

EFFECTS OF PRICE REGULATION
BASED ON VARIABLE COST

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1. Introduction

The Staggers Rail Act of 1980 has created extensive ratemaking freedom for the railroads. It is estimated that two thirds of rail traffic will be priced within the "zone of reasonable rates" that constitutes the major form of rail rate deregulation.¹ Criticism has arisen that this permits the railroads to engage in price discrimination to the full extent, that the zone is so large it is not an assurance of only "reasonable" discrimination.² But some of the rates at the upper end of the zone may be affected if the railroads use the zone to avoid more stringent regulation of rates that lie above the zone. It is a form of regulation that involves the average variable cost of the service as the basis for price control. As other forms of regulation have led to distortions of firms' behavior, so may this form, especially since the basis of the limit on pricing behavior, average variable cost, is essentially within the firms' control.

This paper will attempt to determine the nature of factor use distortions, if any, created by the regulation of railroads under the Staggers Act. Conditions for the regulation to be effective and the ability of regulated firms to affect those conditions will be considered.

2. The Zone of Reasonable Rates as a Regulation

The regulation of railroad rates has always involved a variety of simultaneous controls. Certain practices, such as personal or long-and-short-haul discrimination have either been prohibited or permitted only in specified circumstances. All individual rates have been required to be "reasonable", permitting at least limited price discrimination, as determined by the Interstate Commerce Commission on a case by case basis. ³ Minimum, maximum and actual individual rates have been set by the I.C.C. Rate levels were for a time controlled by rate of return regulation, but since the Emergency Transportation Act of 1933, rate of return regulation has not been required and is one of several forms of control that may, or may not, be applied. ⁴ Credit standards have often been considered as well and were made a more formal part of rate level regulation by the Railroads Revitalization and Regulatory Reform (4R) Act of 1976. ⁵ These types of regulation remain in effect although their jurisdiction was limited by the Staggers Act which added the zone of reasonable rates form of regulation.

Section 201 of the Staggers Act identifies the variable cost, as calculated by a formula to be determined by the I.C.C., as the minimum rate in all cases. The purpose in specifying a minimum here is not to prevent lower rates but to permit rates below the fully distributed cost. Section 202 stipulates that if the carrier does not have market dominance, as determined by the I.C.C., the maximum rate for the unregulated zone of reasonable rates is a certain percent, between 170 and 180 percent, of the average

variable cost. The revenue - variable cost ratio, which will be developed by the I.C.C. to define the upper limit of the zone, is called the "cost recovery percentage". It is intended to provide an adequate rate of return on investment, which the I.C.C. will specify, and earnings that will support the carriers' credit ratings and enable them to generate additional capital. Rates above the zone are permitted but will be subject to full I.C.C. review on a case by case basis.

Rail rates have long shown a wide range of revenue to variable cost ratios, depending on the commodity and the market. Table 1 provides some examples. Some commodities have been consistently priced between average variable cost and fully distributed cost, others have been priced above fully distributed cost. The extent of price discrimination, which is reflected in the ratios, is due to differences in price elasticities of demand. The zone of reasonable rate regulation, by specifying a single cost recovery percentage to determine the maximum rate, will differentially affect rail markets, according to the extent of price discrimination. Rates in markets with highly price elastic demand have received low revenue - variable cost ratios and may be unaffected by the zone. In markets with less elastic demands, ratios are higher and may exceed the rates covered by the zone.

Table 1

Ratios of Revenue to Variable Cost

Commodity or Market	Ratio
Commodity Groups for 1961 ⁸	
Products of Agriculture	118
Animals and Products	111
Products of Mines	106
Products of Forests	117
Manufactures and Miscellaneous	148
Forwarder	111
Coal for 1975 ⁹	
from Illinois, Indiana and Western Kentucky to the Central Freight Association Territory, 33 miles	271
from Western Districts to the Western Trunk Line Territory, 148 miles	108
from Illinois, Indiana and Western Kentucky to the Western Trunk Line Territory, 759 miles	153
from Northern Appalachian to New England Territory, 932 miles	81
Estimated average for all Rail traffic, 1980 ¹⁰	130

3. A Model of Firms' Behavior Under Cost-Based Price Regulation

The zone of reasonable rates will be examined as the form of price control. While other forms of regulation, mentioned in section 2 above, apply elsewhere, they will not be considered. The requirement that revenue at least be equal to variable cost is not an additional constraint to the firm since the short run supply function is defined only for prices greater than or equal to the minimum average variable cost.¹¹

A firm wishing to avoid other regulation, to keep rates within the zone for ratemaking freedom, would be subject to the zone ceiling for individual rates. Denoting the cost recovery percentage as α , the constraint is:

$$(1) \quad \frac{\text{Revenue}}{\text{Variable Cost}} < \alpha \quad \text{and for railroads under the Staggers Act, } 1.70 \leq \alpha \leq 1.80$$

Let

- $p = g(q)$ = the inverse demand function
- $q = f(K, L)$ = quantity of the service
- K = quantity of capital, the fixed factor
- L = quantity of labor, the variable factor
- $R(K, L) = pq$ = revenue
- r = unit cost of capital
- w = unit cost of labor
- π = firm's total profit = $R(K, L) - rK - wL$

The constraint may then be rewritten as:

$$\alpha wL - R(K, L) \geq 0$$

The firm attempts to maximize total profit subject to the price constraint.

The Lagrange function is:

$$(3) \quad Z(K, L, \lambda) = R(K, L) - rK - wL + \lambda[\alpha wL - R(K, L)]$$

The Kuhn-Tucker conditions for a maximum are:

$$(4) \quad \begin{aligned} (a) \quad (\partial Z / \partial K) &= R_K - r - \lambda R_K \leq 0 \\ (b) \quad (\partial Z / \partial L) &= R_L - w + \lambda \alpha w - \lambda R_L \leq 0 \\ (c) \quad (\partial Z / \partial \lambda) &= \alpha wL - R(K, L) \geq 0 \\ (d) \quad (\partial Z / \partial K)K &= 0 \\ (e) \quad (\partial Z / \partial L)L &= 0 \\ (f) \quad (\partial Z / \partial \lambda)\lambda &= 0 \\ (g) \quad K, L, \lambda &\geq 0 \end{aligned}$$

On the assumption that K and L are greater than zero, by conditions (4d) and (4e), conditions (4a) and (4b) become equalities. The Lagrange multiplier, λ , is assumed to be greater than zero so that the constraint is effective, and then by (4f), condition (4c) becomes an equality. Then:

$$\begin{aligned} (5a) \quad (1 - \lambda)R_K - r &= 0 & \text{or: } R_K &= r / (1 - \lambda) \\ (5b) \quad (1 - \lambda)R_L + w(\lambda\alpha - 1) &= 0 & R_L &= w(1 - \lambda\alpha) / (1 - \lambda) \end{aligned}$$

The ratio of marginal revenue products, or equivalently, marginal physical products is:

$$(6) \quad \frac{R_K}{R_L} = \frac{f_K}{f_L} = \frac{r / (1 - \lambda)}{w(1 - \lambda\alpha) / (1 - \lambda)} = \frac{r}{w} \left[\frac{1}{1 - \lambda\alpha} \right] > \frac{r}{w}$$

The cost recovery percentage, α , must be greater than unity, and the Lagrange multiplier, λ , must be greater than zero for the constraint to be effective. The product, $\lambda\alpha$, must meet the following condition:

$$0 < \lambda\alpha < 1$$

or the expression would be negative, while the ratio of marginal physical products is positive. Thus the expression in brackets in (6) is greater than unity, implying a distortion of factor use toward labor, or variable factors.

The firm may charge a rate which is a limited markup on variable cost, and the yield of that markup as a return on capital is not limited by regulation. The firm is led to shift resources from fixed to variable factors, which enables it to increase its profit and rate of return on investment. It is clear that the railroads have engaged in technological progress that has been labor saving,¹² and the effect of this price constraint would counter that trend. Firms would have incentive to structure lease arrangements so that the costs would be treated as expenses rather than long term obligations. There is incentive to purchase from other firms rather than produce themselves for service such as maintenance of way and equipment and for car building. The trend toward private car ownership¹³ should be accelerated.

The constraint causes distortion as it affects variable costs differently, and certain factors give rise to variable costs. If a long run viewpoint is considered, when all costs are variable, then conditions (4a) and (4b) become:

$$(7a) \quad (\partial Z / \partial K) = R_K - r + \lambda \alpha r - \lambda R_K \leq 0$$

$$(7b) \quad (\partial Z / \partial L) = R_L - w + \lambda \alpha w - \lambda R_L \leq 0$$

Labor and capital are affected symmetrically and the factor use distortion disappears. The Staggers Act defined variable cost, without listing particular costs that may be included, as expenses of the specific service which vary directly with the level of service provided. This would seem to permit only a short run view.

A second case in which the constraint is ineffective is if the upper limit of the zone equals or exceeds the firm's average total cost, or fully distributed cost;

$$\alpha AVC = \beta ATC \quad \beta \geq 1$$

$$\alpha AVC = ATC + \gamma \quad \gamma \geq 0$$

For the firm in a single, competitive market, the first order conditions again indicate no distortion.

With the constraint in effect, the firm is led to bias its factor use, but this would not lead to use of unproductive labor or capital.

Let:

$$K^* = \text{unproductive capital}$$

$$L^* = \text{unproductive labor}$$

that is, the firm incurs a cost for the use of the factors, and they are included in the constraint, but they do not enter the production function. The new first order condition replacing (4d) for K^* is:

$$(8) \quad (\partial Z / \partial K^*) K^* = -r K^* = 0$$

and unproductive capital will be used only if capital has zero cost.

The new first order condition replacing (4c) for L^* is:

$$(9) \quad (\partial Z / \partial L^*) L^* = w(\lambda \alpha - 1) L^* = 0$$

and unproductive labor will only be used if it has a zero cost or if the expression in parentheses is zero. From (6), that would occur only if the rate of technical substitution between capital and labor, the ratio of marginal physical products, were infinite; production with fixed proportions.

It is also possible to determine the effect of the constraint on levels of factor use. Treating the first order conditions 4) as a system of equations, the total derivative of the constraint, combining 4c) and (4f) so that it is an equality, with respect to α gives:

$$(10) \quad wL - R_K(\partial K / \partial \alpha) + (\alpha w - R_L)(\partial L / \partial \alpha) = 0$$

With (4d) and (4g), condition (4a) becomes an equality, and its total derivative with respect to α , rearranged is:

$$(11) \quad (\partial K / \partial \alpha) = -(R_{KL} / R_{KK})(\partial L / \partial \alpha)$$

Substituting this into (10) and rearranging yields an expression for the effect of the cost recovery factor on labor use:

$$(12) \quad \frac{\partial L}{\partial \alpha} = \frac{-wL}{R_K(R_{KL} / R_{KK}) + (\alpha w - R_L)} < 0$$

The sign of the derivative can only be determined under several assumptions. If second order conditions for the revenue function are met, then R_{KK} is negative and R_K is positive. If capital and labor are assumed to be substitutes, then R_{KL} is negative. If the firm operates in competitive factor markets, then $w = R_L$ and $(\alpha w - R_L)$ is positive. This may also be satisfied in imperfectly competitive factor markets if the difference between the factor cost and the

marginal factor expense does not exceed what is permitted by α to keep the expression positive. Under these assumptions, the imposition and tightening of the constraint will give the firm incentive to increase its use of variable factors. Doing so will raise average variable cost, the lower and upper limits of the zone of reasonable rates, although the range of the zone will be narrower. The firm will then be able to maximize profit by charging a price within the zone.

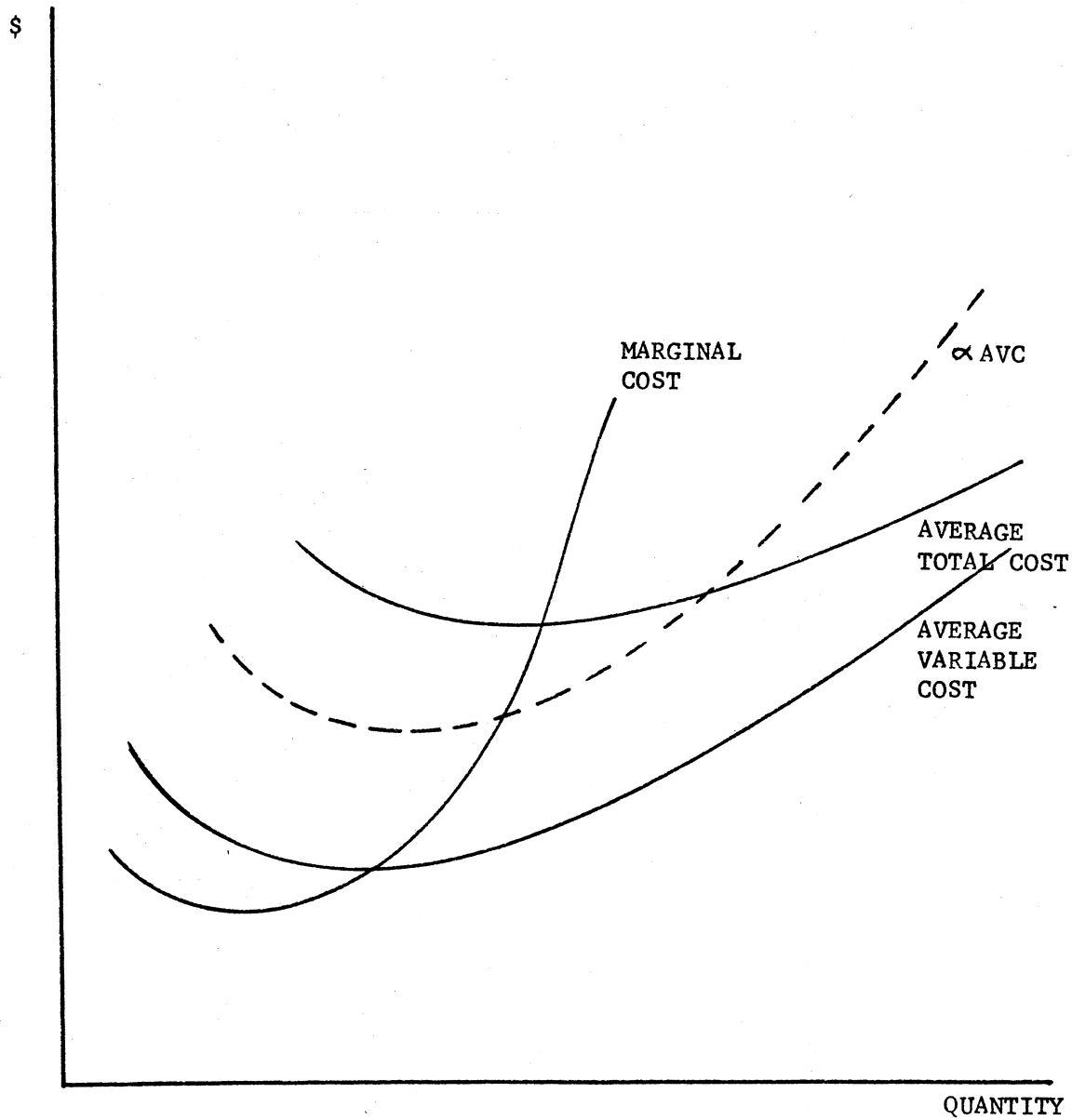
By similar analysis, the effect on capital is:

$$(13) \quad \frac{\partial K}{\partial \alpha} = \frac{wL}{R_K + (\alpha w - R_L)(R_{KK}/R_{KL})} > 0$$

The firm achieves the factor distortion of (6) by increasing use of labor or variable factors and decreasing use of capital or fixed factors.

With factor use changing in opposite directions for capital and labor, it remains to be determined the net effect on the firm's level of output. Baumol and Klevorick have considered this question for the Averch-Johnson effect and determined the direction of the constraint on output by its effect on factor use.¹⁴ With the same reasoning and using equation (11), the sign of $(\partial q/\partial \alpha)$ must be the same as the sign of $(\partial L/\partial \alpha)$, which is negative. In Figure 1, the constraint imposed on the price is represented by the dashed line. Rather than accept the constraint as it is, however, and reduce output until $p = \alpha AVC =$ marginal cost, the firm has incentive to expand output. It does so by increasing use of variable factors

FIGURE 1
COMPETITIVE PRODUCT AND FACTOR MARKETS



and raising the average variable cost. Alternatively, the distortion implied by equation (6) forces the firm off its expansion path, and a given level of output will not be produced at the lowest cost.

4. Conclusions

The form of regulation introduced by the Staggers Rail Act of 1980 is an upper limit on price, determined as a multiple of variable cost. When the constraint is effective, a distortion is created that is similar to the Averch-Johnson effect. Firms subject to a variable cost-based regulation on price will alter factor proportions toward variable factors. Total profit will be maximized by shifting resources to variable costs, permitting profit to be earned as a markup over variable cost, and by increasing output. Average variable cost will be increased by the factor use distortion and by the firm increasing use of labor and other sources of variable cost.

Ultimately, the constraint will not be effective. The firm is able, in several ways, to alter the basis of the constraint, average variable cost. By increasing its output and level of variable cost, the upper limit on the price can be made to equal or exceed the firm's profit maximizing price.

FOOTNOTES

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Privately owned rail freight cars as a percentage of total
rail freight cars in service:

1976	19.5%
1977	20.3
1978	21.6
1979	23.0
1980	25.8

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