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ASSESSING THE IMPACT OF REGULATION OF TRUCKING FIRMS

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Introduction

It has been demonstrated that the imposition of a regulatory constraint may cause a systematic allocative inefficiency by altering a firm's optimizing conditions. (Averch and Johnson (1962)). Subsequent studies (Petersen 1975; Giordano, 1983) retain the original focus on public utilities. Moore (1978) and Cherry (1977) extended the Averch-Johnson model to regulated trucking firms, replacing the fair-rate-of-return constraint with an operating ratio constraint. However, their models are inadequate for the task of examining the impact of regulation on trucking. (Acker, 1983). The model presented in this paper uses firm data rather than aggregated data, and provides an alternative perspective which facilitates more complete assessment of the impact of regulation on this industry.

2. Modelling Firm Behavior Under Regulation

The impact of regulation is examined by extending the approach developed by Petersen (1975). The firm seeks to minimize cost, subject to production technology and regulatory constraints. (See Appendix A for the derivation of the model.)

Using the model's first order conditions it can be seen that

$$Q_L/Q_K = (1 - \lambda)w/r$$

which indicates inequality between the ratio of the marginal products and the ratio of the factor prices. In particular, given that $0 < \lambda > 1$, the firm will hire labor beyond the point at which its marginal product equals its price, and so "over-uses" labor.

The effect of changing regulation on the cost which the firm incurs to produce the given output can be determined by differentiating the Lagrangian function with respect to the operationg ratio. Since λ must be non-negative (Baumol, 1977)

$$\partial C/\partial t = \lambda\overline{PQ} \text{ and hence } \partial C/\partial t > 0$$

Thus, costs increase as regulation "tightens" (i.e., as the operating ratio, t, increases and expenses take up a greater proportion of revenues).

This simple relationship is not sufficient, in and of itself, to confirm an "Averch-Johnson" effect; to indicate an overuse of a factor, it must be demonstrated that the

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share of cost going to that factor also increases in response to the same regulatory change. Again, the first order conditions of the model can demonstrate that the share of cost which goes to labor increases as regulation tightens, an implication analogous to that of the original Averch-Johnson model.

The Statistical Model

The transcendental logarithmic functional form has been widely used in cost and production studies since its first systematic interpretation as a flexible functional form. (Christensen, Jorgenson, and Lau, 1973). It was chosen for use in this study because of the desirable properties which stem from its flexibility; in particular, the form imposes few a priori restrictions on parameters and does not restrict the elasticities of substitution between factors. It is thus seen as having analytical advantages over the Cobb-Douglas form used in previous work.

The form is amenable to estimation using more than one output variable, as well as more than two inputs, and so permits a less simplistic consideration of output. Output is generalized to capture different dimensions of output composition, tons and miles (Q_1 and Q_2 respectively). The complete specification of the translog cost function and the associated share equations are found in Appendix B. While output composition has been considered in more detail in other studies of the cost function for trucking, no other work has been done attempting to examine the impact of regulation in the context of a generalized output.

The statistical analysis is carried out using Ordinary Least Squares estimation and a sample of 265 Class I and Class II common carriers of general freight in 1977. The data used were taken from summaries of individual carrier reports to the Interstate Commerce Commission prepared and published by the American Trucking Associations, Inc.[1]

The dependent variable in the translog cost function is the logarithm of cost (measured in thousands of dollars), where cost is defined to be total operating expenses, minus revenue equipment rents and purchased transportation, plus an opportunity cost of capital (the product of the rate of return on transportation investment and carrier operating property). Output is (as indicated above) generalized to tons and miles, each measured in thousands of the respective units. The wage rate is derived from total salaries, wages, and miscellaneous paid time off, and total fringes, the sum of which is divided by the average number of employees. The cost of capital is the depreciation of revenue equipment plus expenditures on oil, lubricants, coolants, vehicle parts, vehicle maintenance, tires, and tubes (all such expenditures being seen as necessary for maintenance of capital), plus the opportunity cost of capital (calculated as above), the entire sum then divided by carrier operating property. All component variables are measured in thousands of dollars.

The price of fuel is the 1977 price of diesel fuel in the state in which the firm is

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1. The data are published by the American Trucking Associations, Inc., in Financial and Operating Statistics (Washington, D.C.: American Trucking Associations, Inc., annually). This data source has the advantage that the carrier summaries are audited, and discrepancies noted. Hence some data errors can be more easily avoided.

domiciled. Monthly state prices were obtained from the Household Goods Carriers' Bureau and a simple average over twelve months was taken. Prices of gasoline were not included on the grounds that the majority of fuel purchased by most carriers is diesel fuel.

Factor shares are calculated as the firm's total expenditures on the factor divided by cost, where the components are measured as above. All expenditures are measured in thousands of dollars, and the calculated shares are expressed as a percentage of cost.

It should be noted that firm expenditures on rentals of capital and purchased transportation are eliminated from the firm's cost estimates and as a variable in the study. This is largely the result of data limitations; however, purchased transportation is eliminated on the additional ground that it does not reflect actual firm operation.[2]

Testing for Allocative Inefficiency

Duality theory implies that if costs are minimized and the firm is a price taker in purchasing resources, then total cost is a function only of outputs and resource prices. If the regulatory variable is included among the regressors in the cost function its coefficient should be insignificant; otherwise costs are not minimized.

If the coefficient is significant then it can be concluded that regulation is effective in the sense that it induces firms to alter their behavior with regard to resource usage. The first test for allocative inefficiency is testing the significance of the regulatory variable. In the complex translog cost function, the regulatory variable appears several times; here, the significance of any appearance is sufficient to refute the hypothesis of cost minimization.

Additional testing then examines whether the departure from cost minimization takes place in the manner predicted by the model. This involves determining whether the sign predictions of the comparative statics analysis actually obtain. If firms behave in the manner indicated by the model we would expect the derivative of the translog cost function with respect to the operating ratio to be positive, and the operating ratio coefficient in the wage share and fuel share equations to be both positive and significant.[3] The coefficient of the operating ratio in the capital share equation should be significant with a negative sign.

Estimation Results

The results of estimating the translog cost function are presented in Table 1, in which Q1 is tons, Q2 is miles, w is the wage rate, r is the cost of capital, f is the price of fuel, and t is the operating ratio.

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2. Purchased transportation reflects the firm's hiring of another firm to complete a shipment when the limits of the original firm's operating rights are reached.

3. The signs will be the same for both labor and fuel because both constitute operating expenses. The shadow prices of both factors will be altered in the same manner by regulation.

Table 1

Variable	Coefficient	t Statistic
constant	-270.32	-0.88
Q1	18.39	2.67*
Q2	-12.41	-2.18*
w	45.31	2.94*
r	5.95	1.04
f	19.83	0.27
t	75.54	0.95
$(Q1)^2$	0.064	0.75
$(Q2)^2$	0.079	1.36
$(w)^2$	-0.18	-2.18*
$(r)^2$	-0.036	-1.38
$(f)^2$	8.21	1.41
$(t)^2$	-0.49	-0.10
IQ1Q2	-0.14	-0.96
IQ1w	0.54	1.89#
IQ1r	-0.019	-0.19
IQ1f	-0.45	-0.35
IQ1t	-3.83	-2.72*
IQ2w	0.42	-1.80#
IQ2r	0.019	0.23
IQ2f	0.48	0.51
IQ2t	.2.58	2.18*
Iwr	-0.36	-1.69#
Iwf	-7.29	-2.79*
Iwt	-2.997	-1.17
Irf	-2.86	-2.21*
Irt	.1.44	1.93#
Ift	-15.17	-1.00

F statistic 130.780   * α at = .05

R^2 0.9371   # α at = .1

The significance of the interaction terms overall is taken as evidence of the need for a flexible form such as the translog for cost estimation in this industry.

The significance of the interaction terms involving the operating ratio invalidates the neoclassical hypothesis of cost minimization, and is the preliminary indicator of regulation-induced allocative inefficiency.

The relationship between cost and the regulatory variable must be examined next. This relationship is expressed as:

$$d(\ln C)/d(\ln t) = \alpha_6 + 2\beta_6 \ln t + \delta_5 \ln Q_1 + \delta_9 \ln Q_2 + \delta_{12} \ln w + \delta_{14} \ln r + \delta_{16} \ln f$$

Summary and Conclusion

This paper has undertaken to extend and clarify previous investigations into regulation-induced allocative inefficiency in the trucking industry. Support is found for

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the hypothesis of an "Averech-Johnson" type distortion in factor usage. The results also support previous work on the industry with regard to the importance of output dimensions for cost, and illustrate the desirability of estimations employing a flexible functional form.

APPENDIX A

The firm seeks to minimize:

$$C = wL + rK \qquad \text{(A.1)}$$

where C is cost, w is the wage rate, L is the quantity of labor, r is the price of capital, and K is the quantity of capital, subject to the regulatory constraint:

$$t\overline{PQ} - wL \leq 0 \qquad \text{(A.2)}$$

where t is the operating ratio, and subject to the production technology constraint:

$$Q\ (K,L) \leq \bar{Q} \qquad \text{(A.3)}$$

where $\overline{PQ}$ is exogenously determined revenue.

Forming the Lagrangian, we have:

$$\phi = -wL - rK + v\left[-\bar{Q} + Q(K,L)\right] + \lambda\ -t\overline{PQ} + wL \qquad \text{(A.4)}$$

which yields the following necessary conditions:

$$\partial\phi/\partial L = -w + vQ_L + \lambda w = 0 \qquad \text{(A.5)}$$

$$\partial\phi/\partial K = -r + vQ_K = 0 \qquad \text{(A.6)}$$

$$\partial\phi/\partial v = -\bar{Q} + Q(K,L) = 0 \qquad \text{(A.7)}$$

$$\partial\phi/\partial\lambda = -t\overline{PQ} + wL = 0 \qquad \text{(A.8)}$$

Both constraints are considered to be binding, so $v > 0$ and $\lambda > 0$. An upper boundary on can be derived by rewriting (A.5) as:

$$(1 - \lambda) = vQ_L/w$$

Since both Q_L and w are positive, must be less than 1 or else v would be equal to zero, contradicting the assumption that the production technology constraint is binding.

With regard to the share of cost going to labor, we consider:

$$d(wL/C)/dt = wL/C\left[(dL/dt)/L - (dC/dt)/C\right] \qquad \text{(A. 9)}$$

Differentiating (A.1) and substituting into (A.6) we have:

$$d(wL/C)/dt = (wL/C)\left[\frac{(C - wL)}{CL}(dL/dt) - \frac{r(dK/dt)}{C}\right] \qquad \text{(A. 10)}$$

Since $C - wL > 0$, if it can be shown that $(dL/dt) > 0$ and that $r(dK/dt) < 0$, then it is also true that

The sign predictions of the comparative statics of the model are obtained by totally differentiating the first order conditions with regard to L, K, λ, v, and t, and solving the resulting system of equations by Cramer's Rule. It is found that:

$$dL/dt = \overline{PQ}/w \tag{A.11}$$

hence, $(dL/dt) > 0$ (as regulation tightens the firms uses more labor), and that

$$(dK/dt) = -\overline{PQ}Q_L/wQ_K \tag{A.12}$$

Since both Q_K and Q_L are positive (the production function is quasi-concave), it can be asserted that

$dC/dt > 0$ and that $d(wL/C)/dt > 0$.

Hence costs increase as regulation tightens, as does the share of cost which goes to labor.

APPENDIX B

The specification of the translog cost funtion is as follows:

$$\begin{aligned}\ln C = {} & \alpha_0 + \alpha_1 \ln Q_1 + \alpha_2 \ln Q_2 + \alpha_3 \ln w + \alpha_4 \ln r + \alpha_5 \ln f \\ & + \alpha_6 \ln t + \beta_1(\ln Q_1)^2 + \beta_2(\ln Q_2)^2 + \beta_3(\ln w)^2 \\ & + \beta_4(\ln r)^2 + \beta_5(\ln f)^2 + \beta_6(\ln t)^2 + \delta_1(\ln Q_1)(\ln Q_2) \\ & + \delta_2(\ln Q_1)(\ln w) + \delta_3(\ln Q_1)(\ln r) + \delta_4(\ln Q_1)(\ln f) \\ & + \delta_5(\ln Q_1)(\ln t) + \delta_6(\ln Q_2)(\ln w) + \delta_7(\ln Q_2)(\ln r) \\ & + \delta_8(\ln Q_2)(\ln f) + \delta_9(\ln Q_2)(\ln t) + \delta_{10}(\ln w)(\ln r) \\ & + \delta_{11}(\ln w)(\ln f) + \delta_{12}(\ln w)(\ln t) + \delta_{13}(\ln r)(\ln f) \\ & + \delta_{14}(\ln r)(\ln t) + \delta_{15}(\ln f)(\ln t) \end{aligned} \tag{B.1}$$

The associated factor share equations are:

$$\begin{aligned} d(\ln C)/d(\ln w) = wL/C = {} & \alpha_3 + 2\beta_3 \ln w + \delta_2 \ln Q_1 + \delta_6 \ln Q_2 \\ & + \delta_{10} \ln r + \delta_{11} \ln f + \delta_{12} \ln t \end{aligned} \tag{B.2}$$

$$\begin{aligned} d(\ln C)/d(\ln r) = rK/C = {} & \alpha_4 + 2\beta_4 \ln r + \delta_3 \ln Q_1 + \delta_7 \ln Q_2 \\ & + \delta_{10} \ln w + \delta_{13} \ln f + \delta_{14} \ln t \end{aligned} \tag{B.3}$$

$$\begin{aligned} d(\ln C)/d(\ln f) = fF/C = {} & \alpha_5 + 2\beta_5 \ln f + \delta_4 \ln Q_1 + \delta_8 \ln Q_2 \\ & + \delta_{11} \ln w + \delta_{13} \ln r + \delta_{15} \ln t \end{aligned} \tag{B.4}$$