

BEHAVIOR OF A  
VERTICALLY INTEGRATED FIRM  
SUBJECT TO DUAL REGULATORY CONSTRAINTS

by

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ii

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This thesis extends the Averch-Johnson model of the regulated firm to encompass a case in which the regulated firm is vertically integrated with its capital goods supplier. It then examines the behavioral implications of placing a non-market constraint upon the internal transfer price at which the unregulated supply affiliate may sell its output to the regulated firm.

Following a review of the Averch-Johnson model of a non-integrated monopolist that is subject to a binding profit constraint, an alternative model is presented in which the regulated monopolist is assumed to purchase its physical capital exclusively from an affiliated supplier at a price that is constrained not to exceed that charged by the supplier to its other customers. Using standard mathematical optimization techniques a solution to the model is derived and then employed to analyse the behavioral incentives of the regulated firm and its capital goods affiliate. The circumstances under which the two firms will possess an incentive to vertically integrate are discussed and an informal empirical testing of the model is undertaken.

It is concluded that a regulated utility will possess a strong incentive to vertically integrate with its capital goods supplier and that the imposition of a constraint on the capital goods transfer price, while affecting the input/output decisions of the integrated firms, will not in general alter this conclusion. The effects of the transfer price constraint upon the behavioral incentives of the regulated firm are found to qualitatively resemble the effects of a single regulatory constraint upon the behavioral incentives of a non-integrated firm, and the constraint is found to increase the price at which the capital goods supplier will wish

to sell its output to its other customers. The empirical evidence presented provides a measure of support for these findings.

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## INTRODUCTION

The past fifty years has witnessed the emergence of a substantial body of literature concerning the behavior of a regulated monopoly firm. It was not until the 1960<sup>S</sup>, however, that a rigorous mathematical model of such a firm was developed. This development commenced in 1962 when Harvey Averch and Leland Johnson published their pathbreaking American Economic Review article. In that article they attempted to mathematically derive the behavioral incentives of a profit maximizing monopolist subject to a regulatory constraint limiting the firm's allowed rate of return upon it's invested capital. Their findings have been widely commented upon and today remain the subject of continuing debate.

This paper seeks to extend the Averch-Johnson model to encompass an alternative set of circumstances that may more closely describe regulatory practises applied to the major telecommunications common carriers operating in Canada today. The distinctive features of this extended model are that firstly the regulated monopolist is assumed to purchase it's physical capital from an affiliated supplier, and secondly that the capital goods transfer price between the regulated monopolist and it's affiliated supplier is assumed to be constrained by a set of non-market forces. The model is a mathematical one and standard optimization techniques are employed to derive it's solution.

Chapter 1 of the paper provides a brief survey of the existing body of literature that assesses the impact of rate of return earnings constraints upon the behavior of the regulated firm. The extended model is then developed in chapter 2 and the behavioral incentives of the integrated firm are analysed in some detail. A third chapter employs the analysis of chapter 2 to examine the circumstances under which the

regulated monopolist will wish to vertically integrate, and a fourth chapter provides a casual empirical assessment of the model. The paper is essentially a theoretical one and it's normative implications are not discussed here.

CHAPTER 1THE AVERCH-JOHNSON LITERATURE1.1 INTRODUCTION

Under rate of return regulation a regulated firm's allowed revenues are limited to an amount not exceeding the firm's labor and other non-capital costs plus a specified rate of return on its invested capital. Where the specified rate of return exceeds the cost of financial capital to the firm, commentators have long argued that the regulated firm will have an incentive to employ more physical capital than is required for efficient production<sup>1</sup>. It was not until 1962, however, that this proposition was derived as a solution to a constrained maximization problem formulated from a mathematical model of the regulated firm. The exercise was performed by Harvey Averch and Leland Johnson in their paper, "The Behavior of the Firm Under Regulatory Constraint"<sup>2</sup>.

In that paper Averch and Johnson constructed a model of a profit maximizing monopolist, subject to a constraint of the variety described above, producing a single output with the aid of two inputs, capital and labor, both of which were assumed to have positive marginal physical products. Using that model they then analysed the behavioral incentives of the regulated firm and briefly discussed some empirical evidence relating to their findings.

In this chapter we will briefly survey the literature that has arisen from the Averch-Johnson (A-J) paper. We will examine the main results of that paper, explore their robustness under alternative assumptions, comment upon additional propositions that may be derived from the A-J model, and briefly review empirical work that has been

undertaken to test the model. We will then examine one particular extended version of the model and, in so doing, set the stage for the presentation of our own extended model.

## 1.2 INPUT USEAGE OF THE REGULATED FIRM

Using the previously described model, Averch and Johnson derived the result that a profit maximizing monopolist subject to a binding regulatory constraint upon it's rate of return on invested capital<sup>3</sup> will employ more capital and less labour, in producing it's chosen level of output, than is consistent with least cost production<sup>4</sup>. This result is generally referred to as the A-J effect<sup>5</sup> and while Averch and Johnson's original proof of the result has been shown to contain some technical errors<sup>6</sup>, it's derivation remains a fairly straightforward task<sup>7</sup>. It's interpretation, however, has been a source of considerable confusion.

Many commentators have, for example, reasoned that the regulated firm's incentive to produce it's output at a cost in excess of the minimum attainable level implies that it may have an incentive to acquire nonproductive capital inputs and/or pay excessive prices for it's inputs. Several such examples are cited by Dayan(1972). A more recent one is contained in Carr and Halpern(1977) who state that

"Another problem with regulation is known as rate base padding. The dollar profits will depend on the rate of return applied to a rate base. If the rate base can be increased by purchasing 'gold plated' assets, the dollar profits of the firm can be increased." (p.19).

It has in fact been demonstrated that in the A-J model, where the marginal physical product of capital is assumed to be positive, gold  $\frac{\partial \pi}{\partial K} > 0$  plating will reduce the profits of the regulated firm<sup>8</sup> and that the firm will wish to acquire it's capital at the lowest possible strictly

positive price<sup>9</sup>. The A-J effect, then, refers only to the inefficient substitution between inputs and not to these other forms of rate base padding.

When, however, the A-J assumptions are relaxed the regulated firm may have an incentive to either engage in gold plating or to pay excessive prices for its capital inputs. Dayan (1972), among others, has shown that this will indeed be the case where the marginal physical product of capital is non-positive, and Westfield (1965) raises the possibility that it will be where capital is valued, by the regulatory authority, at replacement as opposed to acquisition cost. Perrakis (1976) and Kafgolis (1969) also raise the possibility in the context of models where uncertainty is present or where the regulated firm's objective is other than profit maximization.

In general it has been found that the effect of regulation upon the firm's input usage is highly sensitive to the nature of the firm's objective function<sup>10</sup> and to the presence and nature of any uncertainty<sup>11</sup>. Further, the strength of the A-J effect will be weakened where regulatory lag exists<sup>12</sup> or where the cost of financial capital to the firm is positively related to its level of capital usage<sup>13</sup>. A good summary of those factors that will impinge upon the A-J effect is contained in Bailey (1973), to whom the reader is referred for further discussion.

Bailey (1973), together with McNicol (1973), also provides a good summary treatment of the comparative statics of the A-J model. It is shown, for example, that as the regulated firm's allowed rate of return falls its<sup>h</sup> capital usage will increase and, providing that capital and labour are complements in the production of revenue, its labor usage

will increase. It is also shown that the regulated firm's labor and capital useage are independent of it's cost of financial capital<sup>14</sup>.

A further error that has arisen in interpreting the A-J effect concerns it's possible welfare implications. Shesinski (1971) states , for example, that

"...constraint induces the firm, subject to regulatory control, to increase it's investment and output and also to deviate from the optimal allocation of inputs, because the regulated firm does not equate marginal rates of factor substitution to the ratio of factor costs.....the fair rate of return criterion leads to a non optimal state in the sense of Pareto." (p.175).

Shesinski has no basis, however, for asserting that the regulated firm does not equate marginal rates of factor substitution with the ratio of factor costs. The A-J paper in fact makes no reference to factor costs and concludes only that the regulated firm does not equate marginal rates of factor substitution with the ratio of factor prices. Without specifying the relationship between the ratio of factor costs to factor prices it is meaningless to discuss the welfare implications of the A-J effect. Whereas Westfield (1971) discusses this point at some length it appears to have been ignored by virtually all other writers in the area.

### 1.3 OUTPUT OF THE REGULATED FIRM

While the bulk of the A-J literature has concentrated upon the impact of regulation on the firm's input useage, the original Averch and Johnson article also argued that regulation would affect the firm's output decision. They concluded firstly that "the effect of regulation is to force the firm to expand output from the unregulated position", (p.1057) and secondly that "the firm may have an incentive (that it would not have in the absence of regulation) to enter.....other markets, even if the cost of so doing exceeds the additional revenues.", (p.1058).

Their argument in support of the second conclusion was a simple one. Entering other markets would allow the regulated firm to expand its rate base and thus increase the level of its allowed earnings. The increase in allowed earnings would in turn allow the firm to adjust its operations in its existing markets and thereby capture the increase. Increased profits from existing market operations could thereby be used to offset the loss incurred in the new markets, with a net increase in total profits being attainable<sup>15</sup>. Their argument is formally correct and it is perhaps surprising that this important result has received so little attention in the literature. It has been virtually ignored in most theoretical writings<sup>16</sup>, though considerable attention has been paid to it in applied contexts<sup>17</sup>.

The first A-J output result, namely that regulation will cause an expansion in the firm's output, has received considerably more comment. This likely stems from the fact that the original A-J article provided neither a formal proof nor an informal explanation of the result. Its validity was consequently open to question for some time.

Westfield (1965) was able to establish the conditions under which the regulatory constraint would lead to an output increase but was somewhat obscure in the exposition of his findings. Baumol and Klevorick (1970) also derived these conditions but were unable to adequately interpret them and thus made them appear to be unnecessarily restrictive. Clearer discussions of the conditions are given in Dayan (1972) and Bailey (1973), who conclude that regulation will induce an output increase if and only if capital is not an inferior input, and that the magnitude of the output increase will rise as the allowed rate of return of the regulated firm is lowered<sup>18</sup>. The effect of alternative

assumptions upon this result and a comparative static analysis of it is contained in many of the pieces referred to in the preceding section, and the reader is referred to these for further discussion.

#### 1.4 EMPIRICAL TESTS OF THE A-J MODEL

The Averch-Johnson model of the firm has been widely criticized as being overly simplistic in its assumptions and consequently misleading in its results. Industry practitioners<sup>19</sup> have argued that the model is a static one that assumes an unrealistic objective for the firm and ignores uncertainty, regulatory lag, capital market imperfections, and complex government tax structures. As we have already noted, numerous alternative models have been developed that consider these additional variables and allow for behavioral objectives other than profit maximization. The A-J results have been shown to be highly sensitive to these varying specifications.

As a consequence there has been an increasing tendency to subject the model to empirical testing. This testing has been of both a formal and an informal nature, and not surprisingly the informal evidence has been mixed in its conclusions. Here we will review only the more formal evidence that has been presented. Readers interested in the less formal evidence are referred to Johnson (1973) and Corey (1971)<sup>20</sup>.

The A-J model of a regulated firm yields numerous testable implications concerning the behavior of a regulated firm. It suggests, for example, that the firm's demand for capital goods will vary positively according to the 'tightness' of the regulatory constraint but, *caeteris paribus*, will not be affected by changes in the cost of financial capital to the firm. Empirical estimation of the firm's demand and/or production function, together with the definition and measurement of other



relevant variables, provides a means by which these and other hypotheses may be tested.

The exercise is of course complicated by the need to assume specific functional forms for the relations governing the firm's production and demand functions, and by difficulties involved in obtaining accurate measures of variables such as the cost of financial capital to the firm. Problems of definition also arise with regard to the measurement of inputs and outputs, and this latter factor has resulted in available studies being confined to the electric utility industry, the output of which is less heterogeneous than that of, for example, the telecommunications industry.

Empirical tests of the A-J model have, in toto, been inconclusive. Studies by Hayashi and Trapani (1976), Courville (1974), Spann (1974), and Petersen (1975) all provide evidence consistent with the A-J model, as to the effect of regulation upon the firm's input useage. Stigler and Friedland (1962) concluded that regulation has no effect upon the firm's output decision and studies by Boyes (1976) and Baron and Taggart (1977) detected no evidence of the overcapitalization that is suggested by the A-J model. A study cited by Boyes (1976)<sup>21</sup> found evidence of overcapitalization in the 1950<sup>S</sup> but of undercapitalization in the 1960<sup>S</sup>. These and other studies are critically summarised in Noll (1976) who concludes with us that the evidence is as yet inadequate to allow one to reach any firm conclusions as to the actual effects of regulation on the behavior of the firm.

### 1.5 VERTICAL INTEGRATION AND THE REGULATED FIRM

An implicit, but nonetheless crucial, assumption of the A-J model is that the regulated firm purchases it's capital goods from an independent supplier and that such transactions take place at arms

length. Alternative structural relationships governing such transactions may be envisaged and would be expected to affect the results of the A-J model. Vertical integration constitutes one such alternative structural relationship.

A vertically integrated firm is one that owns successive links in the production and/or distribution process and it has long been argued that a regulated monopoly subject to a rate of return earnings constraint will be able to circumvent the regulatory constraint if permitted to purchase its physical capital from an unregulated supplier with which it is vertically integrated<sup>22</sup>. The argument given is that the regulated firm will be able to satisfy the regulatory constraint, while operating at its unconstrained optimum, by increasing the transfer price at which it purchases physical capital from its supply affiliate and thereby transferring to that affiliate the portion of the monopoly rents that the regulated firm itself is restricted from obtaining.

A formal proof of the above proposition was first provided by Dayan (1972) who shows that regulation may indeed be thus circumvented where the earnings of the supply affiliate and/or the capital goods transfer price are not subject to regulatory control. Dayan further shows that subjecting the two firms to a single rate of return constraint upon their joint earnings will be ineffective where the firms are still permitted to value capital goods in the rate base at an internally determined transfer price. He concludes that

"Effective regulation of a vertically integrated firm requires that the firm's internal or transfer price, or equivalently that each stage of production, be individually regulated."(p.200).

and shows that a measure of regulatory control may be restored by applying separate rate of return constraints to the two firms.

The model presented in the following chapter of this paper is, like Dayan's, intended to examine the impact of regulatory constraint upon the behavior of the vertically integrated firm. It differs crucially from Dayan's, however, in that it considers a case where the capital goods supply affiliate also sells its output in external markets and rather than being subject to a rate of return constraint is subject to a constraint requiring that the internal capital goods transfer price may not exceed the price at which the affiliate sells such goods in external markets. A more thorough analysis of the impact of such a constraint is also provided.

A later chapter will examine an instance in which such a constraint appears to be operative. For now we may note that while such a constraint might be explicitly employed by regulatory authorities it might also be voluntarily imposed by the firms themselves in order to ward off public or governmental criticism, and possible sanctions in response thereto, of the nature of the interfirm relationship. The applicability of the model might therefore be somewhat greater than one would at first suppose.

FOOTNOTES (Chapter 1)

- 1 Corey (1971) briefly discusses the pre Averch-Johnson literature on this subject.
- 2 Averch and Johnson (1962).
- 3 Averch and Johnson assume that the allowed rate of return is at least as high as the cost of financial capital to the firm. The regulatory constraint would otherwise be expected to cause the regulated firm to cease its operations.
- 4 Given that rate of return regulation will also affect the output decision of the firm, this does not imply that the capital to labor ratio of the regulated firm will be higher than it would be in the absence of regulation. This point is obscured in the Averch-Johnson article by the graphical depiction of the firm's expansion path as a straight line in capital and labor space, and is more completely discussed by Baumol and Klevorick (1970).
- 5 Some authors refer to this effect as the A-J-W effect in recognition of the fact that it was independently derived in a paper by Wellisz (1963).
- 6 See Takyama (1969).
- 7 See for example Bailey (1973).
- 8 See for example Dayan (1972), Zajac (1972), and Bailey (1973).
- 9 See for example Westfield (1965), Dayan (1972), and Emery (1973). As to why the price must be strictly positive, one need merely note that were capital to be a free good the regulated firm's allowed profits would be zero.
- 10 See for example Bailey and Malone (1970), Kafgolis (1969), Zajac (1970), Stonebraker (1972), Bailey (1973), and Landsberger and Subotnik (1976).
- 11 See for example Peles and Stein (1976).
- 12 See for example Bailey and Coleman (1971), Davis (1973) and Bailey (1973).
- 13 See for example Bailey (1973).
- 14 The regulated firm's profits are an increasing function of its level of capital usage. It will therefore attempt to maximize its capital usage subject to the imposed regulatory constraint. Where the regulatory constraint is independent of the cost of financial capital to the firm we can therefore intuitively see that while changes in the cost of financial capital to the firm will affect its profitability, they will have no effect upon its input/output decision.

- 15 In the A-J model the regulated firm will employ additional units of capital past the point where the cost of employing an additional unit is equal to its marginal revenue product. In equilibrium a reduction in the firm's capital useage would consequently increase its profits, but in so doing would violate the regulatory constraint. By employing additional capital in new markets, even where it is not fully compensatory to do so, and reducing, though by a lesser amount, its capital useage in existing markets a net increase in company profits may be attainable.
- 16 An exception is Needy (1975) and (1977).
- 17 See for example Babe (1977).
- 18 Scheidell (1976) shows that the magnitude of this output effect will vary inversely with the price elasticity of the regulated firm's demand curve.
- 19 See for example Rosoff (1969), Corey (1971), and Ostergren (1975).
- 20 Corey cites the unwillingness of electric utilitis to install environmental protection equipment as an empirical contradiction of the A-J overcapitalization thesis. Given that such expenditures would not be considered as productive ones by the utilities concerned, the analysis of section 1.2 implies that this particular piece of evidence is of no relevance to the A-J thesis.
- 21 See Boyes, W.J., and D.E.Peseau. Resource Allocation, The Averch Johnson Effect and Federal Energy Policy, paper presented at the 1975 Graduate School of Management Seminar 'Public Utilities Economic Finance'.
- 22 See for example Irwin (1971).

## CHAPTER 2

### THE VERTICALLY INTEGRATED FIRM SUBJECT TO REGULATORY CONSTRAINT<sup>1</sup>

#### 2.1 THE BASIC MODEL

In this chapter we will consider the case of a regulated utility possessing some degree of monopoly power and producing a single output ( $Q$ ) with the aid of two inputs, capital ( $K$ ) and labor ( $L$ ). The firm faces a downward sloping demand curve for its output, the inverse of which is given by  $P=P(Q)$ , and its total revenue function is given by  $R(K,L)=PQ$ . To allow for the possibility of either expense or rate base padding the firm may choose to employ nonproductive labor units ( $L^*$ ) and/or nonproductive capital units ( $K^*$ ). A nonproductive input is defined as being one the employment of which, *caeteris paribus*, does not affect the firm's level of physical output.

A regulatory constraint is assumed to exist and to limit the utility's total revenues to an amount not exceeding its total wage bill plus a specified fair rate of return ( $s$ ) on its total capital investment. This constraint will henceforth be referred to as the earnings constraint. The utility is additionally required to operate upon its demand curve. That is to say that it cannot ration its output by other than price means.

The utility is assumed to purchase its physical capital inputs exclusively from an affiliated manufacturer who faces constant unit costs ( $m$ ) in the production of such inputs. The manufacturer is permitted to sell its output in external markets but in so doing is subject to the constraint that the price ( $t$ ) at which it sells its output in these markets must be no less than the internal transfer price ( $c$ ) at which

it sells its output to the affiliated utility firm. This latter constraint will henceforth be referred to as the price equality constraint. The demand curve faced by the manufacturer in its external market is described by  $D=D(t)$  and its total profits from external market sales are given by  $B=D(t)(t-m)$ .

The affiliated firms are assumed to wish to maximize their joint profits, and both the wage rate ( $w$ ) and the cost of financial capital ( $r$ ) to the firm, considered here as a single entity, are assumed to be constant and independent of the firm's actions. For the sake of simplicity, the depreciation of capital goods is ignored<sup>2</sup>.

## 2.2 NOTATION AND ADDITIONAL ASSUMPTIONS

In this section we will summarise the notation that will be employed throughout the remainder of this paper and state any further assumptions that are necessary in the development of our model.

Let,

$L$ =the number of productive labor units employed by the utility,

$L^*$ =the number of nonproductive labor units employed by the utility,

$K$ =the number of productive capital units employed by the utility,

$K^*$ =the number of nonproductive capital units employed by the utility,

$w$ =the unit labor wage rate,

$c$ =the internal transfer price that the utility must pay for capital inputs,

$r$ =the cost of financial capital to the firm,

$s$ =the allowed rate of return that the utility may earn,

$t$ =the price charged by the manufacturer for capital units in external markets,

$m$ =the unit cost incurred by the manufacturer in producing capital goods,

$Q=Q(K,L)$  describe the utility's production function,

$p=P(Q)$  describe the inverse demand function for utility output,

$R=PQ$  describe the utility's total revenue function,

$D=D(t)$  describe the external market demand function for the manufacturer's output,

$B=D(t)(t-m)$  describe the total profit function of the manufacturer in the external market

$$Q_{kk} = \partial Q / \partial K, \quad Q_{ll} = \partial Q / \partial L, \quad Q_{kl} = \partial Q_k / \partial L = \partial Q / \partial K = Q_{lk}, \quad Q_{kkk} = \partial Q_{kk} / \partial K, \quad Q_{lll} = \partial Q_{ll} / \partial L,$$

$$R_k = \partial R / \partial K, \quad R_l = \partial R / \partial L, \quad R_{kl} = \partial R_k / \partial L = \partial R_l / \partial K = R_{lk}, \quad R_{kkk} = \partial R_{kk} / \partial K, \quad R_{lll} = \partial R_{ll} / \partial L,$$

$$R' = \partial R / \partial Q, \quad P' = \partial P / \partial Q, \quad D' = \partial D / \partial t, \quad B' = \partial B / \partial t, \quad B'' = \partial B' / \partial t,$$

$\xi$  = the price elasticity of the manufacturer's external market demand curve,

$\pi$  = the total profits of the vertically integrated firm,

$\lambda$  and  $\eta$  be lagrangian multipliers.

We will assume that  $Q_k > 0$ ,  $Q_l > 0$ ,  $Q(K,0) = Q(0,L) = 0$ , that

$B$  is concave in  $t$ , and  $R$  is concave in  $K$ , and  $L$ .

### 2.3 FIRST ORDER OPTIMIZATION CONDITIONS

The objective of the vertically integrated enterprise is to select  $K$ ,  $L$ ,  $K^*$ ,  $L^*$ ,  $c$  and  $t$  so as to maximize the combined profits of the regulated utility and it's manufacturing affiliate. The combined revenues of the two firms are equal to the revenues from the sale of utility output,  $R(K,L)$ , plus the revenues from the sale of the manufacturer's output in it's external market,  $D(t)t$ . Revenues from the sale of the manufacturer's output to the affiliated utility may be ignored as they will be exactly offset by a corresponding increase in the utility's recorded costs. The combined costs of the two firms are equal to the costs incurred by the manufacturer in respect of it's external market sales,  $D(t)m$ , plus the utility's labor costs,  $w(L+L^*)$ , plus the costs incurred in respect of the utility's employment of capital,  $rm(K+K^*)$ .



The term  $rm(K+K^*)$  is obtained by multiplying the cost of producing the capital employed by the utility,  $m(K+K^*)$ , by the firm's cost of financial capital,  $r$ , which is the rate of return that investors in the integrated firm require upon their financial investment.

The integrated firm's combined profits may therefore be expressed as

$$\pi = R(K, L) + D(t)t - D(t)m - w(L+L^*) - rm(K+K^*)$$

which yields through rearrangement

$$\pi = R(K, L) - w(L+L^*) - rm(K+K^*) + D(t)(t-m).$$

The utility is subject to a regulatory earnings constraint which requires that its total revenues,  $R(K, L)$ , may not exceed its wage bill,  $w(L+L^*)$ , plus a specified fair rate of return,  $s$ , upon its physical investment in capital goods valued at their acquisition cost,  $c(K+K^*)$ .

We may express this constraint as requiring that

$$R(K, L) - w(L+L^*) - sc(K+K^*) \leq 0$$

which expression may be rearranged to yield

$$\frac{R(K, L) - w(L+L^*)}{c(K+K^*)} \leq s$$

this latter formulation possibly being more familiar to readers who are well acquainted with the literature in this field.

The enterprise is additionally subject to a constraint which requires that the internal capital goods transfer price,  $c$ , may not exceed the price,  $t$ , at which the manufacturing affiliate sells its output in external markets. We may write this constraint as requiring that

$$c - t \leq 0.$$

Using Lagrangian techniques we may thus formulate the firm's problem as,

$$\text{Maximize}_{K, L, K^*, L^*, c, t, \lambda, \eta} \quad = R(K, L) - w(L + L^*) - r_m(K + K^*) + B \\ + \lambda((sc - r_m)(K + K^*) - (R(K, L) - w(L + L^*) - r_m(K + K^*))) \\ + \eta(t - c).$$

The Kuhn-Tucker first order conditions for a maximum are then given by

1. (a)  $\phi_L = (1 - \lambda)(R_L - w) \leq 0$  , (b)  $L\phi_L = 0$  .
2. (a)  $\phi_K = (1 - \lambda)(R_K - r_m) + \lambda(sc - r_m) \leq 0$  , (b)  $K\phi_K = 0$  .
3. (a)  $\phi_{L^*} = -(1 - \lambda)w \leq 0$  , (b)  $L^*\phi_{L^*} = 0$  .
4. (a)  $\phi_{K^*} = -(1 - \lambda)r_m + \lambda(sc - r_m) \leq 0$  , (b)  $K^*\phi_{K^*} = 0$  .
5. (a)  $\phi_c = \lambda s(K + K^*) - \eta \leq 0$  , (b)  $c\phi_c = 0$  .
6. (a)  $\phi_t = B' + \eta \leq 0$  , (b)  $t\phi_t = 0$  .
7. (a)  $\phi_\lambda = R(K, L) - w(L + L^*) - sc(K + K^*) \leq 0$  , (b)  $\lambda\phi_\lambda = 0$  .
8. (a)  $\phi_\eta = c - t \leq 0$  , (b)  $\eta\phi_\eta = 0$  .
9.  $L, K, L^*, K^*, c, t, \lambda, \eta \geq 0$ .

#### 2.4 A NONBINDING PRICE EQUALITY CONSTRAINT

We have assumed that the capital goods supply affiliate is constrained to sell its output to the regulated utility at a price that is no higher than that which it charges in its external market. In this section we will examine the implications of a failure of this constraint to be binding. Having done so we will then analyse those factors that will determine whether the constraint will be binding.

When the price equality constraint is nonbinding it implies that  $\eta = 0$  and thus that the capital goods supply affiliate can set its output price, in both its captive and its external market, at the same level that would obtain in the unconstrained case. For  $s$  and  $K > 0$ , conditions

5(a) and 9 imply that if  $\eta=0$  then  $\lambda=0$ . For  $c>0$  conditions 5(a) and 9 further imply that if  $\eta>0$  then  $\lambda>0$ , and we may therefore state our first proposition as follows.

Proposition 1: The regulatory earnings constraint will be binding if and only if the price equality constraint is also binding.

This proposition implies a further more general proposition.

Proposition 2: The imposition of a regulatory earnings constraint alone will not affect the input/output decision of either the regulated utility or its capital goods supply affiliate.

For  $K$  and  $L>0$  condition 1 reduces to  $R_1=w$  and condition 2 reduces to  $R_k=rm$ . For  $w$ ,  $r$  and  $m>0$  condition 4 implies that  $K^*=0$  and condition 3 implies that  $L^*=0$ . For  $t>0$  condition 6 implies that  $B'=0$ . These are the conditions that would apply in the unconstrained solution and indicate that the regulated utility will employ capital and labor inputs up until the point at which their marginal revenue products equal the cost to the firm of employing additional units of each, will not choose to employ nonproductive inputs, and that the manufacturer will set its external market price at such a level that the marginal profits obtained from an infinitesimally small price change will equal zero. The firm is able to maximize its profits in respect of both utility operations and the manufacturer's external market sales.

An intuitive explanation of this result was provided in section 1.5 where we noted that a vertically integrated enterprise of the sort here described would be able to circumvent a regulatory earnings constraint by artificially raising the capital goods internal transfer price. Where

the constraint on the transfer price is not binding, the same reasoning applies. The utility may operate at its unconstrained optimum and set the transfer price at a level such that profits in excess of those allowed by the regulatory authority are transferred to the supply affiliate, whose profits are not subject to regulatory control.

In these circumstances the only effect of the nonbinding regulatory constraints is to determine the allocation of total profits as between the utility and the manufacturer. The total profits arising out of utility operations are given by  $R(K,L) - wL - rmK$ . The utility is subject to the nonbinding constraint that  $R(K,L) - wL - scK \leq 0$  which implies that  $(R(K,L) - wL) / sK \leq c$ . With  $s$  given and  $K$  and  $L$  uniquely determined the regulatory earnings constraint therefore places a lower bound on  $c$ , the value of which serves to determine the allocation of total profits as between the utility and manufacturer. We may further note that the lower bound on  $c$  will rise as the value of  $s$  falls, and state the following proposition.

Proposition 3: Where the price equality constraint is nonbinding, the regulatory earnings constraint serves only to place an upper bound on the proportion of the vertically integrated firm's profits that are allocated to the regulated utility. This upper bound will fall where the allowed rate of return of the utility is decreased.

We may similarly arrive at,

Proposition 4: Where the price equality constraint is nonbinding it will serve only to place a lower bound on the proportion of the vertically integrated firm's profits that are allocated to the regulated utility.<sup>3,4</sup>

Having thus briefly explored the implications of a nonbinding price equality constraint we must now ask under what circumstances such a constraint will fail to be binding. If we denote by  $t^0$  the price that the manufacturer would charge in it's external market when unconstrained and denote by  $c^0$  the lower bound on the capital goods internal transfer price implied by the regulatory earnings constraint then the price equality constraint will by definition be binding if and only if  $c^0 > t^0$ . On the assumption that the constraint is a binding one it will therefore cease to be so if either  $c^0$  is lowered sufficiently,  $t^0$  is raised sufficiently, or both. Prominent among the factors that would tend to raise  $t^0$  is of course a reduction in the extent of competition in the external market for capital goods, and our earlier analysis indicates that  $c^0$  will fall as  $s$ , the utility's allowed rate of return, is increased. We may therefore state

Proposition 5: A binding price equality constraint may cease to be so where either the utility's allowed rate of return is increased, the degree of competition in the external market for capital goods is reduced, or both.

Before concluding this section we should also note that at no time have we been required to assume that the utility's allowed rate of return,  $s$ , exceeds the cost of financial capital,  $r$ , to the firm. Where the price equality constraint is nonbinding the level of  $s$  serves only to affect the allocation of the vertically integrated enterprise's profits, as between the two affiliated firms, but does not alter their level. This factor may have great relevance to any empirical testing of our model, as in normal circumstances if a firm was constrained to achieve a rate of return below it's cost of financial capital then it would be expected,

in the long run, to quit the industry. Such is not the case here.

## 2.5 A BINDING PRICE EQUALITY CONSTRAINT (GENERAL CASE)

In this section we will examine the implications of a binding price equality constraint. We will assume throughout that the constraint does not induce the utility to cease its operations and that the capital goods supply affiliate continues to sell a portion of its output in external markets. A later section will examine the circumstances under which this last assumption will not be satisfied.

The preceding paragraph, together with condition 9, implies that  $K > 0$ ,  $L > 0$ ,  $\eta > 0$ , and that  $t^* > m$ . This implies, together with condition 8, that  $c = t^* > m$ , and that conditions 1(a), 2(a), 5(a), 6(a) and 8(a) must be satisfied as strict equalities. For  $s > 0$  we also have from 5(a) that  $\lambda > 0$  and that 7(a) must therefore also be satisfied as a strict equality.

As  $\eta > 0$  we have by 6(a) that  $B' < 0$ . This implies that the manufacturing arm of the vertically integrated enterprise is not achieving the maximum attainable level of profits on its external market sales and that strictly positive profits must therefore be being earned by the enterprise in respect of its utility operations. Thus we have that  $R(K, L) > w(L + L^*) + rm(K + K^*)$  which yields, when substituting for  $R(K, L)$  from condition 7(a),  $sc(K + K^*) > rm(K + K^*)$ . This implies that  $sc > rm$ , which condition defines the circumstances under which utility operations will yield positive profits to the enterprise. The condition is sufficiently important to a correct understanding of the remainder of this paper that a brief discussion of it at this point could prove helpful.

The cost to the enterprise of employing a unit of capital in the production of utility output is given by  $rm$  which equals the cost of producing that capital times the cost of financial capital to the

enterprise. When the regulatory earnings constraint is binding the return to each unit of capital employed by the utility is given by  $sc$  which equals the allowed rate of return on capital times the dollar amount at which the utility is allowed to value a unit of capital in its rate base. The profit earned by the enterprise for each unit of capital employed by the utility is therefore given by  $sc - rm$ . For  $sc > rm$ ,  $sc - rm > 0$  and utility operations will therefore yield a positive profit to the enterprise.

Where  $sc > rm$ , condition 4(a) implies that  $\lambda < 1$ . Condition 1(a) therefore reduces to  $R_1 = w$  and the following proposition may be stated.

Proposition 6: Where the price equality constraint is binding, the regulated utility will employ labor units up until the point at which the marginal revenue product of labor is equal to the wage rate.

This is as we would expect. Under the regulatory earnings constraint the allowed revenues of the utility will, caeteris paribus, increase (decrease) by exactly the same amount as expenditures upon labor are increased (decreased). The conditions governing the utility's employment of labor would therefore be expected to be the same as those that would apply in the absence of regulatory constraint. Proposition 6 indicates that indeed they are.

$R_1 = R'Q_1$  and for  $w > 0$ , under the assumption that  $Q_1 > 0$ , condition 1(a) implies that  $R' > 0$ , which allows us to state the following proposition.

Proposition 7: Where the price equality constraint is binding, the regulated utility will always choose to operate upon the elastic region of its demand curve.

This proposition may also be derived in the Averch-Johnson model, and, as Bailey (1973) points out, could prove useful in empirical testing of the model.

Condition 2(a) implies that  $R_k = rm - \lambda(sc - rm)/(1 - \lambda)$  which is less than  $rm$  for  $0 < \lambda < 1$  and  $sc > rm$ . We may therefore state,

Proposition 8: Where the price equality constraint is binding, the regulated utility will employ additional units of capital up to a point at which the marginal revenue product of capital is less than the cost of employing that capital.

To explain this result we will first assume that the internal capital goods transfer price is given and that the utility is operating at its unconstrained optimum where  $R_k = rm$  and  $R_l = w$ . Suppose also that, at this point, the utility's profits are greater than those permitted by the earnings constraint. To satisfy the constraint the utility must therefore adjust its input/output decision which will in turn reduce its profitability. Its optimal adjustment strategy will require that it expand its capital usage and thereby increase both its allowed profits and the rents transferred to its supply affiliate. In the new equilibrium, where the earnings constraint is satisfied, one of the following three conditions must hold: (1)  $R_k > sc$ , (2)  $rm < R_k < sc$ , or (3)  $R_k < rm$ . The second possibility may be discounted immediately as if it held it would imply that the utility could profitably expand its capital usage without violating the regulatory constraint. If the first possibility obtained, while the utility could profitably expand its capital usage to do so would violate the earnings constraint. We may nevertheless discount this possibility by noting that the concavity of the revenue



function assures that by continuing to expand it's capital useage the utility can simultaneously increase both it's affiliate's profits and it's own allowed and earned profits. The third possibility must then apply.

The above analysis is not essentially altered when we remove the assumption that the internal capital goods transfer price is fixed. Our analysis of the three possible conditions that may govern the utility's use of capital in the new equilibrium holds for any value of  $c$  and therefore holds for all possible values of  $c$  in the new equilibrium. That the vertically integrated firms may manipulate the transfer price so as to mitigate the effect of the regulatory earnings constraint implies that quantitatively it's response to the constraint may differ from that of a non-integrated firm. In our model, however, the transfer price itself is constrained and the responses will thus not differ qualitatively. Manipulation of the transfer price is here a complementary, rather than wholly substitute, response, together with enlargement of the capital rate base, to the imposition of the earnings constraint.

Propositions 6 and 8 imply a further proposition that parallels the previously discussed Averch-Johnson thesis as to the expansion path of a regulated firm.

Proposition 9: Where the price equality constraint is binding, the regulated utility will employ more capital and less labor to produce it's chosen output level than is consistent with efficient production.

Again we emphasize that while such production is inefficient in the sense that it does not minimize the costs of the firm, in producing that output, this has no particular relevance to welfare economics in the absence of further information as to factor costs. We also

note that, unlike the Averch-Johnson model, obtaining the result does not require us to assume that the utility's allowed rate of return exceeds its cost of financial capital.

As in the Averch-Johnson model we may also make a distinction between the inefficient use of inputs and the employment of nonproductive inputs. From condition 3, given  $w > 0$  and  $\lambda < 1$ , we obtain  $L^* = 0$ . To show that  $K^* = 0$  we first assume the opposite i.e., that  $K^* \neq 0$ . This implies by condition 4 that  $\lambda = rm/sc$  which when substituted into 2(a) yields  $R_k = 0$ . But  $R_k = R'_k Q_k$  and for  $Q_k > 0$  this implies that  $R'_k = 0$  which would contradict proposition 7. We may therefore state the following proposition.

Proposition 10: Where the price equality constraint is binding, the regulated utility will avoid the purchase of nonproductive inputs.

Intuitively we can see that this proposition follows straightforwardly from propositions 7 and 8. Proposition 7 implies that a small expansion in utility output will increase the total revenues accruing to the utility. By replacing nonproductive inputs with productive ones the total profits accruing from utility operations could thereby be increased if the former were initially being employed. To accommodate this profit increase without violating the regulatory earnings constraint further additional productive capital could be employed. By proposition 9, as  $sc > rm > R_k$ , the use of this additional capital would expand the utility's allowed earnings by an amount in excess of the additional revenue that they generated and could thereby be used to accommodate the increased profits arising out of the utility's replacement of nonproductive inputs. The expanded use of productive capital will further increase the size of the rents transferred to the supply affiliate.

From condition 6(a) we have that  $B' = -\eta$  which for  $\eta > 0$  implies that  $B' < 0$ .  $B' < 0$  implies that a decrease in  $t$ , the price charged by the manufacturing affiliate for its output in external markets, would increase profits arising out of sales in that market. Given also that  $D' < 0$  we may state the following proposition.

Proposition 11: Where the price equality constraint is binding, the capital goods supply affiliate will sell less output, and at a higher price, in the external market for capital goods, than it would if unconstrained.

This is an important result, for it shows that the imposition of regulatory constraints upon the utility/manufacturer relationship can have adverse effects in external markets served by the manufacturer.<sup>5</sup> It does not, however, imply that vertical integration itself is undesirable in this respect. For in the absence of the integrated relationship the demand curve,  $D(t)$ , would be shifted, and the price that the manufacturer would charge when unconstrained thereby affected, by the regulated utility's demand for capital inputs. A further implication of the proposition is that the imposition of the price equality constraint will improve the competitive position of other manufacturers selling in the external market. This arises due to the fact that the price charged by the affiliate in its external market is caused to increase by the imposition of the price equality constraint, and is as we should expect given that additional constraints are not also placed upon the affiliate's competitors.

In interpreting proposition 11 we must firstly recall, from the last section, that the price equality constraint will be binding only where  $c^0 > t^0$ . To satisfy condition 8(a) will then require that either  $c$  be

lowered from  $c^0$ ,  $t$  be raised from  $t^0$ , or both. Crucial to note is the fact that satisfaction of the constraint does not require that only the capital goods internal transfer price,  $c$ , may be lowered. The constraint is, in some sense, flawed in that while it is intended to forestall manipulation of the transfer price,  $c$ , it will also induce manipulation of the price charged by the capital goods supply affiliate,  $t$ , for its output in external markets. The allowed value of  $c$  is determined with reference to a variable whose value is itself in part determined at the discretion of the constrained enterprise.

Both the lowering of  $c$  from  $c^0$  and the raising of  $t$  from  $t^0$  will prove detrimental to the profits of the enterprise. The enterprise will wish to accomplish the adjustment with the smallest possible profit loss and will therefore lower  $c$  or raise  $t$  according to which of the two alternatives will imply the least reduction in profitability. This requirement is formally given by conditions 5(a) and 6(a) which together yield  $\lambda sK = -B'$ . In equilibrium this implies that the increased profits,  $\lambda sK$ , that would be obtained by slightly raising  $c$  will be equal to the reduction in profits,  $-B'$ , that an equivalent increase in  $t$  would engender. In order to determine the extent to which the price equality constraint will impact upon each of  $c$  and  $t$  we must therefore determine what factors will affect the sensitivity of company profits to changes in each of these variables.

Profits arising out of the manufacturing affiliate's external market sales are given by  $B = D(t)(t-m)$ .  $B' = \partial B / \partial t = D'(t-m) + D$  where  $D' = \partial D / \partial t = (\partial D / \partial t)(t/D)(D/t) = \xi(D/t)$  and where  $\xi$  represents the price elasticity of the manufacturer's external market demand for its output. We therefore have

$B' = D(\xi(t-m)/t + 1)$  and from condition 6(a) we know that  $B' < 0$ . Profits will thus be more sensitive to changes in  $t$  as (1) the size of the outside market,  $D$ , is larger, (2) the price elasticity,  $\xi$ , of the outside market demand for the manufacturing affiliate's output is larger, and (3) the larger is the proportion of the outside market price that is made up of profit,  $(t-m)/t$ . Bain (1968) argues that this latter quantity will tend to be higher where, caeteris paribus, the market is characterized by high seller concentration, and we may therefore state the following proposition.

Proposition 12: Where the price equality constraint is binding, it will result in smaller increases in the price charged by the capital goods supply affiliate for its output in the external market when that market is relatively large, when that market is characterized by high seller concentration, and when the price elasticity of demand for the supply affiliate's output in that market is relatively large.<sup>6</sup>

The extent to which the price equality constraint leads to increases in  $t$  will of course also be determined by factors characterising the utility operations. Prominent among such factors would be the scale of utility operations, the nature of the demand curve faced by the utility, the nature of the utility's production function, and the level of  $s$ , the utility's allowed rate of return. Only in respect of this latter factor have we been able to derive any formal results.<sup>7</sup>

Total differentiation of condition 7(a) with respect to  $K$ ,  $L$ ,  $c$ , and  $s$  yields  $(R_k - sc)dK + (R_l - w)dL - sKdc - cKds = 0$ . Given that, from condition

1,  $R_1 = w$ , this expression reduces to  $sKdc = (R_k - sc)dK - cKds$  which implies that

$$(i) \frac{dc}{ds} = \frac{(R_k - sc)}{sK} \frac{dK}{ds} - \frac{cK}{sK}$$

Condition 2(a) implies that  $R_k - rm + (\lambda/(1-\lambda))(sc - rm) = 0$ . From conditions 5(a) and 6(a) we obtain  $\lambda = -B'/sK$  which implies that  $\lambda/(1-\lambda) = -B'/(sK+B')$  and yields when substituted into 2(a), and following rearrangement,  $B'(R_k - sc) + sK(R_k - rm) = 0$ . Totally differentiating this expression with respect to  $K$ ,  $s$ , and  $c$ , while recalling from condition 8(a) that  $c = t$  thereby implying that  $dc = dt$ , yields  $(R_{kk}(B' + sK) + s(R_k - rm))dK - (B'c - K(R_k - rm))ds + (B'(R_k - sc) - sB')dc = 0$ . Rearranging we obtain,

$$(ii) \frac{dK}{ds} = \frac{(B'c - K(R_k - rm))}{(R_{kk}(B' + sK) + s(R_k - rm))} - \frac{(B'(R_k - sc) - sB')}{(R_{kk}(B' + sK) + s(R_k - rm))} \frac{dc}{ds} \text{ implying, from (i),}$$

$$\left( \frac{(B'(R_k - sc) - sB')}{(R_{kk}(B' + sK) + s(R_k - rm))} \frac{(R_k - sc)}{sK} + 1 \right) \frac{dc}{ds} = - \frac{cK}{sK} + \frac{(R_k - sc)(B'c - K(R_k - rm))}{sK(R_{kk}(B' + sK) + s(R_k - rm))}$$

For  $s, c$ , and  $K > 0$ , as we have previously established that  $R_k < rm < sc$  and that  $B' < 0$ , and as  $R_{kk} < 0$  and  $B' < 0$  by the concavity of  $R$  and  $B$ , if we can further establish that  $(B' + sK) > 0$  and that  $(B'c - K(R_k - rm)) < 0$  then it follows from the above expression that  $dc/ds < 0$ .

From condition 4(a) we have that  $\lambda \leq rm/sc$ . In deriving proposition 10 we found that  $\lambda \neq rm/sc$  thus implying that  $\lambda < rm/sc < 1$ . Given that  $\lambda sK = -B'$ ,  $\lambda < 1$  therefore implies that  $(B' + sK) > 0$ . Establishing that  $(B'c - K(R_k - rm)) < 0$  is only slightly more difficult.

From condition 2(a) we have that  $R_k - rm = (-\lambda/(1-\lambda))(sc - rm)$  which yields upon substitution for  $\lambda$ ,  $R_k - rm = (B'/(sK+B'))(sc - rm)$ . We therefore

have that  $B'c - K(R_k - rm) = B'c - K(B' / (sK + B'))(sc - rm)$  which upon manipulation is found to equal  $B'(B'c + Krm) / (sK + B')$ . For  $(sK + B') > 0$  and  $B' < 0$  to establish that  $(B'c - K(R_k - rm)) < 0$  we therefore need only show that  $B'c + Krm > 0$ . To do this we first note that  $\lambda < rm/sc$  implies that  $\lambda scK < rmK$  which, as  $\lambda sK = -B'$ , then implies that  $-B'c < rmK$  or alternatively stated that  $B'c + rmK < 0$  as required.

We may therefore conclude that  $dc/ds < 0$  which then implies that  $dt/ds < 0$ , and state the following proposition.

Proposition 13: Where the price equality constraint is binding, the price at which the capital goods supply affiliate sells its output in external markets will fall as the allowed rate of return of the utility is increased.

This is as we would expect. As the regulatory earnings constraint is relaxed, the effects of the price equality constraint on the supply affiliate's external market performance are weakened. Intuitively we can make sense of the result by noting that as  $s$  increases, were the utility to leave its employment of capital and labor unchanged, by lowering  $c=t$  it could hold the profits accruing to the enterprise from utility operations unchanged while, by condition 6(a), increasing the supply affiliate's profits on its external market sales and thus increasing the total joint profits of the enterprise. While, as we will later discover, the utility would also, as a consequence of any increase in  $s$ , alter its employment of inputs, this analysis allows us to state the further proposition.

Proposition 14: Where the price equality constraint is binding, the joint profits of the vertically integrated enterprise will increase as the allowed rate of return of the regulated utility is increased.

This result is hardly surprising given that the relaxation of a constraint can never be to the disadvantage of a constrained optimizer. From our earlier discussion we may in fact recall that as  $s$  increases the regulatory constraints will eventually cease to be binding and the maximum level of unconstrained joint profits of the vertically integrated enterprise will thereby become attainable by it.

We will now turn to an examination of the impact of changes in  $s$  upon the capital useage of the regulated utility. Our analysis of proposition 8 would lead us to expect that as  $s$  decreases the utility's use of capital will increase. This will in fact be shown to be the case.

Rearranging equation (i) we obtain,

$$(ia) \quad \frac{dK}{ds} = \frac{cK}{R_k - sc} + \frac{sK}{R_k - sc} \frac{dc}{ds} .$$

In the same manner as we obtained equation (ii), we may obtain

$$(iia) \quad \frac{dc}{ds} = \frac{(B'c - K(R_k - rm))}{(B'(R_k - sc) - sB')} - \frac{(R_{kk}(B' + sK) + s(R_k - rm))}{(B'(R_k - sc) - sB')} \frac{dK}{ds} .$$

Substituting for (iia) in (ia) yields,

$$\begin{aligned} & \left( \frac{(R_{kk}(B' + sK) + s(R_k - rm))}{(B'(R_k - sc) - sB')} \frac{sK}{R_k - sc} + 1 \right) \frac{dK}{ds} \\ & = \frac{cK}{R_k - sc} + \frac{sK}{R_k - sc} \frac{(B'c - K(R_k - rm))}{(B'(R_k - sc) - sB')} \end{aligned}$$



$$\begin{aligned}
&= \frac{cK(B'(R_k - sc) - sB') + sK(B'c - K(R_k - rm))}{(R_k - sc)(B'(R_k - sc) - sB')} \\
&= \frac{cKB'(R_k - sc) - sKK(R_k - rm)}{(R_k - sc)(B'(R_k - sc) - sB')} .
\end{aligned}$$

Using earlier results, it is easily determined from the above expression that, as we had expected  $dK/ds < 0$  which implies,

Proposition 15: Where the price equality constraint is binding, the regulated utility will increase it's use of capital as it's allowed rate of return is decreased.

With this result derived we may also determine the impact of changes in  $s$  upon utility output. Total differentiation of condition 1(a), namely  $R_1 = w$ , with respect to  $K$  and  $L$  yields  $dL/ds = (-R_{1k}/R_{11})dK/ds$ . Total differentiation of the utility's production function yields  $dQ/ds = Q_1 dL/ds + Q_k dK/ds$ . Together these two conditions then imply that

$$\begin{aligned}
\frac{dQ}{ds} &= \frac{(-Q_1 R_{1k} + Q_k R_{11})}{R_{11}} \frac{dK}{ds} \\
&= \frac{(-Q_1 Q_{1k} + Q_k Q_{11})R'}{R'Q_{11} + R''Q_1^2} \frac{dK}{ds}
\end{aligned}$$

We have previously established that  $dK/ds < 0$  and that  $R' > 0$ . Therefore for  $Q_1 > 0$  and  $Q_{11} < 0$ , as  $R'' < 0$  by the concavity of  $R$ , the above expression will be strictly negative if and only if  $Q_k Q_{11} - Q_1 Q_{1k} < 0$ . this latter requirement is satisfied by definition if capital is not an inferior input<sup>8</sup> and the following proposition as to the utility's output response to changes in  $s$  may therefore be stated.

Proposition 15(a): Where the price equality constraint is binding, the output of the regulated utility will expand as it's allowed rate of return decreases and providing that capital is not an inferior factor of production.

In interpreting this result we should first recall our earlier explanation as to why the utility's usage of capital will expand as the allowed rate of return is lowered. Given this result the response of utility output to changes in  $s$  will clearly be determined by the nature of the utility's production function which defines the response of output to input changes. Where a factor is not inferior it will always be the case that as it's use expands, even where other input levels are adjusted in response, output will also expand. Hence proposition 15(a) may be directly inferred from our analysis of proposition 8.

Differentiating condition 7(a) with respect to  $K$ ,  $L$ , and  $c$  we obtain  $(R_k - sc)dK + (R_1 - w)dL = sKdc$ . Given that  $R_1 = w$  this implies,

$$(ib) \frac{dK}{dr} = \frac{sK}{(R_k - sc)} \frac{dc}{dr} .$$

At page 30 we derived the equality that  $B'(R_k - sc) + sK(R_k - rm) = 0$ . Differentiating this expression with respect to  $K$ ,  $c$ , and  $r$  we obtain  $((B' + sK)R_{kk} + s(R_k - rm))dK + (B''(R_k - sc) - sB')dc = msKdr$  which, upon rearrangement, yields

$$(iib) \frac{dc}{dr} = \frac{msK}{B''(R_k - sc) - sB'} - \frac{(B' + sK)R_{kk} + s(R_k - rm)}{B''(R_k - sc) - sB'} \frac{dK}{dr} .$$

Substituting for  $dc/dr$  in (ib) and rearranging, we obtain

$$\left( 1 + \frac{((B' + sK)R_{kk} + s(R_k - rm))sK}{(B''(R_k - sc) - sB')(R_k - sc)} \right) \frac{dK}{dr} = \frac{m(sK)^2}{(B''(R_k - sc) - sB')(R_k - sc)} .$$

Using earlier results this latter expression can be shown to imply that  $dK/dr < 0$  which further implies, as per (ib), that  $dc/dr > 0$ . Our proof of proposition 15(a) may then be employed to show that  $dQ/dr < 0$  providing that capital is not an inferior input, and the following proposition may be stated.

Proposition 16: Where the price equality constraint is binding, an increase in the cost of financial capital will raise the internal capital goods transfer price, lower the regulated utility's employment of physical capital, and, providing that capital is not an inferior input, decrease the level of utility output.

This result differs from that obtained in the Averch-Johnson model and thus provides one possible method by which that model and the model of this chapter may be distinguished in empirical testing. It implies that as the cost of financial capital increases, the vertically integrated firm will increasingly prefer a strategy, in response to the imposition of the dual regulatory constraints, of increasing the internal capital goods transfer price as opposed to expanding the utility's rate base. This is as we would expect given that an increase in the cost of financial capital will increase the costs incurred in expanding the capital rate base but does not affect the reduction in profits that an increase in the external market price charged by the supply affiliate, for its output, would engender.

## 2.6 SECOND ORDER OPTIMIZATION CONDITIONS

We have established that  $K^*=L^*=0$  and that the remaining Kuhn-Tucker first order conditions must be satisfied as strict equalities. The second order conditions for a maximum are therefore that  $|H_1| > 0$ ,  $|H_2| < 0$ , and

$|H_1| > 0$ , where  $H_1$  and  $H_2$  are the first and second principal minors of  $H$ , the bordered Hessian shown below.

$$H = \begin{bmatrix} (1-\lambda)R_{11} & (1-\lambda)R_{1k} & 0 & 0 & w-R_1 & 0 \\ (1-\lambda)R_{k1} & (1-\lambda)R_{kk} & \lambda s & 0 & sc-R_k & 0 \\ 0 & \lambda s & 0 & 0 & sK & -1 \\ 0 & 0 & 0 & B'' & 0 & 1 \\ w-R_1 & sc-R_k & sK & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 0 & 0 \end{bmatrix}$$

From condition 1(a) we have that  $R_1 = w$  and therefore,

$$\begin{aligned} |H_1| &= \begin{vmatrix} 0 & 0 & sK & -1 \\ 0 & B'' & 0 & 1 \\ sK & 0 & 0 & 0 \\ -1 & 1 & 0 & 0 \end{vmatrix} \\ &= sK \begin{vmatrix} 0 & sK & -1 \\ B'' & 0 & 1 \\ 1 & 0 & 0 \end{vmatrix} = \begin{vmatrix} 0 & sK & -1 \\ B'' & 0 & 1 \\ 0 & 0 & 0 \end{vmatrix} \\ &= -(sK)^2 \begin{vmatrix} B'' & 1 \\ 1 & 0 \end{vmatrix} \\ &= (sK)^2 > 0 \text{ as required.} \end{aligned}$$

Recalling again that  $R_1 = w$ , we have that

$$|H| = \begin{vmatrix} (1-\lambda)R_{11} & (1-\lambda)R_{1k} & 0 & 0 & 0 \\ (1-\lambda)R_{k1} & (1-\lambda)R_{kk} & 0 & sc-R_k & 0 \\ 0 & \lambda s & 0 & sK & -1 \\ 0 & 0 & B'' & 0 & 1 \\ 0 & sc-R_k & 0 & 0 & 0 \end{vmatrix}$$

$$- \begin{vmatrix} (1-\lambda)R_{11} & (1-\lambda)R_{1k} & 0 & 0 & 0 \\ (1-\lambda)R_{k1} & (1-\lambda)R_{kk} & \lambda s & sc-R_k & 0 \\ 0 & \lambda s & 0 & sK & -1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & sc-R_k & sK & 0 & 0 \end{vmatrix}$$

which implies that,

$$|H| = (R_k - sc) \begin{vmatrix} (1-\lambda)R_{11} & 0 & 0 & 0 \\ (1-\lambda)R_{k1} & 0 & sc-R_k & 0 \\ 0 & 0 & sK & -1 \\ 0 & B'' & 0 & 1 \end{vmatrix}$$

$$+(R_k - sc) \begin{vmatrix} (1-\lambda)R_{11} & 0 & 0 & 0 \\ (1-\lambda)R_{k1} & \lambda s & sc-R_k & 0 \\ 0 & 0 & sK & -1 \\ 0 & 0 & 0 & 1 \end{vmatrix}$$

$$-sK \begin{vmatrix} (1-\lambda)R_{11} & (1-\lambda)R_{1k} & 0 & 0 \\ (1-\lambda)R_{k1} & (1-\lambda)R_{kk} & sc-R_k & 0 \\ 0 & \lambda s & sK & -1 \\ 0 & 0 & 0 & 1 \end{vmatrix}$$

which implies that,

$$\begin{aligned}
 |H| = & \begin{pmatrix} (R_k - sc)(1-\lambda)R_{11} & 0 & sc-R_k & 0 \\ & 0 & sK & -1 \\ & B'' & 0 & 1 \end{pmatrix} \\
 & + (R_k - sc)(1-\lambda)R_{11} \begin{pmatrix} \lambda s & sc-R_k & 0 \\ 0 & sK & -1 \\ 0 & 0 & 1 \end{pmatrix} \\
 & + sK \begin{vmatrix} (1-\lambda)R_{11} & (1-\lambda)R_{1k} & 0 \\ (1-\lambda)R_{k1} & (1-\lambda)R_{kk} & sc-R_k \\ 0 & \lambda s & sK \end{vmatrix}
 \end{aligned}$$

which implies that,

$$\begin{aligned}
 |H| = & (R_k - sc)(1-\lambda)R_{11} (B''(R_k - sc) + \lambda s(sK)) - sK(\lambda s)(1-\lambda)R_{11}(sc - R_k) \\
 & + (sK)^2(1-\lambda)^2 (R_{11}R_{kk} - R_{k1}R_{1k}).
 \end{aligned}$$

Using our previous results this expression can be shown to be positive definite, as required, providing that  $R_{kk}R_{11} - R_{k1}R_{1k} \geq 0$ . This however is assured by the concavity of  $R$ .

Similarly we may show that

$$H_2 = \begin{vmatrix} (1-\lambda)R_{kk} & \lambda s & 0 & sc-R_k & 0 \\ \lambda s & 0 & 0 & sK & -1 \\ 0 & 0 & B'' & 0 & 1 \\ sc-R_k & sK & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 \end{vmatrix}$$

$$=(sc-R_k)^2 B'' + (1-\lambda)R_{kk}(sK)^2 - 2\lambda s(sc-R_k)sK < 0 \text{ as required.}$$

We may therefore conclude that the second order conditions for a maximum are satisfied in our model.

## 2.7 A BINDING PRICE EQUALITY CONSTRAINT (SPECIAL CASE)<sup>9</sup>

In section 2.5 we assumed that while the price equality constraint was binding it would not reduce the profitability of the enterprise to the extent that either the utility would cease its operations or the capital goods supply affiliate would cease to sell its output in external markets. In this section we will examine the circumstances under which one of these latter two possibilities may arise. At the outset we note that should the vertically integrated enterprise cease its operations in one of these two areas then, in the absence of further constraints, it will be able to operate at its unconstrained optimum in the remaining area.

We found in an earlier section that profits would accrue to the vertically integrated enterprise from its utility operations providing that  $s > r$  or, alternatively stated, that  $s > r(m/c)$ . As the capital goods supply affiliate will wish to sell its output in the external market only if  $t > m$ , and given that the binding price equality constraint requires that  $c = t$ , it is clear that the constraint will induce the utility to cease its operations only if  $s < r$ . This implies,

Proposition 17: Where the price equality constraint is binding, the regulated utility will cease its operations only where its cost of financial capital exceeds its allowed rate of return.

The result is an intuitively straightforward one. The capital goods supply affiliate could never be induced to sell its output in the external market at a price below production cost. The capital goods internal transfer price will consequently never be constrained to fall below the cost of producing such goods and utility operations can therefore be forced into a loss position only if the cost of financial capital to the enterprise exceeds the utility's allowed rate of return.

Even where  $s < r$  the utility will not necessarily wish to cease operations. By restating the utility profitability condition as  $c > (r/s)m$ , we see that the utility can always remain profitable to the vertically integrated enterprise, providing that the capital goods internal transfer price,  $c$ , is set at a sufficiently high level. In stating this we are merely repeating our earlier argument that by manipulating  $c$ , rents available from utility operations may be transferred to the supply affiliate. It is only because  $c$  is constrained that a check is put on this process thus raising the possibility that utility operations may be rendered



unprofitable.

Where  $t^0$ , the unconstrained price that the supply affiliate would charge for its output in its external market, is greater than  $(r/s)m$  the utility profitability condition implies that the dual regulatory constraints will never lead to cessation of utility operations. Where  $t < (r/s)m$  this is not necessarily the case. Utility profitability requires that  $c > (r/s)/m$  and the price equality constraint requires that  $c = t$ . Raising  $t$  above  $(r/s)m$  will lead to a reduction in the profits earned on the supply affiliate's outside market sales and for any  $t = c > (r/s)m$  it is possible that the combined profits from utility operations and the supply affiliate's external market sales will be less than the supply affiliate's unconstrained level of profits on its outside market sales. In such an instance the vertically integrated enterprise would find it profitable to cease utility operations.

The factors that could produce such a circumstance include (1) a low value of  $s$ , (2) a low value of  $t$ , which for a given value of  $m$  implies a low value of  $(t-m)/t$ , (3) a high degree of sensitivity of external market profits of the supply affiliate to changes in  $t$ , (4) high rents available from the supply affiliate's external market operations and (5) low rents attainable from utility operations. We may therefore state the following proposition.

Proposition 18: Where the price equality constraint is binding, an allowed rate of return on utility operations that is below the cost of financial capital to the vertically integrated enterprise may induce the utility to cease its operations.

We will now examine the possibility that the imposition of the dual regulatory constraints may induce the capital goods supply affiliate to cease selling its output in the external market for capital goods. We note firstly that the manufacturer will wish to continue operating in these markets only if  $t$  does not fall below  $m$  and that he will be able to only if  $t$  does not rise above some level, denoted  $t^1$ , at which there is no longer a market for its output.

Satisfaction of the price equality constraint requires that  $c=t$ . The constraint will only be binding where  $c^0$ , the lower bound on  $c$  referred to in section 2.4, is greater than  $t^0$ , the price that the manufacturer would charge in the external market when unconstrained. Given that the price equality constraint will lead to an increase in  $t$ , for  $t^0 > m$  the regulatory constraints will never require the manufacturer to lower  $t$  below  $m$ . To interpret this result we need only note that the regulatory earnings constraint places an upper bound only on the utility's rate of return and that for any  $K$  and  $L$  that satisfy the constraint  $c$  can be raised indefinitely without violating the constraint.

For  $c^0 > t^1$ , however, the regulatory constraints may force the manufacturer out of the external market. To continue operating in that market while still satisfying the price equality constraint would require that  $c$  be lowered below  $t^1$  and it is conceivable that for any  $c=t < t^1$  the combined profits from utility operations and the manufacturer's external market sales would be less than the utility's level of unconstrained profits. The factors that could produce such a circumstance may be determined in the same fashion as was done in deriving propositions 12 and 18. We will here content ourselves with stating,

Proposition 19: Where the price equality constraint is binding, the capital goods supply affiliate may under some circumstances, and regardless of whether the utility's allowed rate of return exceeds the cost of financial capital, be induced to cease operating in the external market for capital goods.

## 2.8 SUMMARY

This chapter has been a long and detailed one and it will do well at this point to review it's major findings and attempt to place them in a broader perspective.

We began the chapter by constructing a model of a vertically integrated firm subject to dual regulatory constraints. Our integrated firm was constituted by a regulated utility, possessing some degree of monopoly power, that was subject to a rate of return earnings constraint, and a manufacturing affiliate from whom the utility was assumed to purchase all of it's physical capital, subject to a constraint requiring that the price paid by the utility for such goods could not exceed the price charged by the manufacturing affiliate to it's other customers. It was found that in the absence of this latter constraint, the constraint upon utility earnings could be circumvented by artificially raising the internal capital goods transfer price so as to transfer rents not permitted to the utility under the regulatory earnings constraint to the manufacturing affiliate. While it was also found that, under certain circumstances, the imposition of a constraint upon the level of the internal capital goods transfer price could lead the utility to cease it's operations or force the manufacturing affiliate to leave the external market for capital goods, the bulk of our analysis centered upon the more interesting

case where although the constraint was binding it did not induce an exit from either of these two market areas. Our analysis in this instance focussed upon the effect of the dual regulatory constraints upon the input/output decision of the regulated utility and upon the external market performance of the manufacturing affiliate.

The key responses of the regulated utility to the imposition of the regulatory constraints were found to be qualitatively similar to those that obtained in the Averch-Johnson model. Specifically the utility was found to continue to operate upon the elastic region of its demand curve, shun the use of nonproductive inputs, increase its capital useage and, providing that capital is not an inferior factor of production, increase its output. The strength of the latter two effects was noted to increase as the utility's allowed rate of return was decreased. Further, that the utility's marginal revenue product of capital was, in equilibrium, found to be less than the cost to the vertically integrated firm of employing that capital implies that, as in the Averch-Johnson model, the utility would have an incentive to enter other markets even where it was not fully compensatory to do so.

The similarity of these results to those obtained in the Averch-Johnson model may at first seem somewhat surprising. To explain the similarity it will be helpful to consider a vertically integrated firm, as described here, that is initially not subject to a regulatory earnings constraint and that purchases all of its capital from the supply affiliate at a transfer price that is equal to the price charged by the affiliate to its other customers. Suppose further that a binding regulatory earnings constraint and a binding price equality constraint are then imposed and that the utility's profits are found to be in excess of those permitted under the earnings constraint. In order to bring its actual profits in line with

it's allowed profits the utility must therefore alter either it's input/output decision, the internal capital goods transfer price, or both. It will choose between these alternatives on the basis of which of them is least detrimental to the profits of the integrated enterprise.

Raising the capital goods internal transfer price will involve, due to the presence of the price equality constraint, a reduction in the profits earned on the manufacturer's external market sales. The transfer price will therefore not be raised past the point at which the additional profits thereby obtained by the enterprise in respect of it's utility operations are exactly offset by a corresponding reduction in the manufacturer's external market profits. Were the utility to leave it's input/output decision unchanged and adjust to the regulatory earnings constraint solely by raising the internal capital goods transfer price, this last condition would be violated as in the new equilibrium the additional profits that would accrue to the enterprise from raising the transfer price would equal zero while an increase in the external market capital goods price of the manufacturer would have a negative impact upon the profitability of sales in that market.

Some of the adjustment to the regulatory earnings constraint will therefore take the form of an alteration in the utility's input/output decision. The considerations that will guide the utility in making this adjustment are essentially the same as those that apply in the Averch-Johnson analysis. Specifically, the utility will wish to expand it's capital base so as to increase it's allowed profits and transfer additional rents to it's supply affiliate. The transfer of these rents implies that the analysis is quantitatively different from that of the A-J model, but not that it will differ qualitatively (see for example our discussion of proposition 8).

In discussing the impact of the constraints upon the external market performance of the manufacturing affiliate we noted that, in effect, the vertically integrated enterprise was forced to make a tradeoff between profits from the manufacturer's external market sales and profits accruing from utility operations. By constraining the internal capital goods transfer price to hold a particular relation to the supply affiliate's external market price, the vertically integrated enterprise was induced to manipulate the external market price so as to mitigate the effects of the constraint. Because the relation was such that the manufacturer's external market price placed an upper bound upon the internal capital goods transfer price, the constraint was found to result in an increase in the external market price. The constraint is, in some sense, flawed in that it determines the allowed value of the internal transfer price with reference to a variable whose value may, in part, be determined at the discretion of the constrained enterprise.

FOOTNOTES (Chapter 2)

- 1 The techniques of problem formulation and analysis employed in this chapter lean heavily on the work of Bailey (1973), who employed similar techniques in her study of the Averch-Johnson model. In deriving some of the propositions reached in this chapter our debt is particularly great. The proofs employed in deriving propositions 7, 10, and 15(a) are taken almost entirely from her work.
- 2 The effects of including depreciation in the basic Averch-Johnson model are discussed in Dansby (1974).
- 3 Where the price equality constraint is not binding, the value of the internal transfer price,  $c$ , is nevertheless constrained in the sense that increases in  $c$  beyond a certain level would violate the price equality constraint. The upper bound on  $c$  thereby implied defines the lower bound on the proportion of the vertically integrated firm's profits that may be allocated to the regulated utility.
- 4 The relevance of propositions 3 and 4 is likely to be greatest where the entity that controls the regulated utility and its manufacturing affiliate does not hold full title to one or another of the firms. The allocation of profits between the two firms there becomes a matter of more than mere accounting considerations.
- 5 The higher price charged by the capital goods supply affiliate for its output in external markets would clearly be considered adverse from the viewpoint of customers in that market.
- 6 Economic theories of oligopoly suggest that an individual firm may face highly elastic demand for its output in a market characterized by a high degree of seller concentration.
- 7 While formal mathematical results were obtained in this regard, it was not possible to assign them a meaningful economic interpretation.
- 8 See Bear (1972), Bilas and Massey (1972), and Bear (1965) for a discussion of factor inferiority.
- 9 In section 2.7 we examine only whether regulation will render one portion of the vertically integrated firm's activities unprofitable and thus lead to its cessation. In chapter 3 we examine the broader question of whether it would be more profitable for the firms to engage in these activities as non-integrated entities.

THE INCENTIVE OF A REGULATED FIRM TO VERTICALLY INTEGRATE3.1 INTRODUCTION

Having previously considered the impact of a particular species of regulatory constraint upon the behavior of a vertically integrated enterprise, we are now in a good position to undertake a detailed examination of the circumstances in which a regulated firm will possess the incentive to vertically integrate. Our discussion will begin by positing the existence of an upstream utility that purchases all of its physical capital from a downstream manufacturer with which it is initially unaffiliated. We will no longer assume that the manufacturer faces constant unit costs in the production of its output, but we will assume that neither the costs of the utility nor of the manufacturer are dependent upon whether the two firms are vertically integrated with each other.<sup>1</sup>

We will specifically examine the impact of regulatory activity and of the structure of the market in which the manufacturer operates upon the incentive of the two firms to vertically integrate. The first case that we will examine is one in which the manufacturer operates in a perfectly competitive market. Throughout we will assume that the upstream utility possesses some degree of monopoly power.

3.2 MANUFACTURER OPERATES IN A PERFECTLY COMPETITIVE MARKET

That the manufacturer operates in a perfectly competitive market implies that the market price for capital goods will be competitively determined at a uniform level such that price equals marginal cost for all firms selling in that market. For marginal producers price will also equal average cost, but this will not necessarily be the case for all



firms. Positive profits may therefore be being earned by some firms. All firms will however be pricetakers.

In the absence of regulation, vertical integration will here yield no benefits to either the utility or the manufacturing firm. As the original price paid by the utility for its capital goods will be equal to the marginal cost of producing such goods, vertical integration would not affect the utility's input/output decision and the combined profits of the two firms would thus remain unchanged. Any alteration in the internal capital goods transfer price would serve only to alter the allocation of such profits as between the manufacturer and the utility. It would not affect their combined level.

If, however, the utility is subject to a binding earnings constraint, then it will be achieving less than its maximum level of unconstrained profits. We saw in chapter 2 that vertical integration would, in the absence of a binding constraint on the capital goods internal transfer price, allow the utility to operate at its unconstrained optimum and that the integrated enterprise would be enabled to extract the maximum attainable level of unconstrained profits available from utility operations. Under such circumstances, then, a powerful incentive to vertical integration would exist.

Where a price equality constraint is imposed upon the capital goods internal transfer price this result may be altered. Any adjustment in the manufacturing affiliate's external market capital goods price that is designed to satisfy the price equality constraint will lead him to forego all sales in that market. The resulting profit loss could conceivably be greater than the increase in profits accruing from utility operations as a result of the price adjustment, and any incentive to vertical integration would thereby be removed. The price equality constraint would in this

instance effectively prevent any manipulation of the capital goods internal transfer price that was designed to circumvent the regulatory earnings constraint.

In some cases, however, the gain to the integrated enterprise from raising the internal transfer price could exceed the loss thereby entailed to the manufacturing affiliate from its external market operations. This would clearly be the case where the utility's supplier was a marginal producer who earned zero profits in the external market. We have not however assumed that this is so and thereby have no basis for asserting that vertical integration would prove profitable in this instance .

It might be thought that we can resolve this difficulty by allowing the utility to integrate with a capital goods producer with whom the utility initially did no business. While this would free the utility to select a marginal producer with whom to integrate it would not guarantee that the producer's output was sufficient to meet utility requirements. Nor would this guarantee be necessarily met if we permitted the utility to integrate with more than one producer. Allowing the utility to purchase some of its capital from affiliated suppliers and some of its capital from nonaffiliated suppliers would facilitate our analysis but would require that we specify whether the regulatory authority would permit the utility to purchase capital from different suppliers at different prices. Without making additional restrictive assumptions such as these we are unable to determine whether the utility will wish to integrate. We therefore state,

Proposition 20: Where the market for capital goods is perfectly competitive, we cannot in the general case determine whether the regulated utility will find it profitable to vertically integrate with a capital goods supplier.<sup>2</sup>

### 3.3 MANUFACTURER OPERATES IN AN IMPERFECTLY COMPETITIVE MARKET

Where market power exists at two successive stages of production it can easily be shown that, in the absence of outside regulation, a strong incentive to vertical integration will exist<sup>3</sup>. To see this we should firstly note that by setting all decision variables at the levels that would obtain in the non-integrated case, the integrated firm is assured that it will be able to achieve it's non-integrated level of profits. To establish that, under such circumstances, an incentive to vertically integrate exists we need therefore only show that vertical integration affords an opportunity to improve upon this profit level. We will perform this exercise in the context of the utility/manufacturer relationship that we have to date been discussing. The analysis is, however, of more general application.

In the non-integrated case the utility will select it's input mix, for any level of production, in a fashion such that the marginal revenue product of each input is equal to the cost to the utility of employing an additional unit of that input. Where the price that the utility pays, in the non-integrated case, for it's capital goods exceeds the marginal cost of producing such goods the integrated firm will be able to lower the cost, to the firm as a whole, associated with producing any level of utility output by adjusting it's input mix so as to employ more capital and less labor. It is the cost of producing capital goods, as opposed to their selling price, that is now relevant to the utility's input/output decision. That the cost of producing any level of utility output falls in the integrated case implies that the joint profits of the integrated firms, associated with any level of utility output, are increased above their non-integrated level. Vertical integration will thus always constitute a

profitable alternative in such circumstances.

Given the preceding analysis we might also expect that following vertical integration with its capital goods supplier the unconstrained utility would alter its chosen output level. Dayan (1973) has in fact shown that, providing that capital is not an inferior factor of production, vertical integration will result in an expansion of utility output where both firms possess some market power. The expansion of utility output is, however, commonly a primary regulatory objective and we have already noted that, providing that capital is not an inferior factor of production, the imposition of a binding regulatory earnings constraint upon a non-integrated utility will induce the utility to expand its output. Where the capital goods market is imperfectly competitive, regulation and vertical integration constitute alternative means of inducing an expansion of utility output. We should note also that in both of these instances, for any given level of utility output, the utility would employ more capital and less labor than it would when unregulated and non-integrated.

Where the utility is subject to a binding earnings constraint, the incentive to vertical integration can be shown to exist in an even more straightforward manner. For we know from chapter 2 that vertical integration will allow the earnings constraint to be circumvented and maximum attainable profits thereby extracted from utility operations. By setting all decision variables at the levels that would obtain in the non-integrated case, the integrated firm will always be able to achieve its non-integrated level of joint profits, as was earlier noted. By permitting circumvention of the earnings constraint, vertical integration can therefore only enhance the profits available to the joint enterprise.

To assess the impact of vertical integration in these circumstances we may choose to compare the level of utility output when the utility is non-integrated but subject to a binding earnings constraint and when the utility is vertically integrated but not subject to a binding earnings constraint. In respect of the latter of these cases we emphasize that the utility is not subject to a binding earnings constraint not because such a constraint was not imposed but rather because vertical integration permits it's circumvention. We have already noted that, providing that capital is not an inferior input, in both of these instances utility output will be expanded above the level that would apply in the unregulated and non-integrated case. It therefore remains to consider the magnitude of the output expansion when the utility is not integrated but is regulated and when the utility is not regulated but is integrated. While we have been unable to derive any formal results in this regard we have been able to analyse some of the factors that will determine the size of the output expansion in each of the two cases being considered.

With regard to regulation we saw in chapter 1 that as the allowed rate of return of a non-integrated utility was decreased the utility's output would increase, providing that capital is not an inferior input. It can also be shown that where capital is not an inferior input the output of an unconstrained firm will rise as the price of capital falls. Vertical integration lowers the price, for decision making purposes, of capital to the utility from the market price to the marginal production cost and we may therefore conclude that vertical integration will lead to larger output increases as the market price of capital is further above it's production cost. We noted earlier that the price of a good will, *caeteris paribus*, tend to exceed it's production cost by greater amounts where the market for that good is characterized by high seller concentration

and we may therefore state,

Proposition 21: in the absence of a binding price equality constraint, and where the market for capital goods is imperfectly competitive, vertical integration will increase or decrease the output of the regulated utility according as to whether the utility's allowed rate of return is higher or lower and the market for capital goods is characterized by more or less seller concentration

We will now examine the impact of placing a binding price equality constraint on the internal capital goods transfer price. We saw in chapter 2 that when this constraint was binding so too would be the regulatory earnings constraint. This implies that the vertically integrated enterprise will no longer be able to separately maximize its profits from both utility operations and external market sales of the manufacturing affiliate. Profits subject to these restrictions will be less than in the unconstrained case of vertical integration and could therefore conceivably be below those that would be obtained in the absence of vertical integration.

For the general case, however, it can be shown that vertical integration will remain a profitable alternative for the firm. In chapter 1 we found that a regulated utility that is not integrated but is subject to a regulatory earnings constraint of the variety described herein, will attempt to purchase its capital goods at the lowest attainable price. Providing that this price is no higher than that charged by the capital goods supplier to its other customers then, even when the price equality constraint is binding, the vertically integrated enterprise would be able to set all variables at their non-integrated levels and thus obtain the corresponding level of joint profits.

To show that vertical integration will be profitable for the two firm's we need therefore only show that when integrated the firms will alter the level of one of their decision variables from it's non-integrated level. While it has not been possible to conclusively establish such a result we are able to show that in any instance where vertical integration would not alter the behavior of the firm, a slight movement in the utility's allowed rate of return would evoke different responses from the firm when integrated and when non-integrated.

We established in the previous chapter that for the integrated firm subject to binding regulatory constraints of the variety described herein, the expression describing the utility's response, in respect of it's capital useage, to changes in it's allowed rate of return is given by  $dK/ds=(cK/(R_k-sc))+sK/((R_k-sc))dc/ds$ . The expression was obtained by differentiating condition 7(a) and consequently does not rely upon any assumptions as to the functional form of the manufacturing affiliate's cost curve. The equivalent expression, as derived by Bailey (1973), describing the behavior of a non-integrated firm subject to regulatory constraint is  $dK/ds=(cK/(R_k-sc))$ . For  $dc/ds \neq 0$ , if  $c, K$ , and  $R_k$  are initially set at the same level in both cases we see that the utility will respond differently to changes in  $s$ , according as to whether or not it is vertically integrated.

Given that  $s$  can take on an infinite range of values we may therefore state,

Proposition 22: Where the market for capital goods is imperfectly competitive, the regulated utility subject to a binding earnings constraint will find it profitable to vertically integrate with it's capital goods supplier providing that prior to so doing it was able to

purchase it's capital at a price no higher than that charged by the supplier to it's other customers.

That we should be able to derive this result in the imperfectly competitive market case though not in the competitive market case may at first seem somewhat surprising. The reason lies in the fact that in the competitive market case the supplier is faced with an all or nothing tradeoff whereby any increase in the internal capital goods transfer price will cause it to forego all external market sales. In the imperfectly competitive market case, however, marginal increases in the capital goods price, while affecting profits earned on external market sales, will not result in a total loss of external market sales, and no all or nothing tradeoff is thus implied. Because changes in the utility's allowed rate of return will affect the marginal profits accruing from utility operations in consequence of a change in the internal transfer price,  $c$ , while not affecting the marginal profits accruing from external market capital goods sales as a result of changes in  $t$ , the preferred level of  $c=t$  will be a function of the utility's allowed rate of return. Changes in the allowed rate of return of the utility will therefore induce the vertically integrated enterprise to alter the level of one of it's decision variables from the level that would obtain in the non-integrated case<sup>4</sup>, thereby allowing us to establish the result of proposition 22.

Where, in the imperfectly competitive market case, prior to integration the utility purchased it's capital goods at a price in excess of that charged by the supplier to it's other customers, no such result may be established. The price equality constraint here prevents the integrated enterprise from exercising the option of setting all decision variables at their non-integrated levels and thereby invalidates the above analysis..



### 3.4 SUMMARY

In this chapter we have briefly analysed the circumstances under which a regulated utility subject to a binding earnings constraint will have an incentive to vertically integrate with its capital goods supplier.

Where vertical integration does not lead to the imposition of a price equality constraint upon the capital goods internal transfer price, we found that such an incentive to integrate will always exist. This result follows from our analysis of chapter 2 in which we showed that vertical integration would permit circumvention of the regulatory earnings constraint and consequently permit the vertically integrated enterprise to extract all potential rents available from utility operations, while at the same time being able to separately maximize profits in respect of the capital goods supplier's external market sales.

Where vertical integration does lead to the imposition of a price equality constraint upon the internal capital goods transfer price, our findings were less conclusive. In the case where the manufacturer operates in a perfectly competitive market we were unable to determine as a general case whether vertical integration would yield additional profits to the enterprise. This indeterminacy arose due to the fact that as the capital goods supplier is a pricetaker in the external market, any adjustment in the internal transfer price, while allowing the enterprise to extract all potential rents from utility operations, would entail foregoing all external market sales of capital goods. Without imposing additional restrictive assumptions on our analysis we had no basis for asserting whether in any given instance a net gain in profits might thereby accrue to the enterprise.

In the case where the manufacturer operates in an imperfectly

competitive market we found that, providing that prior to vertical integration the utility purchased it's capital goods at a price no higher than that charged by it's supplier to it's other customers, vertical integration would yield additional profits to the two firms. Where the above proviso is not satisfied no such general conclusion may be reached.

FOOTNOTES (Chapter 3)

- 1 A good summary of the possible cost economies or diseconomies that vertical integration may effect is contained in Williamson (1975). The assumption of the absence of such cost economies or diseconomies is here made for simplifying purposes only and alternative assumptions can easily be treated within the framework laid out in chapter 3.
- 2 One assumption that would allow us to resolve the indeterminacy of proposition 20 is that the utility's capital goods supplier faces constant unit costs in the production of it's output. This would imply that the supplier was a marginal producer and that vertical integration would thus prove profitable. Further, as the regulatory earnings constraint would be circumvented in such an eventuality and the utility freed to operate at it's unconstrained optimum, and given that we noted in chapter 1 that the imposition of a regulatory earnings constraint would in general lead to an expansion of utility output, we would conclude that in this instance vertical integration would lead to a contraction of utility output.
- 3 On the vertical integration of successive monopolies see Machlup and Taber (1960), Wu (1964), and Dayan (1972).
- 4 A change in the utility's allowed rate of return would of course, in the non-integrated case, alter the utility's demand for capital. We have implicitly assumed that this would not affect the price at which it may purchase capital from an unaffiliated supplier. This assumption is sufficient, though not necessary, to ensure the validity of proposition 22. In the absence of this assumption proposition 22 would in general retain it's validity, but it's proof would become considerably more complex.

CHAPTER 4THE CANADIAN TELEPHONE INDUSTRY4.1 INTRODUCTION

In this chapter we will apply the model of chapters 2 and 3 to an analysis of certain of the issues that have been raised in connection with a current inquiry of the Canadian government into the effects of vertical integration in the Canadian telephone industry. The inquiry referred to was initiated in 1966 by the Director of Investigation and Research under the Canadian Combines Act as an examination of the structure of the Canadian telecommunications equipment industry. It terminated in 1973 but was subsequently reopened and in 1977, at the request of the Director, the Restrictive Trade Practices Commission commenced a series of public hearings, under section 47 of the Combines Act, to determine the impact of vertical integration in the Canadian telecommunications equipment market. In 1976 the commission, whose hearings are still underway, had received from the Director a statement of the evidence that had been collected in the course of his inquiry. This evidence is contained in Canada, Director of Investigation and Research, Combines Act (1976), which document will henceforth be referred to as the Green book, and provides a useful focus for the analysis of this chapter.

The aim of the chapter is twofold. Firstly we wish to informally test our model by comparing the predictions that it yields as to the likely behavior of a regulated utility with existing empirical evidence. Secondly we wish to examine the theoretical validity of certain assertions made during the aforementioned inquiry. We will not attempt to survey the full range of issues raised by this investigation but will rather examine a few selected areas to which our model has particular relevance and that

emphasize the features of the model that differentiate it from earlier developments in the Averch-Johnson literature.

#### 4.2 VERTICAL INTEGRATION IN THE CANADIAN TELEPHONE INDUSTRY

The telephone industry in Canada is dominated by Alberta Government Telephones, Manitoba Telephone Systems, Saskatchewan Telecommunications, Bell Canada, and the British Columbia Telephone Company. These companies together with their subsidiaries account for approximately 97% of all telephones in Canada, the remainder being provided by small independent systems. While some competition exists with respect to data communications and other non-voice services, each of these companies possesses a geographic monopoly with respect to the provision of telephone services and derives the bulk of its revenue from that source.

The three prairie telephone companies, which in total account for approximately 13% of all telephones in Canada, are provincially owned and regulated. As government corporations we would not expect their operations to conform to the predictions of our model and shall therefore exclude them from further study<sup>1</sup>. Our interest, then, will center upon the operations of Bell Canada and the British Columbia Telephone Company and their subsidiaries.

Bell Canada and the British Columbia Telephone Company (hereinafter referred to as Bell and B.C. Tel), together with their subsidiaries account for approximately 71% and 13%, respectively, of all telephones in Canada<sup>2</sup>. Both they and their subsidiary telephone companies are regulated on the basis of an allowed return on capital investment, though the exact nature of the calculation has varied by both historical period and regulatory jurisdiction. Minimal regulatory scrutiny has been devoted to assessing carrier investment plans and individual service rates. In part this has been the result of the limited resources available to the regulatory

authority and in part the result of a general unwillingness to interfere with so called management perogatives.

The analysis of earlier chapters would then lead us to expect that both Bell and B.C. Tel would have a strong incentive to vertically integrate with their capital goods suppliers. This is in fact exactly what has occurred. Bell has, since the early part of this century, been the majority shareholder in Northern Telecom Limited<sup>3</sup>, which company is one of Canada's largest manufacturing concerns and from whom Bell and it's subsidiaries purchase the vast bulk of their telecommunications hardware equipment. A controlling interest in B.C. Tel<sup>4</sup> was acquired in 1955 by the General Telephone and Electronics Corporation (GTE), a U.S. holding company that indirectly holds 100% ownership in GTE Automatic Electric (Canada) Limited and GTE Lenkurt(Canada) Limited, from which companies B.C. Tel purchases the overwhelming majority of it's telecommunications hardware<sup>5</sup>. Both of these companies, then, are vertically integrated and purchase the bulk of their physical capital from their manufacturing affiliates.

It has long, however, been argued that the vertical integration of a regulated utility could reduce the impact of regulatory sanctions upon the utility<sup>6</sup>. It would therefore be surprising if further regulatory sanctions were not imposed in respect of this possibility. One such alternative would be the complete prohibition of vertical integration in the regulated sector. This alternative would appear to be most appealing where vertical integration did not yield any substantial cost savings to the integrated firms. The telephone industry has, however, forcefully argued that vertical integration yields substantial benefits in areas such as product design, production scheduling and planning, and marketing. It is therefore not difficult to understand any reluctance of the regulatory

authorities to impose such a sanction in this instance.

Other forms of sanction that could be employed include (1) requiring that the regulated firm employ competitive tendering for all major equipment purchases, (2) directly regulating the manufacturing affiliate's profits or (3) placing restrictions upon the price at which the manufacturing affiliate may sell its output to the regulated firm. Dayan's model involves the second of these alternatives. Ours bears upon the third.

Actual Canadian practices, in this regard, in the regulation of the telephone industry have been mixed. The first of the above alternatives does not appear to have ever been employed in this context and neither the second nor the third have been adopted in a formal sense. Bell and Northern Telecom have, however, since 1912 been party to a supply contract which dictates that Northern must supply Bell with its required capital equipment at a price no higher than that which Northern charges to its other customers. This pricing policy has also been extended to include Bell's telephone company subsidiaries and results in their obtaining prices below Northern's general trade price, though often in excess of those charged to Bell. While the original rationale for the contract is not known, it is now customary for it to be discussed at length and its performance reviewed at Bell Canada rate hearings. Its value as a regulatory defense of the Bell/Northern relationship has been acknowledged by Northern executives in their internal correspondence,<sup>7</sup> and the Green book goes so far as to state that,

"the regulatory imperatives facing Bell Canada were the main factors influencing the prices which Northern Electric was allowed to charge in the market..." (p.8).

Although B.C. Tel is not party to a similar supply contract with its manufacturing affiliates, there is evidence to suggest that the

enterprise's internal pricing policy may be constrained by considerations of the same nature that apply in the Bell/Northern complex. B.C. Tel is, like Bell, regulated by the Canadian Radio-Television and Telecommunications Commission<sup>8</sup>, and the matter of it's purchasing policies in general and of the reasonableness of the prices paid by it for equipment purchased from it's manufacturing affiliates has been widely discussed at B.C. Tel rate hearings. Additionally a Canadian government study<sup>9</sup> was commissioned in 1975, at the request of the provincial government of British Columbia, to specifically examine the purchasing policies of B.C. Tel, and adressed at some length the issue of the reasonableness of the prices paid by B.C. Tel for it's in house capital goods purchases. Faced with pressures of this nature the B.C. Tel complex could well find it to be to it's own advantage to self impose a constraint upon it's internal capital goods transfer prices, and the 1975 study referred to above did in fact conclude that B.C. Tel does not pay higher prices for equipment purchased from it's affiliates than are charged to the affiliates' other customers.

There is therefore evidence to suggest that these two vertically integrated enterprises have self imposed a constraint upon in house equipment sales pricing that is similiar to the constraint employed in formulating the model presented in chapter 2. The constraint appears to be most severe in the case of Bell and Northern Telecom where it is formalized under the terms of the supply contract and where, in actuality, prices charged to Bell by Northern are typically substantially below the Northern general trade price. In the case of B.C. Tel and it's manufacturing affiliates no formal supply contract exists and the prices charged to B.C. Tel by it's affiliates are, on many product lines, equal to rather than below those charged by the affiliates to their other customers.



The analysis of chapter 3 found that in a limited but fairly general set of circumstances the imposition of a price equality constraint would not remove the incentive of a regulated utility to integrate with its capital goods supplier. That this appears to have been true in the context of the Canadian telephone industry thus constitutes additional supportive evidence for our model.

#### 4.3 IMPACT OF PRICE EQUALITY CONSTRAINT UPON THE EXTERNAL MARKET

##### PERFORMANCE OF THE MANUFACTURING AFFILIATE.

Proposition 11 states that the imposition of a binding price equality constraint requiring that the prices paid by the regulated utility for capital goods purchased from its manufacturing affiliate can be no higher than those charged by the affiliate to its other customers will have the effect of increasing prices charged by the affiliate to its other customers. While such a constraint is intended to prevent the manipulation of the internal transfer price so as to prevent any transfer of monopoly rents to the manufacturing affiliate, it is flawed by the fact that it ties the transfer price to another variable that may be adjusted at the firm's discretion. The constraint will thus serve to lower the one price but to raise the other, the degree of movement in each being determined according to the sensitivity of company profits to such changes.

We noted in the last section that constraints of this variety appear to have been imposed upon both the Bell/Northern and B.C. Tel/Automatic/Lenkurt complexes. We would therefore expect to find indications that Bell and B.C. Tel's manufacturing affiliates are sacrificing potentially profitable sales in their external markets so as to satisfy the constraints. Such indications do in fact exist.

An internal Northern Telecom memorandum, reproduced in part in the Green book, states

"Today Northern faces highly competitive market conditions which are likely to become even more competitive in the future..... In a highly competitive market the traditional and narrowly restrictive interpretation of the supply contract is actually contrary to the interests of both companies..... it seems evidence that the pricing commitment Northern makes to Bell in it's supply contract should be so worked and interpreted as to make it proper and appropriate for Northern UNDER CERTAIN CONDITIONS to sell to other customers at prices lower than those at which it sells to Bell." (p.44).

The Green book notes that these conditions include the penetration of new markets and instances where non-Bell customers purchase a product in quantities greater than does Bell.

The quotation clearly indicates that the price equality constraint has, as we would expect, led to a loss of external market sales by the manufacturing arm of the Bell/Northern complex and that this has induced Northern to consider the possibility of attempting to 'loosen' the constraint. The memorandum from which the quote is taken was written in 1965 and some evidence does exist to indicate that just such an attempt may since have taken place.

Over the 1973-75 period Bell's ownership interest in Northern<sup>10</sup> was reduced from 100% to approximately 60% and it may be argued that this reduces the advantages to Bell of transferring rents to Northern by paying inflated equipment prices and thus mitigates any need for the price equality constraint. While we do not fully accept this argument<sup>11</sup> there does appear to have been a concurrent loosening of the constraint, that this change in ownership holdings may have facilitated. Firstly, ending some uncertainty on the matter, it has been decided that export sales are excluded from the terms of the supply contract, and secondly there is evidence that, on some product lines at least, the differential between the Bell price and the general trade price for Northern products has diminished since the early

sixties.<sup>12</sup>

If the above two examples do reflect a general loosening of the price equality constraint then we would expect to detect an improved trend in Northern's external market performance over the same time period. Such a trend is in fact evident. In the period from the early fifties to early sixties Northern's share of the non-Bell domestic market for telecommunications equipment fell from approximately 70% to below 50%. In the early seventies, by contrast, Northern's share of this market was increasing and its export performance rapidly improving. Its total sales approximately doubled from 1970 to 1975 and its sales to Bell as a percentage of its total sales has steadily declined.

The evidence is therefore that the price equality constraint has hurt Northern's external market performance but that this performance has improved concurrently with a loosening of the constraint. This is in general conformity with what we would expect given the analysis of chapter 2.

#### 4.4 IMPACT OF PRICE EQUALITY CONSTRAINT UPON CARRIER TECHNOLOGY

We found in chapter 2 that a vertically integrated regulated monopolist would not in general have an incentive to acquire nonproductive inputs. In this section we will examine an instance in which it has been alleged that vertical integration has led B.C. Tel to employ technologically outdated capital equipment. While this occurrence would at first appear to be in direct conflict with the predictions of our model, we will discover that the model enables us to substantially improve upon existing analyses of the event.

In 1959 B.C. Tel opted to continue installing step by step switching offices rather than converting to crossbar technology as were most other North American telephone systems at that time. B.C. Tel argued that their decision was based upon a belief that by the mid 1960<sup>s</sup> improved electronic

common control switching technology would be available and that consequently interim conversion to crossbar would prove uneconomic. Yet, when electronic common control equipment did become available B.C. Tel was considerably slower than many other carriers in commencing it's conversion program.<sup>13</sup>

Contemporaneously coincidental with the 1959 B.C. Tel decision was a decision by Automatic Electric not to enter the crossbar market. Noting this coincidence many commentators have argued that the B.C. Tel decision was influenced by that of Automatic Electric and that B.C. Tel consciously chose to employ an inferior switching technology so as not to remove profitable business from it's manufacturing affiliate<sup>14</sup>. The argument is flawed, however, in that it does not explain why Automatic Electric made the initial decision not to enter the crossbar market. If we accept the contention that B.C. Tel did indeed adopt an inferior technology as a result of it's relationship with Automatic Electric it is this earlier decision that we must explain.

A possible explanation may arise from our analysis of section 2.7, in which we explored the impact of the price equality constraint upon the manufacturing affiliate's outside market performance. There we found that the imposition of the constraint could force the manufacturer out of the external market where the optimal value of  $c=t$  was above the level at which any sales would be forthcoming in that market. Having left that market the enterprise could set the value of  $c$ , the capital goods internal transfer price, at it's unconstrained level and thus transfer additional rents to the supply affiliate. Such a strategy would not however be feasible where it led to increased regulatory scrutiny and the imposition of additional constraints such as those involving a comparison of the capital goods internal transfer price with the price charged by other manufacturers for similar products. In these circumstances a preferred strategy for the

manufacturing affiliate might involve the introduction of a major change in product quality that reduced the feasibility of making price comparisons with the products of other manufacturers, but that was not so severe as to exclude it from achieving a small volume of external market sales so as to give the impression that the price equality constraint remained a restraining influence upon the level of the capital goods internal transfer price and thus stave off the imposition of further regulatory sanctions.

To judge the applicability of the foregoing analysis to the 1959 B.C. Tel switching decision would require a far more detailed study than is possible here. The analysis does however illustrate that such a decision could be motivated by a desire to reduce the impact of a price equality constraint upon the profitability of the vertically integrated enterprise. Unlike previous analyses it can help not only to explain the B.C. Tel purchasing decision, but also to explain the decision of Automatic Electric not to enter the crossbar market.

#### 4.5 REGULATION IN THE VERTICALLY INTEGRATED COMPLEX <sup>15</sup>

At several points the Green book discusses the impact of vertical integration upon the regulation of Bell Canada. In this section we will argue that the Director's analysis of this issue is wholly deficient and that his conclusions, as they relate to this issue, are unwarranted and quite possibly incorrect.

The Green book states at page 136 that,

"The vertical integration of the regulated firm, Bell Canada, with the unregulated Northern Electric causes serious impacts in two areas.....In the first areas, questions are raised about the ability of a regulatory body to adequately regulate part of a vertically integrated complex.",

and concludes at page 156 that,

"there is evidence that vertical integration in telecommunications continues to hinder effective regulation and that the most effective remedy would

be a further lessening or breaking of vertical ties."

The analysis, however, is completely inadequate in that while arguing that vertical integration hinders "effective regulation", it at no point discusses what constitutes either effective regulation or its goals. It does indicate that current regulatory practices designed to determine the reasonableness of the prices paid by Bell for goods purchased from Northern are problematic in certain respects and that alternative known practices may be similarly flawed. This, however, is irrelevant to the conclusion, to support which it would be necessary to firstly delineate the goals of regulation and to secondly determine the extent to which these goals might be approached with and without vertical integration. The Green book does neither.

If the goal of regulation is to maximize the output and minimize the price of utility services, we saw in chapter 3 that one could not a priori determine whether or not vertical integration would further this goal even where integration led to the circumvention of the regulatory earnings constraint. Given that the imposition of a binding price equality constraint has been shown to result in movements in utility output, that are in addition to those that vertical integration alone will produce, such a determination becomes even more difficult to make. Crucial to such a determination would be an accurate assessment of the likely competitive nature of the capital goods supply market in the presence and absence of vertical integration. No such assessment is made in the Green book and we must therefore repeat that the Director's conclusions as to the impact of vertical integration upon the achievement of regulatory goals finds no justification in the analysis that he makes.

#### 4.6 SUMMARY

In this chapter we have attempted to informally test the model of chapters 2 and 3, and to apply its findings to an analysis of selected issues that are of current interest with regard to the Canadian telephone industry. We do not pretend that our analysis was of either sufficient depth or sufficient detail to allow us to reach any firm conclusions as to the merits and/or usefulness of the model. The contents of the chapter do, however, provide an encouraging measure of support for the model and indicate that it is not without useful applications.

FOOTNOTES (Chapter 4)

- 1 It should be noted that none of the three prairie telephone companies is vertically integrated with its capital goods supplier. Our model has little relevance to this situation given that both the constraints applied to and the objectives of a provincially owned company are likely to dramatically differ from those assumed in our model. While the small size of these systems might preclude their vertical integration, of greater relevance to our observation is the simple fact that provincial governments generally lack both the incentive and the desire to enter industrial sectors that are generally considered the domain of the private sector.
- 2 Excluding their subsidiaries, Bell and B.C. Tel account for approximately 60% and 10%, respectively, of all telephones in Canada.
- 3 Northern Telecom was formerly known as Northern Electric.
- 4 Bell is a widely held, majority Canadian owned corporation.
- 5 Given that foreign firms are likely to require a substantial risk premium on their non-domestic investments, (see Caves (1971)), and that regulated utilities do not generally yield high returns, B.C. Tel would not be considered a very likely candidate for foreign ownership. CTE has in fact kept its shareholdings of B.C. Tel at close to the minimum level that is required to ensure control of the company, thus strengthening any suspicion that control may be desired only so as to foster the profitability of the wholly owned supply affiliates.
- 6 See for example Hale, G.E. "Vertical Integration: Impact of the Antitrust Laws upon Combinations of Successive Stages of Production and Distribution," Columbia Law Review 21 (1949) and Comment "Vertical Forestalling Under the Antitrust Laws," University of Chicago Law Review 19 (1952), both cited in Irwin (1971).
- 7 See Canada, Director of Investigation and Research, Combines Act (1976).
- 8 Prior to 1976 both Bell and B.C. Tel were regulated by the Canadian Transport Commission.
- 9 Canada, Department of Communications (1975).
- 10 Prior to 1956, Western Electric held 44% of Northern's common shares with Bell holding the remainder. Over the 1956-62 period Bell gradually acquired all of Western's holdings in Northern.
- 11 The argument is formally correct in the sense that under these circumstances the advantages to Bell of transferring rents to Northern are reduced. They are not however totally eliminated. The effects of Bell's reduced holdings in Northern could be formally analysed in a context similar to that of our discussion of proposition 16.



- 12 See exhibit B-76-424 in Canadian Radio-Television and Telecommunications Commission (1977).
- 13 This episode is detailed in Taylor (1975), British Columbia, Attorney General of (1975), Canada, Department of Communications (1975), and the Green book.
- 14 An alternative argument is contained in a Gamma Engineering Ltd. study commissioned by B.C. Tel and reproduced in summary in Taylor (1975).
- 15 The argument put forward in this section is essentially the same as that made in Carr and Halpern (1975).

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