5 Cost Models: Comporting with Principles

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Abstract - Recent public policy initiatives in telecommunications prescribe tying certain prices and subsidies to cost. The apparent motive behind these policies is a desire to mimic competitive outcomes when markets are too frail to be trusted with the task of achieving economic efficiency. Indeed, it is true that an outcome of "perfect competition" as portrayed in university textbooks has all prices equal to respective marginal costs. However, the conditions behind this relationship include an onerous requirement that all markets be present and operating. Missing in telecommunications are markets for the present and future use of the network capacity created by both incumbent and new firms. Just as "real options" in financial markets allow for the present trading of future options to purchase financial securities, options to presently trade future network capacity would greatly improve the incentives to build optimal network capacity. In addition, such options would provide a mechanism to realize present financial rewards for the expected future value of those networks. Yet economic efficiency requires that prices reflect the option costs in addition to the costs of productive resources. Because the "cost" of capacity options is not available today, any attempt to link regulated prices to resource costs could result in prices very different than market prices. Perhaps the wiser public policy is to encourage the development of present and future capacity markets, complete with associated real options.

Standard economics pedagogy tells of firms maximizing profits through the selection of market-priced inputs, prices, and output levels that bring marginal cost into perfect alignment with market prices. It is a familiar story: costless entry and exit into and out of industries; the self-serving expansion and contraction of output by these profit-maximizing firms moves society's resources according to the needs and whims of consumers.

Recent literature pertaining to "real options" suggests that firms cannot function so in the real world. Entry decisions entail irreversible resource commitments. Uncertainty about future demand makes it difficult to justify the employment of resources, thus putting wealth at risk. But this notion of "real options" is not new. This paper reflects on some early microeconomic literature to shed light on the conformance of the pertinent cost models (models designed to formulate public policy in telecommunications) with the principles of real options.

1. MARGINAL COST PRICING

The basic principles of marginal cost pricing were developed more than a century ago. Adam Smith's "invisible hand" (1776) would silently move resources to their highest and best use in response to the selfish actions of protfit seekers and informed buyers. More formal and mathematically complete analyses began in earnest with Walras (1877), who worked out the first formal statement of the conditions for general equilibrium. During this century, increasingly advanced mathematical techniques have revealed virtually all of the conditions that must hold for there to be a general equilibrium at which prices bear mathematical relationships to cost. The results are taught in every economics program today: economic efficiency as defined by economist Vilfredo Pareto (1909), is achieved when market prices equal long-run marginal cost. It is long-run marginal cost that is relevant because the presence of fixed costs (then presumed to be only a short-run phenomenon) may require deviations from marginal cost pricing.[1]

Further insight into this peculiar p = mc relationship was gained in the 1950s and 1960s when Kenneth Arrow, Gerard Debreu (1954), and others revealed that these efficiency relationships were not just due to the convenient conventions of calculus. Using the mathematics of topology, it was discovered that, with certain "continuity" and "convexity" assumptions, competitive prices would support an efficient allocation of resources, and that each such allocation could be supported by a set of competitive prices. In an obscure way, this meant that competition would bring about economic efficiency through forces that would set prices equal to marginal cost.[2] These results were soon taken to be a prescription for economic efficiency in addition to being a descriptive characteristic of that state of affairs. But, the issues raised by the "real options" literature call this practice into question.

2. REAL OPTIONS: THE PROBLEM

"Separating hyperplane theorems," or a variant of these theorems, were the primary tool used in deriving the relationship between prices and costs. In essence, the set of possible output combinations and the set of most desirable consumption options were separated by a hyperplane that touched each set at a point where they met. The fact that the two sets met indicated that supply equaled demand. The hyperplane had a "slope" that represented the marginal costs of outputs and prices of consumable goods. Two critical assumptions embedded in the mathematical derivations of these conditions for general equilibrium did not escape the notice of mathematical economists. The mathematical results could not be produced without assuming *complete markets* and that all resources were *perfectly divisible*[3] (tiny fractions of resources such as machines and people must be available to be em-

ployed). At first, little concern was raised since one could, in principle, "rent" arbitrarily small fractions of resources rather than buy them.[4]

Soon, however, when real options to employ resources were recognized, new mathematical techniques unambiguously revealed broken ties between marginal cost pricing and economic efficiency. In a world that offers up indivisible units of resources or requires that minimum thresholds of activities be attained to be efficient, competitive prices can bring about less than efficient resource allocations. Likewise, a fog bank of uncertainty about the future demands the introduction of infinitely more markets to place prices on contingencies that depend on unknown future states of nature and the economy. The culprits, of course, are the twin assumptions that made the early mathematical results so easy to derive: the perfect divisibility of resources and the completeness of markets.

2.1 Indivisibilities

Two papers published in the late 1960s and early 1970s showed that when firms do not have real options to buy resources in arbitrarily small amounts, or when efficient levels of resource use are available at only selected scales of employment, competitive prices might be associated with inefficient resource allocations.[5] That is, the traditional laws of supply and demand might bring about equilibrium market prices, but the resulting state of affairs could be inefficient. It is precisely these market failures that invite laws and regulations to overcome inefficient or abusive practices. For example, when an incumbent firm is viewed to have good reason to operate under less than competitive market conditions (a natural monopoly, for instance), regulators may attempt to impose a set of prices and subsidies equal to or formulated from long-run marginal (or incremental) cost.

A question of foremost concern in telecommunications is whether certain prices (or prices plus subsidies) should be set at long-run marginal cost to simulate efficient prices. Indivisibilities are relevant to answering this question; their presence in telecommunications may cause fixed and common costs to exist in the long run. For example, just as the presence of fixed costs in the short run may require prices to be set above or below marginal cost,[6] the presence of fixed costs in the long run may require efficiently regulated prices to deviate from long-run marginal costs. Thus, the "real options" of firms to acquire inputs having lumpy capacities disturbs the desirability of marginal cost pricing.

2.2 Complete Markets

Perhaps more disturbing than input and output indivisibility is the problem of incomplete markets. The mathematical models that justify setting prices equal to marginal cost require that all prices have this relationship. Setting aside the well-known problem of "second best" prices, some critical prices are missing from the real economy. An example will serve better than theory to explain. When a firm is required to invest irrevocably in resources (e.g., building a wire line telephone network), invariably, there are some components of the investment in resources that cannot be liquidated if the productive capacity of the resources is not fully used. This does not present a problem to the student of general equilibrium (the discipline that deals with advanced models of marginal cost pricing); it is assumed there is a market for such risk. In the real world, insurance markets and futures markets play this role. But there are not enough insurance or futures markets to set prices for every contingency faced by telephone companies, incumbent or newly forming. Thus, financial markets imperfectly reflect the *overall* risk of the company (e.g., through the beta component of the return on equity). But one price (the risk-adjusted cost of money) is not sufficient to meet the requirements of complete markets; more prices (in theory, one for each unique risk) would be needed for markets to be complete.

This issue is relevant to the present debate: prices set equal to long-run marginal costs are not sufficient to achieve efficiency if only the costs of the physical and financial resources were included in the calculations. Additional prices are needed for the various irreversible and risky resource commitments that accompany the business. Because the real options of the operating company are limited, costs and associated prices will be missing from the calculation.

3. HOW DO THE MODELS COMPORT WITH THEORY?

All of the cost models now under scrutiny by the FCC (the BCPM, HAI, and HCPM) attempt to adhere to a set of rules set out in the FCC's dictums, beginning with the First Report and Order and proceeding through the many subsequent meetings and processes. These rules require that only the most efficient means of serving inhabited (or perhaps habitable) areas be used in the cost calculations. Prices and subsidies are then calculated to equal an approximation of long-run incremental cost. This approximation calculates the incremental costs of the service(s) in question and adds a parsed component of common costs under the presumption that true long-run marginal costs would include these costs.[7]

The models have captured, at least in spirit, the problem with indivisible resources and related matters of fixed and common costs. But the models have not captured the remainder of the real options characteristics. Among the reasons why none of the models under consideration comports with the real options are two of particular importance. The first is practical: a model sufficiently complex to capture real options is simply beyond the state of the art and science of modeling today, or at least beyond the resources of the models' sponsors. The second is the present inability of models to simulate complete markets. Each point is taken in order.

The current cost study practices in telecommunications generally accept that there are fixed and/or common costs in long-run cost studies. By acknowledging that common costs may exist and that such costs would be reflected in competitive prices, the models do comport in practice with the pertinent principles. Although the accuracy and elegance of the solutions could be improved, at least the conceptual structure of the models allows for appropriate inclusion of the proper considerations.

On the other hand, the models are not sufficiently complex to capture certain other "real options." At the simplest level, none of the models builds a network that has been demonstrated to be functionally real. For example, the BCPM recognizes that network construction encounters concrete and asphalt only in proportion to their incidence in the overall terrain being served. The reality is that plant is built on rights of way having a very different mix of such terrain. The HAI and HCPM models collect customers into distribution areas that disregard physical barriers such as freeways and rivers. Any model will necessarily fall short of the real options due to the sheer magnitude of complexities that must be considered. Of course, this is the nature of modeling. A model is deliberately an abstraction from reality and therefore ignores details of reality that do not materially affect the uses of the model. Do the models abstract too much or too little? This is the subject of ongoing debate and adversarial proceedings, and one that cannot be resolved here. "Informational deficiencies" do not by themselves render a model impotent.

The second issue, incomplete markets, is the area where the models seriously fall short, in theory and practice, of "real options." Even if it were demonstrated that the models reflect a telephone network that can operate at a point in time, it is unlikely that any company would construct such a network, either in a cost minimizing monopoly or competitive environment.

The reason is simple: the rules of model construction require that an efficient network underlie the cost calculations. This network is constructed to an existing set of premises (just which premises differs by model) using the technology com-

mercially available today. The "real options" open to any operating company are: a) to build the most efficient *increment* to an *existing* network that evolves (and minimizes cost) over time, not knowing just where and when new premises might appear; or b) to construct a *new* network to a set of existing premises anticipating what market shares or customers might demand service. Besides the uncertainty and irreversibility for which there may be no costs modeled in these scenarios (recall the incomplete markets problem), the rules require that each model build a network assumed to be the only network serving the area. Thus, another incomplete market surfaces: under the very competitive conditions that call for cost models, there will be underused network capacity in either scenario. Because there will be more than one competitive alternative, and because an efficient network operator will not engage in "just-in-time" network inventory practices, not every customer for which the network is built will opt to use that network.

This all points to the critical incompleteness of markets. The missing markets are most prominently capacity markets. There are not fully developed markets for selling the capacities (present and future) of telephone networks. While the clear impact (if not intention) of the FCC policies that have followed the Telecommunications Act of 1996 are to promote the sale and lease of network capacity (unbundled network elements and wholesale offerings), there are still limited opportunities to trade future network capacities in robust markets like those for financial securities.[8]

Can the missing capacity market problem be fixed in the context of the current models? In part yes, in part no. There are, in each of the models, parameters that can approximate many of the costs of real options. By selecting the proper fill factors (the size of the modeled network in excess of the current demand) and uncertainty in demand, a risky but possibly efficient anticipation of new premises can be accommodated. By selecting the proper depreciation rates and related cost of money, the "real options" associated with the general uncertainty and irreversibility (sunk costs) can be practicably incorporated. And so forth. However, these "fixes" can only be considered as rough and largely uninformed approximations to what real competitive markets would do.

4. THE COMPETITIVE MARKET STANDARD

Multiproduct firms in competitive markets price individual products and product lines more to meet the competition than to recover specific costs that may be allocated to those products. Common costs (using the FCC's definition)[9] are recovered from pricing above incremental costs (as they are defined today) according to the discipline exerted by competition. Similar firms, not entirely identical,

are usually the source of this competition. Each firm examines its unique economies of scale and scope to determine what prices it can afford to charge. In order to remain profitable, or at least viable, firms choose to adjust combinations of prices and products. This results in a widely varying mix of markups over marginal or incremental costs that are easily formulated on paper. In other words, there is no cost-based formula that generates market prices; extensive information about demand must be taken into account.

In addition, entry into or exit from specific product markets or industries may entail costs associated with "real option" frictions as firms adjust their scope of services. The "real options" problem associated with the general issue of irreversible investments pales by comparison to the "real option" uncertainty that arises from the dynamics of market competition. It is inconceivable that adjusting cost-based formulas that reflect "real options" in a competitive environment could usefully proxy real-market prices. Only the evolution of markets for the capacities of the assets that are largely sunk upon entry will bring prices into alignment with "real options." A good central control mechanism that substitutes for well functioning markets does not exist.

5. POLICY IMPLICATIONS

The models proposed for use in developing public policy can certainly be improved by recognizing the "real options" phenomenon. Indeed, engineering assumptions, inputs (e.g., fill factors), and model parameters can partially incorporate such concerns in a crude but useful way.

However, the intention of the Telecommunications Act of 1996 appears to be one that supplants regulation with competition over time.[10] The "real options" problem is ultimately solved by competition itself. Competition presents "real options" to firms in complex and ever changing forms. Surviving in the real business landscape is both the challenge of successful companies and the beauty of the competitive process. The "real options" debate is really about how to best make the telecommunications industry competitive.

In the long run, the most important changes in public policy should not focus on revising models. The emphasis should be on creating policies that encourage the rapid development of capacity markets. Great strides in efficiency will come from facilitating the creation and evolution of spot and futures markets for the capacity of communications and information networks.

NOTES

[1] An excellent discussion of the necessary deviations from marginal cost pricing in the presence of fixed costs is found in Baumol, W. 1988. *Superfairness*, Cambridge, Massachusetts: MIT Press, Ch. 7.

[2] More accurately, the *ratios* of prices to one another would be equal to the respective ratios of marginal costs.

[3] More generally, the topological properties of continuity and convexity used in the mathematical proofs were necessary to obtain the desired results. See Arrow, K. 1971. *General Competitive Analysis*. San Francisco: Holden Day.

[4] Of course the fundamental problem remains: rental markets that would be capable of generating arbitrarily small amounts of each resource would themselves require resources that amount to an indivisibility.

[5] Emmerson, R. 1973. *Journal of Economic Theory*, Starr, Ross. 1969. "Quasi-Equilibria in Markets with Nonconvex Preferences," *Econmetrica* 37.

[6] For example, textbooks frequently depict situations where average variable cost equals marginal cost. In these circumstances, prices equal to marginal cost provide no contribution to fixed costs.

[7] Among many parties to this argument, there is a presumption that "all costs are variable in the long run" and therefore common costs are an artifact of the short-run nature of the real world analysis. As discussed above, indivisibilities can result in long-run fixed costs. Thus, the need to address common costs in the long run cannot be so conveniently discarded. An equally important misconception is that common costs are fixed costs. In fact, common costs may exist even if all costs were variable in the long run. In any case, the FCC has chosen correctly to recognize that common costs are included in competitive prices.

[8] There are a few evolving international markets for trading country-to-country traffic. If these markets flourish and extend to intracountry traffic, the missing markets problem may be largely solved.

[9] In re Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, CC Docket No. 96-98, at & 677. Defining "common costs" as "costs that are incurred in connection with the production of multiple products or services, and remains unchanged as the relative proportion of those products or services varies."

[10] Telecommunications Act of 1996. See in particular: SEC. 257. (a), (b) (MARKET ENTRY BARRIERS PROCEEDING); and SEC. 401. (REGULATORY FORBEARANCE) as amended by the new section SEC. 10. (COMPETITION IN PROVISION OF TELECOMMUNICATIONS SERVICE).