{Maximize } \pi=(1-u)(PQ-wL-rcK) \tag{1}$$

$$\begin{aligned}\text{subject to } &(1-u)(PQ-wL)+urcK-scK\leq 0\\ &P\geq 0,\ Q\geq 0,\ L\geq 0, \text{ and } K\geq 0\end{aligned} \tag{2}$$

where P is price per unit of output[4]

L = labor and other noncapital inputs

K = capital stock in physical units (*e.g.*, units of generating equipments, transmission cables and other transportation equipments)

$Q = f(K, L)$[5]

[4] Which is in turn determined by a monotonically decreasing, bounded, and at least twice differentiable inverse demand function or g: $R_+ \rightarrow R_+^2$ with $P'<0$. In addition, the constraint equation (2) can be rewritten as $\pi \leq (s-r)ck$ or the net profit cannot exceed the product of $s-r$ and the value of the capital stock, cK.

[5] As usual, we assume that Q is a well-behaved and a least twice differentiable production function of positive inputs or f: $R_+^2 \rightarrow R_+$, with $Q_L>0$, $Q_K>0$, $Q_{LL}<0$, $Q_{KK}<0$, $Q(k,0)=Q(0,L)=0$, and only the efficient portion of the isoquant is considered. In addition, in order to invoke the use of the chain rule, we focus on the output space where the domain of g intersects the range of f. In other words, we assume that the functional mapping f is from R_+^2 onto R_+ such that each element of the output space is also an image of an element in input space R_+^2.

$R = PQ$ = total revenue[6]

w = wage rate

c = cost per unit of physical capital

r = financial cost of capital or weighted cost of capital

s = allowed rate of return

The resulting Lagrangian equation is

$$\gamma = (1-u)(PQ - wL - rcK) - \beta[(1-u)(PQ - wL) + urcK - scK] \tag{3}$$

The first-order conditions for the interior maximization problem are:

$$\gamma_L = (1-u)(1-\beta)(R_L - w) = 0 \tag{4}$$

$$\gamma_K = (1-u)(1-\beta)R_K - rc + urc + \beta sc - \beta urc = 0 \tag{5}$$

or

$$\beta = \frac{rc - urc + uR_K - R_K}{sc - urc + uR_K - R_K} \neq 1 \text{ [7]} \tag{6}$$

$$\gamma_\beta = scK - urcK - (1-u)(PQ - wL) = 0 \tag{7}$$

Equations (4) and (6) imply $(R_L - w) = 0$ if u is not equal to one.

Differentiating equations (4), (5) and (7), we obtain:

$$\begin{vmatrix} (1-u)(1-\beta)R_{LL} & (1-u)(1-\beta)R_{LK} & (1-u)(w-R_L)=0 \\ (1-u)(1-\beta)R_{KL} & (1-u)(1-\beta)R_{KK} & sc-urc-(1-u)R_K \\ (1-u)(w-R_L)=0 & sc-urc-(1-u)R_K & 0 \end{vmatrix} \begin{vmatrix} dL \\ dK \\ d\beta \end{vmatrix} = \begin{vmatrix} 0 \\ (1-\beta)(R_K - rc)du \\ (rcK + wL - PQ)du \end{vmatrix} \tag{8}$$

[6] Following convention, we assume that the total revenue function is strictly concave and have continuous second-order partial derivatives such that $R_{LK} = R_{KL}$.

[7] This analysis follows along the line of Baumol and Klevorick (1970) and Bailey (1973). Elegant results can also be obtained via the approach by Takayama (1969) and El-Hodori and Takayama (1973).

The second-order sufficient condition requires that the value of the determinant of the first term in equation (8) be positive or

$$|H| = -[(sc - urc) - (1-u)R_K]^2(1-\beta)(1-u)R_{LL} > 0 \tag{9}$$

This will require $\beta < 1$ for $R_{LL} < 0$ and $u \neq 1$. The fact that $0 \leq \beta < 1$ makes $sc - urc + uR_K - R_K > 0$ from equation (6).

Using Cramer's rule from equation (9), we can derive the following comparative statics:

$$\frac{dL}{du} = \frac{(-PQ + wL + rcK)R_{LK}}{-[(sc - urc) - (1-u)R_K]R_{LL}} \neq 0 \tag{10}$$

$$\frac{dK}{du} = \frac{wL + rcK - PQ}{(sc - urc) - (1-u)R_K} < 0 \tag{11}$$

$$\frac{dQ}{du} = Q_L \frac{dL}{du} + Q_K \frac{dK}{du} = \frac{(wL + rcK - PQ)(Q_L R_{LK} - Q_K R_{LL})}{-[sc - urc - (1-u)R_K]R_{LL}} \neq 0 \tag{12}$$

It is evident from equation (10) that if $R_{LK} > 0$, *i.e.*, labor and capital are complements in generating revenue, a higher corporate profit tax will cause the employment of labor to decrease for a profit-making regulated monopolist. Notice that a higher profit tax can actually lead to an increased use of labor if labor and capital are substitutes in generating revenue. An examination of equation (11) indicates immediately that a higher tax rate always leads to a lower employment of capital input as long as the monopolist's profit is positive. Equation (12) implies that if the capital is not an inferior input[8] then a higher tax rate will reduce output. Well-known in the neoclassic production function (Ferguson 1969), if capital is not an inferior input, then $Q_L Q_{LK} - Q_K Q_{LL} > 0$ or $R'(Q_L Q_{LK} - Q_K Q_{LL}) = Q_L R_{LK} - Q_K R_{LL} > 0$, which is the second term in the numerator of equation (12). In brief, under normal circumstances, total output and capital are negatively related to the profit tax rate.

[8] See Bailey (1973) or Ferguson (1969) for further information on inferior inputs.

However, the impact on labor employment cannot be determined without further information on the sign of R_{LK}.[9]

III. The Welfare Anomaly of the Rate-of-Return Regulated Monopoly Model

In this section, we adopt the standard measure of welfare: the sum of consumer surplus, profit and tax revenue. The first component of the welfare measure is the consumer surplus[10] or

$$CS = \int P(Q)\, dQ - \bar{P}\bar{Q} \tag{13}$$

The sum of the profit and tax revenue is

$$(1-u)\pi + u\pi = \bar{P}\bar{Q} - w\bar{L} - rc\bar{K} \tag{14}$$

The welfare measure can be written as

$$wel = \bar{P}\bar{Q} - w\bar{L} - rc\bar{K} + \int P(Q)\, dQ - \bar{P}\bar{Q} \tag{15}$$

Hence, the impact of a change in the corporate profit tax rate u on the welfare is

$$dwel/du = (\bar{P} + \bar{P}'\bar{Q} - \bar{Q}\bar{P}')\, d\bar{Q}/du - w(dL/du) - rc(dK/du) \tag{16}$$

since

$$dCS/du = -\bar{Q}\bar{P}'(d\bar{Q}/du)$$

Substituting equations (10), (11), and (12) into equation (16) and rearranging, yields:

[9] Bailey (1973, p. 126) reported the same results (without showing the proof). However, we shall proceed beyond these results to prove the existence of the welfare anomaly under very general conditions.

[10] In using the consumer surplus as a measure of welfare we make the conventional assumption that the marginal utility of income is constant. This implies that the portion of the consumers' income spent on the regulated good is relatively small.

$$dwel/du = (-\bar{P}\bar{Q} + w\bar{L} + rc\bar{K})[R_{LK}(\bar{P}Q_L - w) + R_{LL}(-\bar{P}Q_K + rc)] \\ / -[sc - ruc - (1-u)R_K]R_{LL} \tag{17}$$

The sign of the denominator must be positive since (1) the term in the bracket is positive due to equation (6) and $0 \leq \beta < 1$ and (2) $R_{LL} < 0$ from the assumption of a strictly concave revenue function. The first term in the numerator is negative if the monopolist makes a positive profit. In the bracket, we have $\bar{P}Q_L - w > 0$ since $\bar{P}Q_L - w > R_L - w = 0$ from equation (4) for price exceeds its marginal revenue. However, the sign of $rc - \bar{P}Q_K$ cannot be determined. That is, from equation (6) and $0 \leq \beta < 1$, it follows that $rc - urc + uR_K - R_K = (rc - R_K)(1-u) > 0$ or $rc - R_K > 0$. But $\bar{P}Q_K > R_K$ and hence the sign of $rc - \bar{P}Q_K$ is ambiguous. The closer the marginal revenue is to its corresponding price, the more likely that $rc - \bar{P}Q_K$ will be positive. Given equation (17), we establish some sufficient conditions for the welfare anomaly to occur.

Proposition 1

Given a well-behaved demand and production functions with a strictly concave revenue curve ($R'' < 0$), a profit tax on the rate-of-return regulated monopolist will lead to an improvement in welfare, *i.e.*, increase in the tax revenue exceeds the reductions in consumer surplus and profit, if the following three situations prevail:

1. The greater the substitutability of labor and capital in generating revenues is, the more likely the welfare anomaly may occur. This in turn means that R_{LK} has a larger negative value, *i.e.*, an additional employment of capital will cause marginal revenue product of labor to decrease.[11]
2. The gap between price and marginal revenue is small for a given output; that is, the price cannot be very low on a given demand curve.
3. The greater the initial monopoly profit (before the tax) is, the more revenue the tax authority can collect to realize this improvement in welfare.

[11] See Bailey (1973) for negative R_{LK}.

TABLE 1

OPTIMUM SOLUTION UNDER THE CORPORATE PROFIT TAX

Tax Rate (%)	L	K	Q	CS	Tax Revenue	π	wel
0	649.0*	1163.3	466.7	108.9	0	58.2	167.1
5	653.5	1147.2	465.2	108.2	3.0	57.4	168.6
10	660.3	1129.6	464.0	107.7	6.3	56.5	170.4
15	667.6	1110.5	462.4	106.9	9.8	55.5	172.2
20	675.9	1089.6	460.5	106.0	13.6	54.5	174.1
25	685.7	1066.7	458.2	104.9	17.8	53.3	176.1
30	697.0	1041.3	455.2	103.6	22.3	52.1	178.0
35	710.1	1013.1	451.5	101.9	27.3	50.7	179.8
40	725.4	981.5	446.5	99.7	32.7	49.1	181.5
45	743.5	945.7	440.1	96.8	38.7	47.3	182.8
50	762.5	904.7	430.9	92.8	45.2	45.2	183.3
55	782.8	856.9	418.2	87.4	52.4	42.8	182.7
60	800.3	800.0	400.0	80.0	60.0	40.0	180.0
65	807.9	730.3	373.8	69.9	67.8	36.5	174.2
70	792.3	641.5	335.5	56.3	74.8	32.1	163.2
75	785.2	623.2	327.1	53.5	80.2	26.7	160.5

Note: Simulation results are based on the GINO package (Liebman *et. al.* 1986) with the following parameters: $c=1$, $r=0.15$, $s=0.2$, $w=0.025$, noncapital share=0.25, capital share=0.75, $P=1-0.001Q$.

The proof is evident from equation (17): the third condition that the greater the initial profit $(-\bar{P}\bar{Q}+w\bar{L}+rc\bar{K}<0)$ is the more likely the improvement in welfare will be, holds if the first term in the bracket of the numerator is negative. The paradoxical result applies to different demand and production functions. It should be pointed out that each of these conditions is neither necessary nor sufficient for an improvement in total welfare. However, combined they represent a set of useful sufficient conditions. Naturally, the question arises as to how relevant these conditions are with respect to the rate-of-return regulated monopoly. First, for a small or moderate tax rate, L and K are substitutes in the sense that a reduction in

K is likely to be compensated via an increase in L. For a large tax rate, however, both L and K will decrease as output decreases sharply as shown in Table 1. Viewed in this perspective, *ceteris paribus*, a prohibitively large income tax rate will not lead to an improvement in total welfare. Second, the difference between price and marginal revenue depends on the price elasticity of demand.[12] The absolute value of the price elasticity of demand for electricity is generally not large even for relatively more elastic industrial customers. Thus, the gap between the price and marginal revenue is not insignificant. This tends to prevent the welfare anomaly from occurring. Third, although some utility companies make positive economic profits, many earn low rates of return due to competitive pressures or poor investments (such as some investments in nuclear power plants). Therefore few utilities enjoy the large economic profits that would promote this welfare anomaly. Note that the occurrence of the welfare anomaly depends on the joint satisfaction of the three conditions which, as the above discussion indicates, would tend to be rare. Care must be exercised that satisfaction of the three conditions requires more information on production technology, demand, and revenue functions regarding substitutability, price elasticity and curvature of total revenue function, which may not be readily available to decision makers.

To facilitate the understanding of the welfare anomaly in the rate-of-return regulated model, we present in Figure 1 the overcapitalization or the *A-J* effect on point *A*. Note that the tear-drop like curve in Figure 1a is the projection of the profit hill onto the *K-L* space (see Zajac (1970)) and its boundary is defined by the rate-of-return constraint. For the isoquant Q_0, the maximum profit under the rate-of-return regulation is represented by point *A* as compared to point *C* without the constraint. The profit level at point *C* exceeds that at point *A*, *i.e.*, $\pi(C) > \pi(A)$. In the case of unregulated monopoly, output remains unchanged at point *C* since a profit tax is neutral even though profit level is expected to decrease. A profit tax rate u would "shrink" the whole profit as shown by the depressed smaller line contour (Figure 1a). The reduction in overcapitalization manifests itself in $(K_0 - K_1)$ as one moves from point *A* to *B*. A slight reduction in output from Q_0 to

[12] Specifically $R' = MR = P - P/E_d$ or $P - MR = P/E_d$ where E_d is the absolute value of the price elasticity of demand.

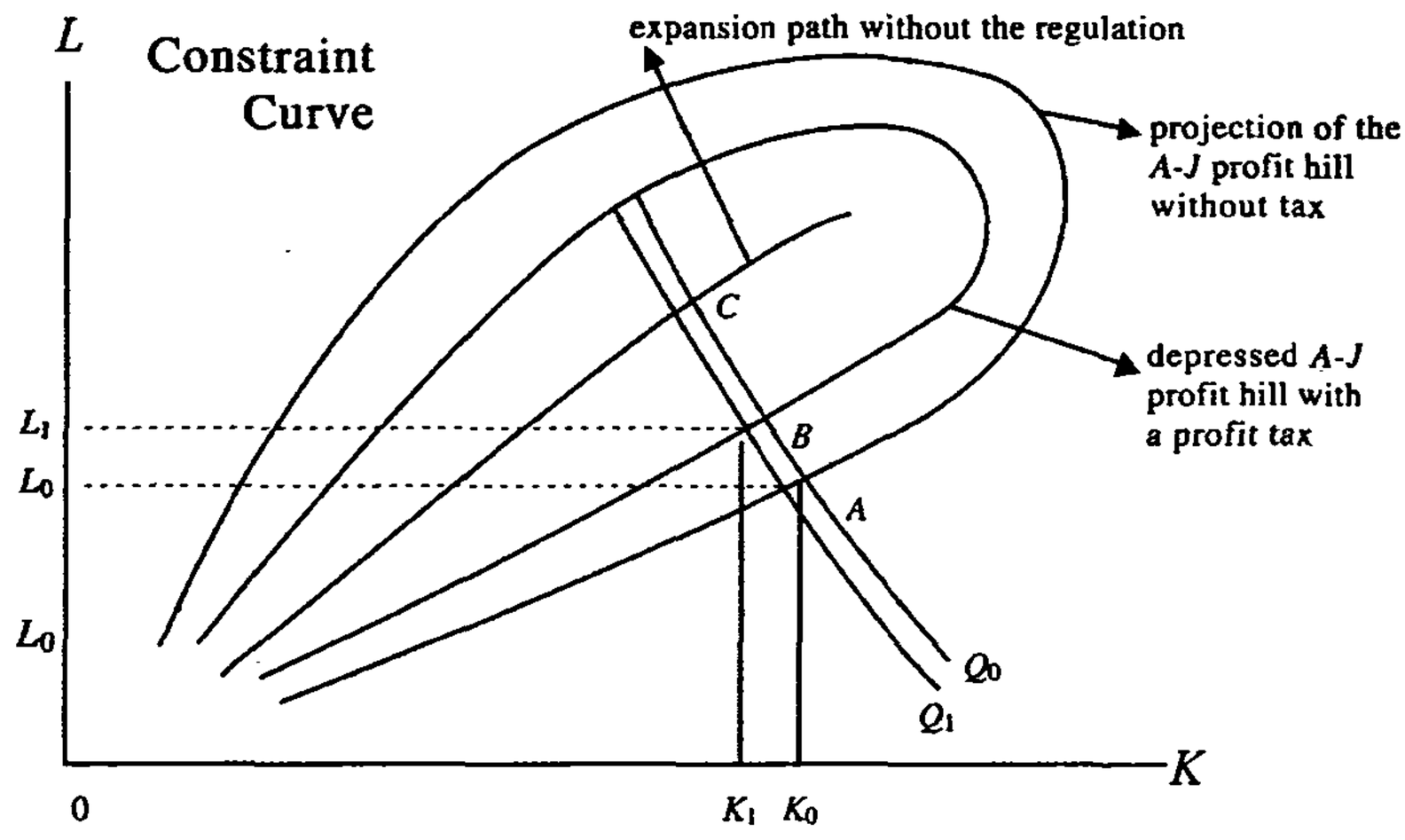

FIGURE 1a

THE *A-J* EFFECT WITH A PROFIT TAX

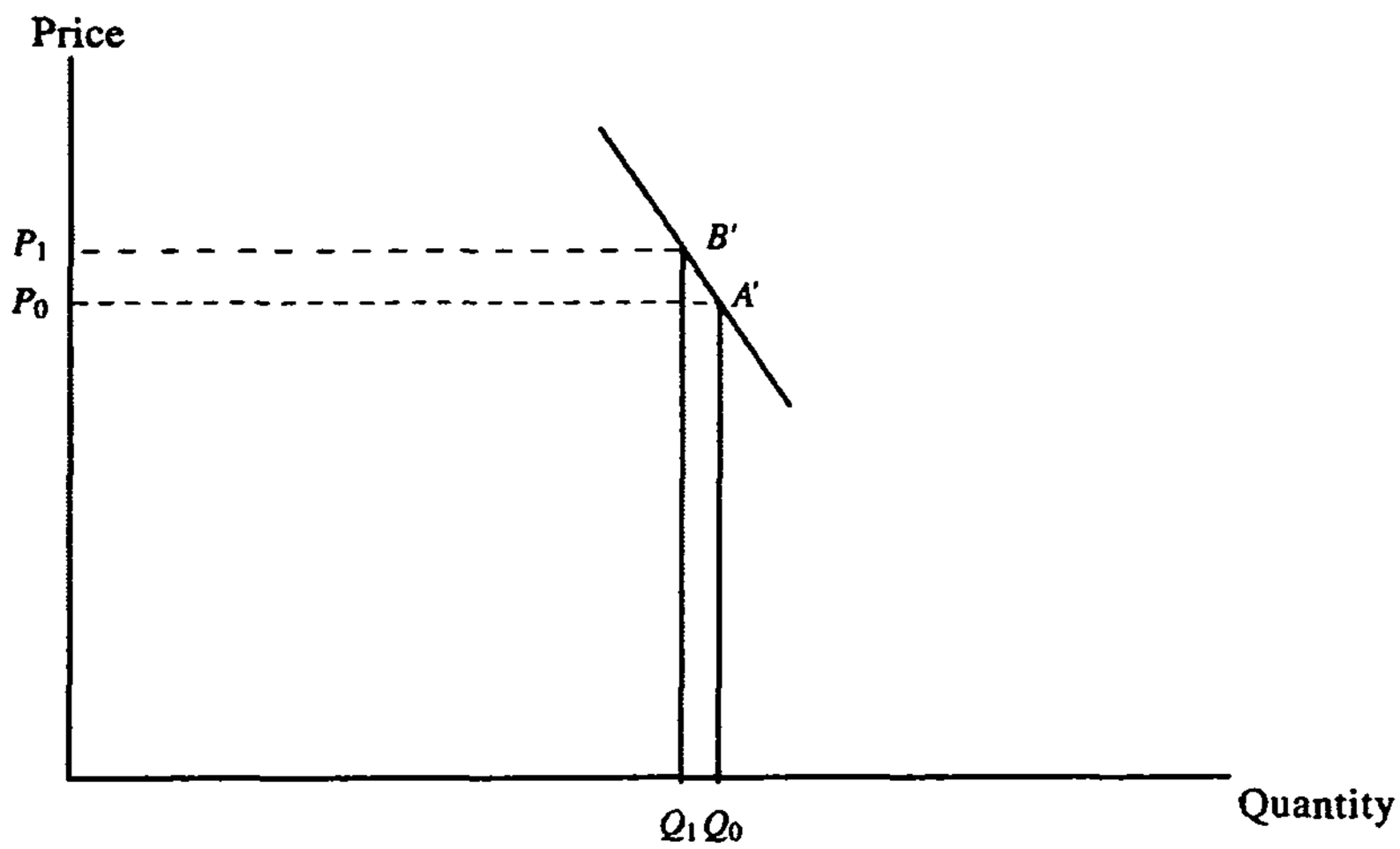

FIGURE 1b

THE IMPACT OF THE PROFIT TAX ON CONSUMER'S SURPLUS

Q_1 due to the profit tax leads to the relatively small reduction in consumer surplus $P_0 P_1 A' B'$ (Figure 1b) while the tax revenue has increased noticeably since the output reduction is not likely to be sizeable. It is to be pointed out that if $dQ/du > O$ (if capital is an inferior input), the welfare anomaly can certainly occur. In order to verify our proposition, we employ:

1. a linear demand function $P = 1 - 0.001Q$
2. a linear homogeneous *CES* function $Q = 0.5[0.25L^{-\rho} + 0.75K^{-\rho}]^{-1/\rho}$, and with $c = 1$, $r = 0.15$, $s = 0.2$, $w = 0.025$, $\rho = 2$.

These parameters are chosen for illustration purposes and as such, they are not necessarily empirically accurate. Note that L measures all noncapital inputs (such as fuel and other material inputs). The simulation results are shown in Table 1. An examination of Table 1 indicates that between corporate profit tax rates of 5% to approximately 59%, one actually obtains a "deadweight gain." To consider the cases in which different parameter values are assumed, we perform two more simulations using the following parameter values: (1) $c = 100$, $r = 0.15$, $s = 0.2$, $w = 2.5$, noncapital share $= 0.25$, capital share $= 0.75$, and $P = 100 - 0.1Q$, and (2) $c = 100$, $r = 0.08$, $s = 0.09$, $w = 2.5$, noncapital share $= 0.67$, capital share $= 0.33$, $P = 100 - 0.1Q$. The simulation results are reported in Tables 2 and 3. As can be seen from the tables, the paradoxical result occurs in both cases. In Table 2, the value of c is no longer normalized at one. Note that the size of w and c are relative, and the inverse demand function is altered to avoid small (negative) price or quantity. Realistically, the value of r and s are rather close and the noncapital share could be relatively large. We take these factors into consideration and again find similar results as shown in Table 3. Note that when allowed rate of return s increases from 0.09 to 0.2, the paradoxical result still holds.

It can now be stated that such an improvement in welfare is achieved without resorting to a nonlinear demand curve. Nor does it require the presence of increasing returns to scale. This occurs even when we employ linear demand functions. A very convex demand curve is known to give unusual results (Greenhut, Hwang, and Ohta 1974).

TABLE 2

OPTIMUM SOLUTION UNDER THE CORPORATE PROFIT TAX

Tax Rate (%)	L	K	Q	CS	Tax Revenue	π	wel
0	648.3	1163.3	466.4	10878.5	0	5816.7	16695.1
5	653.9	1147.2	465.3	10825.8	301.9	5735.8	16863.5
10	660.2	1129.6	464.0	10764.0	627.6	5648.0	17039.6
15	667.5	1110.5	462.4	10690.5	979.9	5552.5	17222.9
20	675.9	1089.6	460.5	10602.0	1362.0	5448.0	17412.0
25	685.5	1066.7	458.1	10493.8	1777.8	5333.3	17604.8
30	696.7	1041.3	455.2	10359.0	2231.3	5206.5	17796.8
35	709.8	1013.1	451.4	10188.0	2727.5	5065.4	17981.0
40	725.0	981.5	446.5	9966.8	3271.6	4907.3	18145.6
45	742.5	945.7	439.9	9674.4	3868.7	4728.4	18271.4
50	762.1	904.7	430.8	9280.5	4523.3	4523.3	18327.1
55	782.3	856.9	418.1	8741.6	5236.4	4284.4	18262.4
60	800.0	800.0	400.0	8000.0	6000.0	4000.0	18000.0
65	807.9	730.3	373.8	6986.2	6781.4	3651.5	17419.2
70	792.1	641.5	335.5	5628.0	7484.0	3207.4	16319.4
75	785.2	623.2	327.1	5349.7	8024.6	2674.9	16049.2

Note: Simulation results are based on the following parameter values: $c=100$, $r=0.15$, $s=0.2$, $w=2.5$, noncapital share$=0.25$, capital share$=0.75$, $P=100-0.1Q$.

This paradoxical result may now be easily explained. The rate-of-return regulated monopolist tends to operate inefficiently by overcapitalizing. Thus a profit tax which reduces capital use does not cause a substantial reduction in output. This is especially true if labor and capital are good substitutes in the production function and generating revenue. This means that the reduction of capital employment is, to some extent, balanced out by increased labor input (see Table 1). The small decrease in output due to the higher profit tax implies a relatively small decrease in consumer surplus despite a sizable increase in tax revenue. This implies that demand is relatively inelastic as is the case in utility industry. Thus an

TABLE 3

OPTIMUM SOLUTION UNDER THE CORPORATE PROFIT TAX

Tax Rate (%)	L	K	Q	CS	Tax Revenue	π	wel
0	801.4	2549.8	478.03	11425.4	0	2549.8	13975.2
10	801.8	2518.6	478.00	11423.5	279.8	2518.6	14222.0
20	802.3	2480.6	477.94	11421.1	620.1	2480.6	14521.9
30	803.0	2433.4	477.87	11417.9	1042.9	2433.4	14894.2
40	804.0	2373.2	477.78	11413.6	1582.1	2373.2	15368.9
50	805.3	2293.7	477.65	11407.6	2293.7	2293.7	15995.0
60	807.5	2183.8	477.43	11397.1	3275.8	2183.8	16856.7
70	811.3	2022.3	477.06	11379.1	4718.6	2022.3	18120.0
80	820.1	1761.0	476.18	11337.5	7044.6	1761.0	20142.5
90	855.7	1265.8	472.25	11151.2	11391.9	1265.8	23808.8
95	978.6	797.6	452.98	10259.3	15154.1	797.6	26211.1

Note: Simulation results are based on the following parameter values: $c=100$, $r=0.08$, $s=0.09$, $w=2.5$, noncapital share$=0.67$, capital share$=0.33$, $P=100-0.1Q$.

improvement in welfare is quite possible especially at low profit tax rates.

IV. Concluding Remarks

The neutrality of the corporate profit tax has been long established in the unregulated monopoly and perfectly competitive markets. Given that unregulated monopoly markets are rare, and that rate-of-return regulated firms will continue to account for an important portion certain markets, an analysis of these markets is warranted. This paper has shown that under some conditions, an income or profits tax can yield an improvement in total welfare. We show for the first time that a profit tax on a regulated monopolist can alter both optimal price and quantity in the Averch-Johnson model. Despite the recent partial deregulation on the utility industry in California, the Averch-Johnson model remains the mainstay in the U.S. today. The neutrality of the profit tax on an unregulated monopolist recognized by Cournot in 1838 is still one

of the popular topics in microeconomics textbooks. We have shown in this paper, however, that such a tax can lessen the over-capitalization effect embedded in the Averch-Johnson model. Consequently, an improvement in welfare is likely when we take the profit of the monopolist, consumer welfare and tax revenue into consideration. It can occur with a linear demand function and homogeneous production functions. That is, it is neither a mathematical quirk nor a statistical fluke; it can occur in various conditions. However, one must be on guard that determination of the profit tax is more of a political matter, which is taken independent of social welfare consideration.

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