Regulatory Induced Distortions
in Telecommunications

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Comments Welcome

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Abstract

The effects of regulation on firms has been a fruitful area of research since Averch and Johnson first examined the problem in 1962. Most researchers, however, studied the effects upon a generic firm or perhaps an electric utility since data are readily available. The telecommunications industry, although it has been ignored to some extent, suffers from the lack of consideration of the structure of costs and revenue allocation: separations and settlements. In this paper the effects of separations and settlements will be examined in a static AJ model, and compared to the benchmark case of efficiency in both the input and output markets.

I. Introduction

Since the early 1960s when Averch and Johnson (AJ) described the comparative-static effects of a regulatory rate of return constraint, hundreds of articles have been written extending the model and testing it empirically. AJ originally applied their model (in an institutional sense) to the operations of AT&T, while most of the theoretical elaboration and the empirical tests applied to electric utilities. Yet, as pervasive as the regulatory constraint is in telecommunications, the AJ formulation and subsequent analyses have not incorporated the key cost and revenue allocation formulas employed in the telecommunications industry which affect input choice.

This paper examines the operations of AT&T prior to the 1982 consent decree, using the cost and revenue allocation scheme employed in the telecommunications industry. Averch and Johnson's comparative static model is used to show how separations and settlements affect the efficient input use by the firm operating in two markets and subject to regulation in two jurisdictions. The introduction of this aspect of telecommunications regulation yields important insights into the regulatory process. Furthermore, with the Bell break-up, rate of return regulation will have reduced impact on the industry, but cost and revenue allocation procedures will remain as key decision variables. Thus, it is important that it is understood how cost separations and revenue settlements may affect efficiency in telecommunications.

Structure of AT&T--Pre-Consent Decree

The American telephone service industry is made up of over 1600 telephone companies ranging from Vista Telephone Company, serving Disney World, Florida, to the American Telephone and Telegraph Company (AT&T), which through its regional operating companies serves approximately 80 percent of all telephone subscribers in the United States.

As the largest corporation in the world, with total assets of $125.5 billion, 1 million employees, and over 300,000 stockholders, the Bell System handles over 190 billion messages each year and has over 138 million telephones in service. The Bell System that had emerged prior to the 1982 Consent Decree consisted of a group of telephone companies, an equipment manufacturer, and a research development branch.

AT&T was the central coordinator of the Bell System, with its General Department managing the growth and development of the system. Another department, Long Lines, the only operating part of the Bell System that was not a separate company, provided telephone lines and circuits between states, and across oceans and international boundaries. Its interstate plant and equipment was jointly owned by the Bell Operating Companies (BOCs), with the revenues being shared through the settlements process to be discussed in some detail later. The BOCs, assigned to various geographical areas, provided local telephone service and some long distance service within their respective territories.

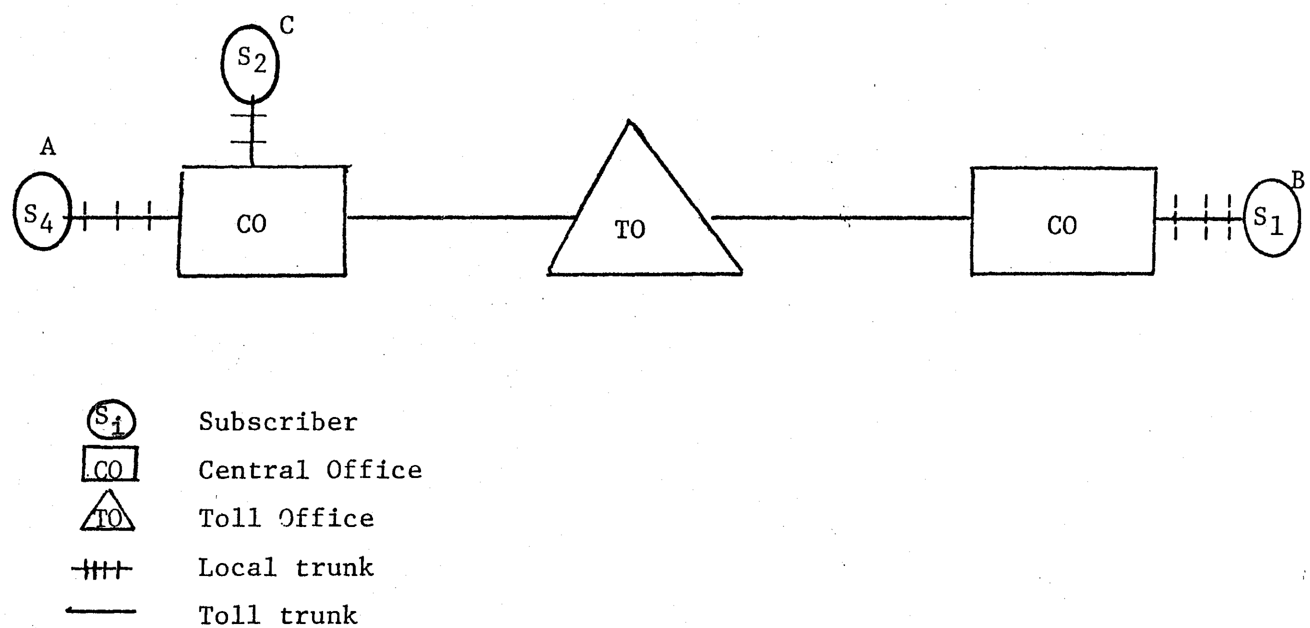
AT&T was regulated on two distinct and sometimes competing levels. Long distance (interstate) rates were set by the Federal Communications Commission while local rates and intrastate rates were set by each state's Public Utilities Commission. The FCC had a constituent interest in the past of keeping interstate rates low while the states' interests were in keeping local service rates low. The resolution of this conflict occurred through the development of methods for allocating costs and revenues: these were formalized in separations and settlements procedures.

Introduction to Separations and Settlements

It is easier to see the problems of a joint costs and common equipment with a diagram of a telephone call. Figure 1 provides a simplified description of the equipment used in the production of a telephone call. When subscriber A places a call to B, two types of plant are used. The telephone (or station) is used along with the local trunk to route the call to the central office, where it is routed to the toll office over toll trunks to another central office, where it is routed to B. The two types of plant employed were the joint plant used in the production of all calls (i.e., the subscriber station, the local connecting trunk, and the equipment used solely in the production of a toll call). For a local call from A to C, a similar route is undertaken, except the CO routes the call through local circuits and completes the call to subscriber C. In both instances, the same plant and

Figure 1

Diagram of a Call



equipment were used to complete the call. For the sake of economic efficiency it would be best to charge a price that would cover the costs of supplying local calls and a price to cover the provision of long distance services. With the use of joint inputs and common plants however, this is not possible without the use of some allocative formula.

Separations

The cost allocation problem has led to the development, through many revisions, of a separations formula based upon a concept of relative use. The subscriber plant factor (SPF), an arbitrary procedure for allocating costs, has three major parts. The first, the subscriber line usage factor (SLU), is a measure of how long subscriber equipment is used for the long distance calls divided by the time the equipment is used for providing all services (irrespective of when calls are made). The SLU is then multiplied by the ratio of average amount of plant allocated to each subscriber (SPC) to the total subscriber plant (TSP). Added to this component is another multiplicative function consisting of two SLUs and what is called the composite station ratio (CSR). The CSR is a ratio of how much it costs on the average to provide a three-minute station-to-station call on a local basis divided by the average cost of the same call on a nationwide basis. So, the weighting formula takes the following form:

$$SPF = SLU(\frac{SPC}{TSP}) + 2SLU(CSR).$$

The plant, which is classified by the National Association of Regulated Utility Commissioners (NARUC) Separations Manual, is allocated to the local and long distance markets through the SPF. For example, the SPF multiplied by the amount of common capital is the amount of capital allocated to the long distance market. It is important to note that the SPF is an arbitrary measure of relative <u>use</u>: is is not a measure of <u>cost</u>.

It is unlikely that the firm subject to both separations procedures and a rate of return regulatory constraint can operate at the cost minimizing position. The theoretical basis for questioning rate of return regulation was laid by Averch and Johnson who showed that an inappropriate input mix would arise under certain circumstances. Although the empirical tests of the AJ hypothesis have yielded mixed results, policy-makers' concern for potential distortions has not diminished. The potential AJ distortion is augmented by the arbitrary cost allocation formula. A telephone company is subject to two differnet (and often competing) regulatory bodies, the separations formulas, and the settlements process. It is unlikely that these additional constraints add appropriate incentives for economic efficiency.

Settlements

The settlements process essentially puts all interstate billings for all companies into a nationwide pool for distribution. The telephone companies participating in the toll revenue pool then aggregate their plant according to the rules specified in the NARUC separations manual using the SPF. The companies are then allowed to recover their expenses from the pool. The pool is then redistributed using a ratio of each company's total income to the total interstate investment for the industry. Given this relationship, some incentives are added to the pricing mechanism which ultimately detract from incentives to minimize costs.

Models of Regulatory Impacts: Two Markets

After this brief review of the institutional idiosyncracies of telecommunications regulation, it is instructive to turn to a more abstract formulation of the situation. This section examines a monopoly operating in two markets. The second section goes beyond the impact of rate of return regulation to cover the effects of separations and settlements. Before examining the distortions involved it is necessary to formulate the model which will be used as a "distortion free" benchmark.

Unregulated Monopoly Profit Maximization

Assume that an unregulated monopoly operating in two distinct markets has the following production and cost characteristics:

$$q_1 = f(K_1, K_3, L_1)$$
$$= \text{production function for market 1},$$
$$q_2 = g(K_2, K_3, L_2)$$
$$= \text{production function for market 2},$$
$$C(q_1, q_2) = w(L_1 + L_2) + r(K_1 + K_2 + K_3),$$
$$R_i(q_i) = p_i(q_i)q_i, \qquad \text{for } i = 1, 2,$$
$$\frac{\partial R}{\partial K_i}, \frac{\partial R}{\partial L_i} > 0,$$
$$\frac{\partial^2 R}{\partial K_i^{\,2}}, \frac{\partial^2 R}{\partial L_i^{\,2}} < 0,$$

where K_1, K_2 and L_1, L_2 are the amount of capital and labor employed in markets 1 and 2 respectively, while K_3 is a joint input used in the production of both goods. $C(\cdot)$ is the firm's cost function, $R_i(\cdot)$ is the firm's revenue function for market i, and w and r are the respective wage rates for K and L.

The firm's objective is to maximize profits. Using this model, the profit function takes the usual form:

$$\text{Max } \pi = R_1(q_1) + R_2(q_2) - w(L_1 + L_2) - r(K_1 + K_2 + K_3),$$
$$\text{w.r.t. } K_i, L_i.$$

The first order conditions give the following results:*

$$\pi_{K_1}: \quad R^1_{K_1} - r = 0 \; . \tag{1.1}$$

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*For convenience, we adopt the following conventions:

$$\pi_{K_1} = \frac{\partial \pi}{\partial K_1},$$

$R^i_{K_j}$ is the marginal revenue product of K_j in market i.

$$\pi_{K_2}: \quad R^1_{K_2} - r = 0 \ . \tag{1.2}$$

$$\pi_{K_3}: \quad R^1_{K_3} + R^2_{K_3} - r = 0 \ . \tag{1.3}$$

$$\pi_{L_1}: \quad R^1_{L_1} - w = 0 \ . \tag{1.4}$$

$$\pi_{L_2}: \quad R_{L_2} - w = 0 \ . \tag{1.5}$$

Taking the ratios by markets gives the following relationship:

$$\frac{w}{r} = \frac{R^1_{L_1}}{R^1_{K_1}} = \frac{R^2_{L_2}}{R^2_{K_2}} = \frac{R^i_{L_j}}{R^1_{K_3} + R^2_{K_3}} \ . \tag{1.6}$$

The ratio of the wage rates is equal to the ratio of the marginal revenue products. This standard result reflects the fact that profit maximization requires hiring inputs up to where the price of the input equals its marginal revenue product. For completeness it is also expected that the second order conditions hold. The Hession determinant is negative definite if $\pi_{x_i x_i} < 0$, where x is an input and $\pi_{x_i x_j} > 0$, where $i \neq j$. From the initial condition $\frac{\partial^2 R_i}{\partial x_i^2} < 0$, which shows a declining value of the marginal product, and if $\frac{\partial^2 R_i}{\partial_{x_i} \partial_{x_j}} > 0$, where $i \neq j$, the inputs are gross substitutes. These give the necessary conditions for profit maximization. From (1.6), the ratios of the marginal revenue products, the benchmark for efficient use of inputs is derived, and will be used below. Of course, too little output is produced for each market compared to the allocatively efficient amount.

Two Market Regulated Monopoly

Using the AJ approach, we can examine the firm's behavior under regulatory constraint. Some assumptions regarding the rate of return ceiling for each regulatory jurisdiction are added, in the form of

$$\frac{R_1(q_1) - wL_1}{K_1 + \alpha K_3} \leq s_1 \text{ for the long distance}$$

(toll) market, and $\dfrac{R_2(q_2) - wL_2}{K_2 + (1-\alpha)K_3} \leq s_2$ for the local market, where α is a parameter describing the allocation of shared capital between the two markets or regulatory jurisdiction, and s_i is the allowed rate of return on the firm's rate base in each jurisdiction. It can also be assumed that each firm will earn its rate of return allowing the use of an equality in the constraint, and that $s_1 \lesseqgtr s_2$, but $s_i > r$. The goal of the firm is to maximize profits, but these profits are not to exceed the level of profits dictated by the state and federal regulatory agencies. Forming the Lagrangian, the following equation is derived:

$$\begin{aligned} L = \; & R_1(q_1) + R_2(q_2) - w(L_1 + L_2) - r(K_1 + K_2 + K_3) \\ & - \lambda_1[R_1(q_1) - wL_1 - s_1(K_1 + \alpha K_3)] \\ & - \lambda_2[R_2(q_2) - wL_2 - s_2(K_2 + (1-\alpha)K_3)]. \end{aligned}$$

Finding the relevant first order conditions:

$$L_{K_1}: \quad R^1_{K_1} - r - \lambda_1(R^1_{K_1} - s_1) = 0 \ . \tag{2.1}$$

$$L_{K_2}: \quad R^2_{K_2} - r - \lambda_2(R^2_{K_2} - s_2) = 0 \ . \tag{2.2}$$

$$L_{K_3}: \quad R^1_{K_3} + R^2_{K_3} - r - \lambda_1(R^1_{K_3} - \alpha s_1) - \lambda_2(R^2_{K_3} - (1-\alpha)s_2) = 0. \tag{2.3}$$

$$L_{L_i}: \quad R^1_{L_i} - w = 0 \ . \tag{2.4}$$

$$L_{\lambda_1}: \quad R_1(q_1) - wL_1 - s_1(K_1 + \alpha K_3) = 0 \ . \tag{2.5}$$

$$L_{\lambda_2}: \quad R_2(q_2) - wL_2 - s_2(K_2 + (1-\alpha)K_3) = 0 \ , \tag{2.6}$$

where λ_i is the Lagrangian multiplier in market i and reflects the degree of regulatory "tightness." For example, since $s_1 > r$ from the original assumptions and from (2.1), where $(1 - \lambda_1)R^1_{K_1} - r = -\lambda s_1$ it is implied that $(1 - \lambda_1)R^1_{K_1} - (1 - \lambda)s_1 = 0$. It is possible to see that if $\lambda_1 = 1$, (2.1) would let $r = s$, violating our original assumptions about the relationship between s and r. If on the other hand, $\lambda_1 = 0$, the Lagrangian yields the same results as the unregulated profit maximum problem, thus λ_i lies between 0 and 1.

Once again taking ratios of the first order conditions and solving in terms of the marginal revenue products

$$\frac{L_{L_i}}{L_{K_i}}: \quad \frac{R^j_{L_i}}{R^j_{K_i}} = \frac{w}{\dfrac{r - \lambda_i s_i}{1 - \lambda_i}} > \frac{w}{r} \ . \tag{2.7}$$

It is useful to show that $\frac{(r - \lambda_i s_i)}{(1 - \lambda_i)} < r$ to demonstrate the AJ effect.* Multiplying both sides by the denominator we find that $r(1 - \lambda_i) > r - \lambda_i s_i$. Solving this in terms of s and r, it is found that $s_i > r$, which implies

$$\frac{w}{\frac{(r - \lambda_i s_i)}{(1 - \lambda_i)}} > \frac{w}{r} .$$

For the common capital (K_3) the demonstration is a bit more complex, as can be seen by equation (2.8).

$$\frac{\pi_{L_i}}{\pi_{K_3}} : \frac{R^j_{L_i}}{(1-\lambda_1)R^1_{K_3} + (1-\lambda_2)(R^2_{K_3}) + \lambda_1 \alpha s_1 + \lambda_2 (1-\alpha) s_2} = \frac{w}{r} . \tag{2.8}$$

Interpretation of Results

Comparing equations (2.7) and (2.9) with equation (2.6), it can be seen that the overcapitalization as a result of a smaller denominator is evident. This result is exactly what the static Averch-Johnson model would predict if there is no uncertainty. No longer is the firm going to produce at the cost-minimizing point given the bias towards the use of capital. If the firm is constrained to a specific level of profit through regulation, the firm will take the allowed return into account by switching resources to capital to take advantage of the fact that $s_i > r$.

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*For second order completeness: if, as in this case, inputs are substitutable in the revenue function (except with itself), the bordered Hessian is negative definite.

This analysis indicates that to produce specific levels of q_1 and q_2, a regulated firm would use more capital than an unregulated firm and would not operate with the efficient capital-labor ratio.

The effect on q_1 and q_2 individually, depends upon their capital-labor ratios. For example, if $\frac{K_1}{L_1} > \frac{K_2}{L_2}$, then the regulatory constraint pushes the firm to use more K_1 than K_2, thus, a relatively greater share of capital will go to the more capital intensive jurisdiction causing a relatively greater amount of output to be produced in that jurisdiction. So if $\frac{K_1}{L_1} > \frac{K_2}{L_2}$ with given rate of return constraints, q_1 will increase more than q_2.

Despite the overuse of capital caused by the regulatory constraint in this simple model, there are other issues to address in the labor input market. From (2.7) and (2.8) it may be inferred that $w = MRP_i$ which at first glance could be interpreted to say the regulated firm will employ the optimal quantity of labor. However, the firm subjected to regulatory constraint employs a smaller amount of labor than is efficient for all levels of production, that is $P_i > MR_i$. Baumol and Klevorick (1970) prove that as r gets closer to s (if K_i and L_i are complementary in the revenue function) then as the amount of capital used increases (from the regulatory constraint), the amount of labor employed also increases. If, however, K_i

and L_i are substitutes in the revenue function, an increase in K_i will cause a decrease in L_i. The three input model used here is even more complicated since the role of K_3 must be taken into account by decision-makers.

Using the AJ framework, we note that the firm adjusts to the regulatory constraint by substituting capital for labor and expanding total output. If the unregulated firm were constrained to move along the efficient expansion path (where $\frac{w}{r} = \frac{MRP_{L_i}}{MRP_{K_i}}$), the firm would operate at a price above average cost reflecting the fact that s > r.

4. AJ Model Introducing Separations and Settlements

With the introduction of Separations and Settlements in 1947 as a method of allocating capital and pooling revenues and returning them to the various phone companies, potential distortions going far beyond those posited by the static AJ model are present. The α used in the above model is defined by the Separations Manual (with subsequent updates) to be a subscriber plant factor (SPF) which is a function of time and distance.

$$SPF = SLU\left(\frac{SPC}{TSP}\right) + 2\ SLU\left(\frac{NIA_L}{NIA_N}\right),$$

where $SLU = \dfrac{\text{Interstate Minutes of Use}}{\text{Total Minutes of Use}}$,

NIAj = nationwide industry average cost for a 3 minute station to station call,

j = Local (L) or National (N),

SPC = subscriber plant charge, average amount of plant allocated to each subscriber, and

TSP = total Subscriber plant.

The additive SPF with all its numerous parts was designed to recognize the deterrent effects of a toll call originating in a particular area. Toll calls are priced according to distance and time and the use of what is called the composite station ratio (NIA_L/NIA_N) effectively increasing the assignment of costs to the interstate jurisdiction as the length of time and the distance of the haul increases. It is important to note that the separations plan is inefficient because, like fully distributed cost pricing, allocates cost based on use rather than actual causation.

Specification of the Model

Settlements to each individual phone company are the result of allocating the pool of all toll income. The pool is distributed based upon the relative amounts of capital that each company employs in the provision of toll services. First we shall consider a group of regulated monopolists.

$P_j = B_j \rho$ = the amount of revenue firm j receives, j = 1 to n,

$$\rho = \frac{\text{Total income from interstate services for n companies}}{\text{Total interstate investment for n companies}},$$

B_j = Interstate plant and equipment for company j,

$$P_j = \frac{\sum_j R(q_1)j - r\left(\sum_j (K_{1_j} + \alpha K_{3_j})\right) - w\sum_j L_{i_j}}{\sum_j (K_{i_j} + \alpha K_{3_j})}\left(K_{i_j} + \alpha K_{3_j}\right),$$

where

$R(q_1)j$ = toll revenue function for firm j,

K_{1_j} = capital employed in toll production for firm j,

L_{1_j} = labor employed in toll production for firm j,

K_{3_j} = shared capital employed by firm j, and

α = allocation mechanism for K_{3_j}.

It must be remembered that the firm is trying to maximize profit, not necessarily settlement income, but depending on costs, a higher settlements income (P_j) could cause profits to be higher than without the settlements pool.

For a preliminary analysis of the settlements formula, an examination of the first order conditions is useful.

$$P_{K_{1_1}} : \frac{D\left[(K_{1_1} + \alpha K_{3_1})(R^1_{K_{1_1}} - r)\right] + \sum_j R(q_1)j - r\left[\sum(K_{1_j} + \alpha K_{3_j})\right] - w\sum_j L_{1_j} - N}{D^2} = 0 , \tag{3.1}$$

$$P_{L_{1_1}} : \frac{D\left[(R_{L_{1_1}} - w)(K_{1_1} + \alpha K_{3_1})\right]}{D^2} = 0 , \tag{3.2}$$

$$P_{K_{3_1}} : \frac{D}{D^2}\Bigg[R_{K_{3_1}}(K_{1_1} - \alpha) + \alpha R(q_1)_2 - r\alpha\left(2(K_{1_1} + \alpha K_{3_1}) + (K_{1_2} + \alpha K_{3_2})\right) - w\alpha(L_{1_1} + L_{1_2}) - N\Bigg] = 0 , \tag{3.3}$$

where D and N stand for the denominator and numerator respectively of the expression P_1. The firm in question can charge the amount of capital used in the production of toll calls, the amount of joint plant, and the amount of labor assigned to the production of toll calls. By themselves, the first order conditions are not very helpful, but if they are examined as ratios of the marginal productivities, an interesting result is obtained. For the sake of simplicity, let

$$a = K_{1_1} + \alpha K_{1_3} ,$$

$$b = K_{1_2} + \alpha K_{2_3} , \text{ and}$$

$$c = L_{1_1} + L_{1_2} .$$

Taking the ratios of the first order conditions yields

$$\frac{P_{L_{1_1}}}{P_{K_{1_1}}} = \frac{\frac{D}{D^2}\left[a(R^1_{L_{1_1}} - w)\right]}{\frac{D}{D^2}\left[a(R^1_{K_{1_1}} - r) + \left(\sum R(q)j - r(a+b) - wc - N\right)\right]} = 0,$$

$$= \frac{a(R^1_{L_{1_1}} - w)}{a(R^1_{K_{1_1}} - w) + \left(\sum R - r(a+b) - wc\right) - a\left(\sum R - r(a+b) - wc\right)}$$

$$= \frac{a(R^1_{L_{1_1}} - w)}{a(R^1_{K_{1_1}} - r) + (1-a)\left(\sum R - r(a+b) - wc\right)} \Rightarrow$$

$$\frac{R_{L_{1_1}}}{R_{K_{1_1}}} = \frac{aw}{ar - (1-a)\left(\sum R - r(a+b) - wc\right)}$$

$$= \frac{w}{\frac{ar}{a} - \frac{(1-a)}{a}\left(\sum R - r(a+b) - wc\right)} .$$

For simplicity let $\frac{1-a}{a} \cong -1$, since $(K_{1_1} + \alpha K_{3_1})$ is a large number; then

$$\frac{R_{L_{1_1}}}{R_{K_{1_1}}} = \frac{w}{r + \sum R - r(a+b) - wc} < \frac{w}{r} \quad . \tag{3.4}$$

Equation (3.4) is very interesting result: The ratio of marginal revenue productivities is equivalent to the ratio of the wage rates if and only if economic profits across the toll segment of the industry are zero. As long as the expression $R(q)_j - r(a+b) - wc \neq 0$ there will be an incentive not to use the optimal amount of labor with respect to capital for efficient operation of the firm. Costs can be recovered from the toll market via a formula which provides no incentive to hold down labor costs, since more expenses just increase the individual monopolist's claim on the pool. This result, which is in an opposite direction from the overcapitalization obtained in the static AJ model, will be analyzed within the AJ framework below.

Settlements with Rate of Return Regulation

It is now useful to look at the maximization problem for a firm that receives revenue through the settlements process and is subject to regulation in two markets.

$$\max_{\text{w.r.t. } K_{i_1},\, L_{i_1}} \Lambda = P_1 + R(q_2)_1 - wL_{2_1} - r\left(K_{2_1} + (1-\alpha)K_{3_1}\right)$$

$$-\lambda_1\left[P_1 - s_1\left(K_{1_1} + \alpha K_{3_1}\right)\right] - \lambda_2\left[R(q_2)_1 - wL_{2_1} - s_2\left(K_{2_1} + (1-\alpha)K_{3_1}\right)\right]. \tag{3.5}$$

For the toll market, the return from the settlements pool can not be greater than the allowed rate of return and for the local market the normal constraint is used.

The first order conditions then give

$$\Lambda_{K_{1_1}} : \frac{\partial P_1}{\partial K_{1_1}} - \lambda_1\left[\frac{\partial P_1}{\partial K_{1_1}} - s_1\right] = 0 , \tag{3.6}$$

$$\Lambda_{L_{1_1}} : \frac{\partial P_1}{\partial L_{1_1}} = 0 , \tag{3.7}$$

$$\Lambda_{K_{2_1}} : R_{K_{2_1}} - r - \lambda_2\left[R_{K_{2_1}} - s_2\right] = 0, \tag{3.8}$$

$$\Lambda_{L_{2_1}} : (R_{L_{2_1}} - w)(1 - \lambda_2) = 0 , \tag{3.9}$$

$$\Lambda_{K_{3_1}} : \frac{\partial P_1}{\partial K_{3_1}} + R_{K_{3_1}} - r(1-\alpha) - \lambda_1\left(\frac{\partial P_1}{\partial K_{3_1}} - \alpha s_1\right)$$

$$-\lambda_2\left(R_{K_{3_1}} - (1-\alpha)s_2\right) = 0 . \tag{3.10}$$

Now, examining once again the ratio of the marginal revenue productivities of capital and labor employed solely in the production of toll calls the following results are obtained:

$$\frac{\Lambda_{K_{1_1}}}{\Lambda_{L_{1_1}}}: \frac{(1-\lambda_1)\left[a(R^1_{K_{1_1}} - r) + (1-a)\left(\sum R(q)j - r(a+b) - wc\right)\right] - \lambda_1 s_1}{a(R_{L_{1_1}} - w)} \Rightarrow \tag{3.11a}$$

$$\frac{(1-\lambda_1)aR^1_{K_{1_1}}}{aR_{L_{1_1}}} = \frac{-(1-\lambda_1)\left[-ar + (1-a)\left(\sum R(q)j - r(a+b) - wc\right)\right] + \lambda_1 s_1}{aw}$$

$$\frac{R_{K_{1_1}}}{R_{L_{1_1}}} = \frac{(1-\lambda_1)ar - (1-\lambda_1)(1-a)\left(\sum R(q)j - r(a+b) - wc\right) + \lambda_1 s_1}{aw(1-\lambda_1)}$$

$$= \frac{\frac{(1-\lambda_1)ar}{a} - (1-\lambda_1)\frac{(1-a)}{a}\left(\sum R(q)j - r(a+b) - wc\right) + \frac{\lambda_1 s_1}{a}}{w(1-\lambda_1)}$$

$$= \frac{(1-\lambda_1)r + (1-\lambda_1)\left(\sum R(q)j - r(a+b) - wc\right) + \frac{\lambda_1 s_1}{a}}{w(1-\lambda_1)}, \tag{3.11b}$$

since $\frac{1-a}{a} \approx -1$, due to the size of a. At this point an interesting result can be seen. If s_1 was constrained to equal r, it would be expected that industry profits would be zero. The term $R(q)_j - r(a+b) - wc$ represents the industry profits (π), and if π was zero, the results of the ratios of the marginal revenue productivities would appear as follows:

$$\frac{R_{K_{1_1}}}{R_{L_{1_1}}}: \frac{(1-\lambda_1)r + \frac{\lambda_1 s_1}{a}}{w(1-\lambda_1)} .$$

The term $\frac{\lambda_1 s_1}{a}$ is very small due to the assumptions that $0 < \lambda_1 < 1$, $0 < s_1 < 1$, and a is very large, so we drop it for now. Simplifying, the following result is obtained:

$$\frac{R_{K_{1_1}}}{R_{L_{1_1}}} = \frac{r}{w} .$$

So, if there are zero industry profits a "competitive-like" result is obtained from the settlement process. This, however, is a truly unlikely situation. Given the fact that there are positive profits in the industry (say) equal to $\delta\left(\sum(K_{1_j} + \alpha K_{3_j})\right)$, where $s_1 - r = \delta_1$, and with rearrangement of equation (3.11b), the following result is obtained:

$$\frac{R_{K_{1_1}}}{R_{L_{1_1}}} = \frac{r(1-\lambda_1)\left[1 + (a+b)\right] + (1-\lambda_1)\delta_1(a+b) + \frac{\lambda_1 s_1}{a}}{w(1-\lambda_1)} , \qquad (3.11c)$$

which when inverted to compare to the benchmark case reduces to

$$\frac{R_{L_{1_1}}}{R_{K_{1_1}}} = \frac{w}{\frac{r(1-\lambda_1)\left[1 + (a+b)\right] + (1-\lambda_1)\delta_1(a+b) + \frac{\lambda_1 s_1}{a}}{(1-\lambda_1)}} . \qquad (3.11d)$$

Since $\frac{\lambda_1 s_1}{a} \simeq 0$, the $(1-\lambda_1)$ terms cancel giving

$$\frac{R_{L_{1_1}}}{R_{K_{1_1}}} = \frac{w}{r\left[1 + (a+b)\right] + \delta_1(a+b)} < \frac{w}{r} \text{, showing that} \qquad (3.11e)$$

the firm will employ more of the variable input (labor) when subject to settlements requirements than will a firm operating optimally.

From (3.11e) it is clear that the firm is no longer operating at the point it would operate without the effects of regulation or settlements and separations. In Figure 2, point M is where the firm would operate if there were neither regulation nor separations and settlements. At this point the ratio of the wage rates is equivalent to the ratio of marginal productivities. Point R, the point determined by the Averach-Johnson effect shows the bias towards the use of the fixed input capital as a result of rate of return regulation. Point S shows where the firm would operate if it was subject to cost and revenue allocation procedures reflected in the present settlements and separations process. From the model it is not entirely clear where point S is in relation to point M. Equation 3.11e and 2.7 show that point S will be to the left of point R. It is, however, indeterminate just how far. If the settlements effect just balanced out the AJ effect the firm would be operating on the efficient expansion path shown as the dotted line going through point M. If it is to the right or left of the expansion path an inefficiency in input use results. It is also possible that another inefficiency results in terms of output. Too much q_1 may be produced adding an additional cost to society in the form of overconsumption. S is on a higher isoquant than R and M. Since M is the monopoly output (Q_0) it is socially inefficient. With rate of return regulation, output increases to a more socially desirable level (Q_1) with the settlements formulation, however, a "subsidy" is given to the

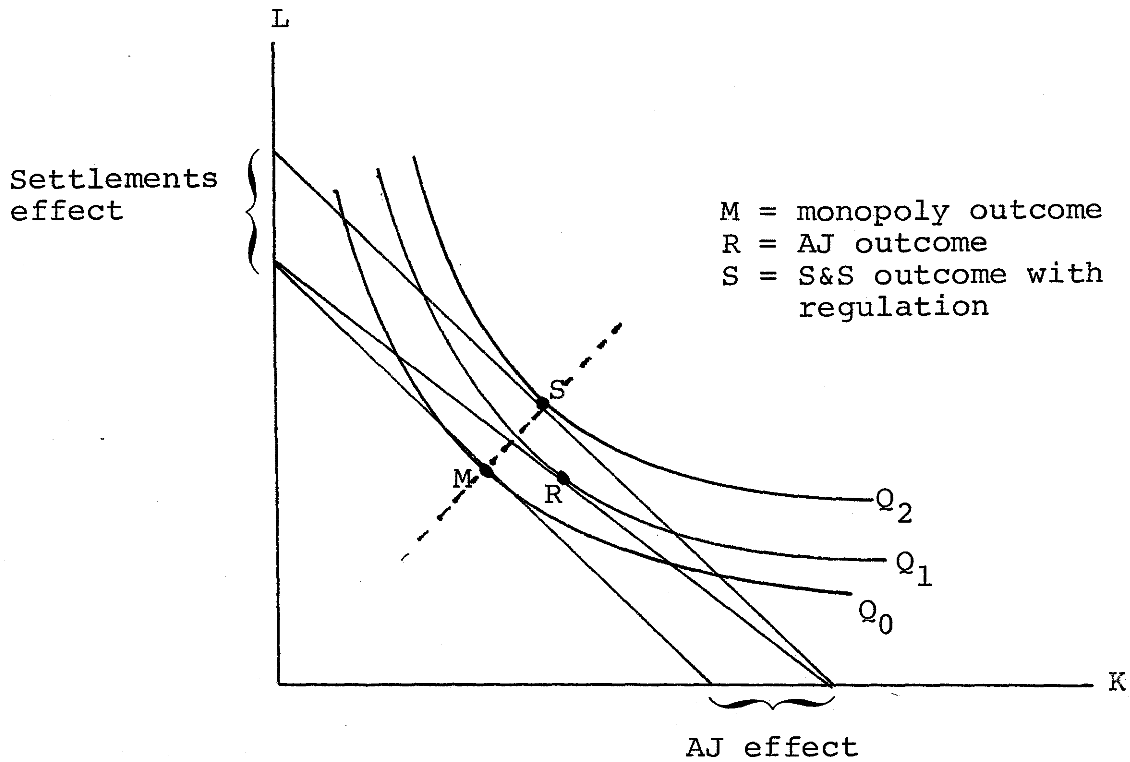

Figure 2

Relative Input Use Under Alternative States firm by the fact that all labor costs are passed through to the toll revenue pool. This causes the implicit wage rate for labor to fall, shifting the isocost line, and setting production at a higher level (Q_2). Thus, the settlement effect has implications for inefficiencies in both inputs and output, but the size of the distortion is difficult to determine.

5. An Analysis of the Shared Input

The shared capital (K_{3_j}) can be looked upon as a quasi-public good. Both toll and local services enjoy its use, leading to what Baumol et al. (1982) have termed economies of scope. The key question, what is the allocative procedure (separation) is that distributes the cost burden between the two products? Does the SPF (or α in the above models) approximate the per unit valuation of K_3 in its marginal use in producing q_1 and q_2? This question definitely needs to be studied in light of the recent antitrust settlement between AT&T and the Department of Justice. Will there be two firms using the quasipublic good? Or can one firm continue to allocate in between markets charging an "access fee" to the long distance company? Optimally, if there was perfect competition, it would be expected that a Lindahl solution would result such that the sum of the marginal productivities is equivalent to the cost of capital,

$$\frac{\partial R_1}{\partial K_{3_1}} + \frac{\partial R_2}{\partial K_{3_1}} = r \,, \tag{3.12}$$

where R_i is the revenue function for market i. This ideal solution is unachievable at present, given the arbitrariness of the SPF and the regulatory process.

Substituting the result of equation (3.3) into equation (3.10) and solving for r, the cost of capital, the following result is obtained:

$$r = \frac{(1-\lambda_1)\left(R^1_{K_{3_1}}(K_{1_1}-\alpha)\right) + R(q_1)_2 - wc + (1-\lambda_1)R^2_{K_{3_1}} - \lambda_1 \alpha s_1 - \lambda_2(1-\alpha)s_2}{(1-\lambda_1)\left(2(a+b)\right) - (1-\alpha)} \quad (3.13)$$

Equation (3.13), for efficiency, should look similar to (3.12), but due to the effects of regulation, settlements, and the SPF, a much more complicated result is obtained, leading to inefficient uses of the shared capital.

From the earlier discussion of the SPF, it was stated that the SPF is a function of time, length of haul, and a ratio of regional average costs to national average cost. For the sake of argument, assume there is no settlement effect and the SPF calculated is actually the correct valuation of the amount of plant and equipment that is used in the production of toll calls, (say) $K_{3_1}/K_{1_1} = 0.30$. Assume for some reason, the policy makers who determine the SPF change it to 0.50. The result is that the local market is subsidized by taxing the long distance market, adding additional capital costs to the toll market. This results in an overconsumption of local services and an underconsumption in the toll market. In Figure 3, the welfare

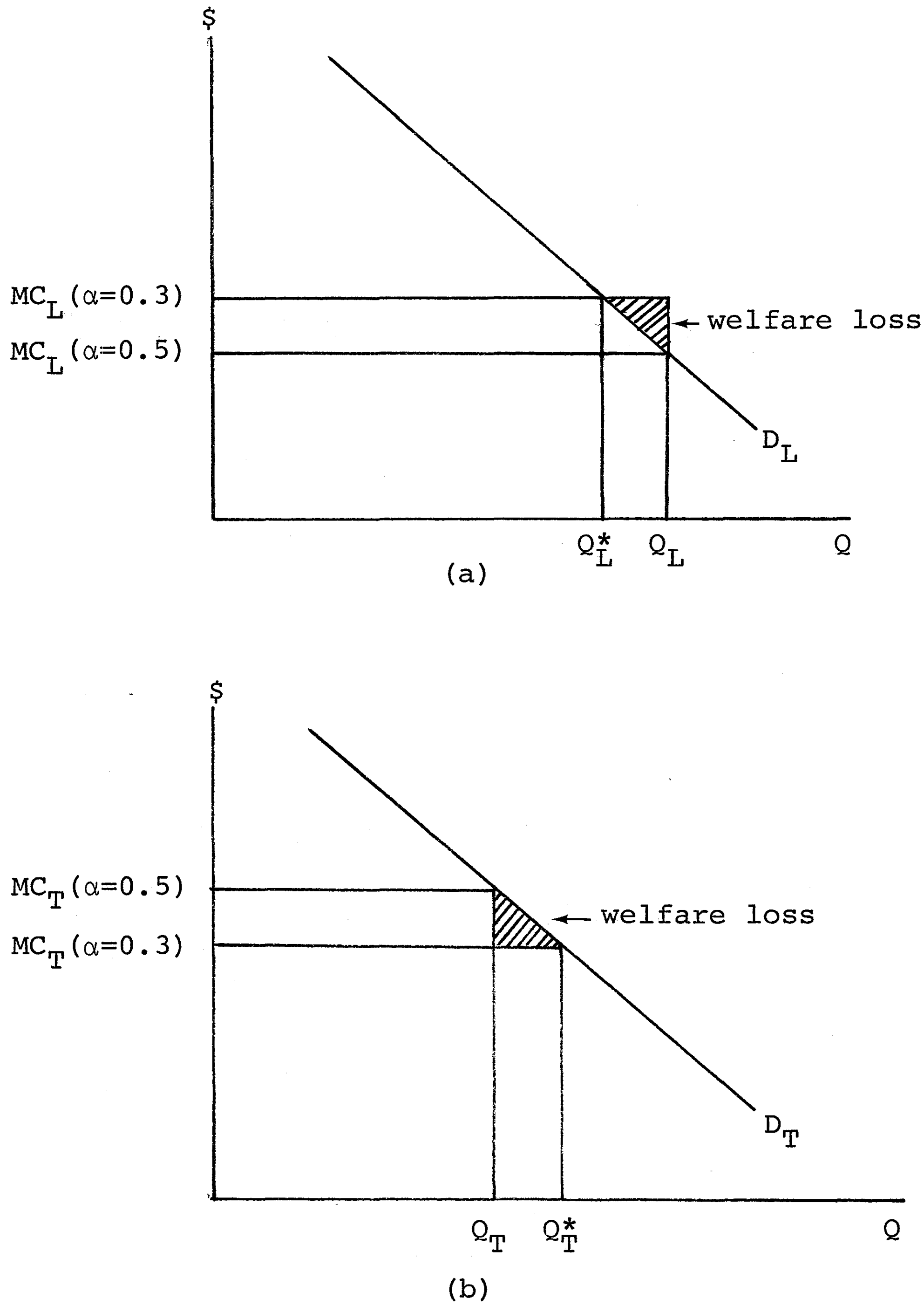

Figure 3

Welfare Effects of Altering α (Subscriber Plant Factor) effects are described due to a change from the efficient level of α. At $MC_L(\alpha = 0.3)$, the efficient levels of toll (Q_T*) and local (Q_L*) calls are produced. When α is increased to 0.5, the amount of capital assigned to the long distance jurisdiction increases, which in turn increases costs in that market while simultaneously decreasing costs for the provision of local services. The changing cost characteristics give different pricing signals from the $\alpha = 0.3$ level, resulting in a welfare loss of the shaded area in (a) due to over consumption of local calls and the shaded area in (b) due to underconsumption of toll calls. Also, note that so far only the <u>output-mix</u> effect has been introduced. Input choices are also affected by α.

According to Gable (1967), when faced (historically) with relatively larger technological changes in the long distance market, as compared to the local market, regulators have altered α and the definition of $^{K}3_{1}$ in order to subsidize the local market, the objective being to promote universal and affordable service for all. It has been the goal of government since the 1934 Communications Act to promote universal service. When toll costs are falling due to increased technological efficiency, the FCC forced AT&T to either lower its toll rates, against the state regulator's wishes (since it took away a potential cross subsidy), or alter the amount of joint capital costs to give the local companies a benefit and thus lower local rates. In pursuing this policy though, the efficiency of the firm has been lessened. An interesting question would be to see how much the true allocation of shared capital in production differs from the regulatory imposed definition. The important idea to notice, however, is that the farther the SPF is from its true value in production, the larger will be the welfare loss stemming from inefficient output mixes. In addition, for the static model, input choice is affected by α as well as s_1 and s_2.

6. Conclusions

A comparative-static analysis of the cost and revenue allocative procedures in the telecommunications industry reveals certain inefficiencies in the use of capital and labor inputs. Following the static approach of Averch and Johnson, a two jurisdiction model was developed to characterize regulation in the long distance and local service markets. In addition, the toll revenue distribution process and the cost allocation process were incorporated into the model. In all cases the results were compared to the competitive benchmark situation.

By itself the settlements formula gives incentives to the firm to employ a larger amount of labor than it would under competitive conditions. This result is also found in the profit maximization problem when rate of return is regulated such that even when the toll market is regulated the incentive exists to use more labor than the competitive capital labor ratio would allow. This over-use of the variable input is exactly opposite the standard AJ result, as it reflects the added revenue allocation procedure.

The separations formulation, or the allocation of a shared input between the toll and local markets, presents other problems. The farther the SPF (or α) is from its true value in production, the larger will be the cross subsidization from toll to local markets and the larger will be the welfare loss from incorrect price signals.

This paper raises more questions than it answers; yet it underscores many issues in telecommunications regulation. The issues are especially important now that AT&T and the local operating companies will no longer be working in a tandem relationship. Interesting conflicts will arise in asset valuation and their distribution throughout the Bell System. Should regulators shoulder AT&T with substantial costs of holding jointly used capital in order to promote universal service? This issue not only affects how much customers will pay for local service, but the future competitive possibilities of AT&T's long lines division. This is a first attempt in trying to examine the cost structure of the telecommunications industry under an AJ model. Despite the model's simplicity, it does highlight some tough regulatory issues.

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