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public utility pricing and finance

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Abstract

The theory of public utility pricing provides clear recommendations when the regulator and utility have same information about the underlying economic environment – the structure of demand and the production process. In reality, the utility has private information about the underlying economic environment, and the incentives created by the regulatory process can cause it to exploit this information by producing in an inefficient manner. This insight complicates virtually all aspects of the theory of public utility pricing, and has led to theoretical characterizations of the public utility price-setting process as the solution to a mechanism design problem.

Keywords

asymmetrical information; Averch–Johnson effect; cost functions; cost-of-service regulation; increasing returns to scale; inverse elasticity pricing rule; multi-part tariffs; multi-product firms; natural monopoly; optimal pricing; price cap regulation; principal and agent; privatization; public utility pricing and finance; Ramsey pricing; regulatory contracts; two-part tariffs

Article

Public utilities typically provide goods and services using a physical or virtual network infrastructure under a legal monopoly status. Public utilities can be privately owned, government-owned and customer-owned. Products provided by public utilities include electricity, natural gas, water, sewage treatment, waste disposal, public transport, telecommunications, cable television and postal delivery services. In the United States, all the different ownership forms can exist within the same industry. For example, in the electricity supply industry, there are privately owned, investor-owned and municipally owned utilities, and cooperative utilities owned by their customers.

Many explanations have been offered for the public utility industry structure. The standard economic efficiency argument is that the industry is natural monopoly, meaning that a single cost-minimizing firm is the least-cost way to serve the current level of demand. However, this logic relies on the implicit assumption that the single firm will produce in a cost-minimizing manner, which is unlikely to occur under government ownership or government regulation, for the reasons discussed below. In addition, although the current level of demand may be served at least cost by one cost-minimizing firm, this is unlikely to be that case for all future levels of demand as the number of customers or their purchasing power grows. Recognizing that public safety and health concerns argue for universal access to many of these services and the fact that the demand is very inelastic with respect to its own price leads to political economy explanations for this public utility industry structure. As Waterson (1988) notes, a government-owned or -regulated monopoly may better ensure that all customers have access to these services at reasonable prices.

Over the 100 years or more of state and federal regulation of public utilities in the United States there has been debate over what constitutes a reasonable price for goods and services of public utilities. A price that recovers the firm's operating costs including return on its capital stock is generally considered to meet the legal standard of a reasonable price. This form of price regulation in the United States is often referred to as ‘cost-of-service’ regulation. However, as Joskow (1974) has persuasively demonstrated, the price-setting process for privately owned utilities in the United States does not guarantee the firm a fixed rate of return on its capital stock or full operating cost recovery. In that sense, to call this regulatory price-setting process ‘cost-of-service’ regulation is a misnomer. Joskow (1974, p. 325) states: ‘The rate of return aspect of regulation is merely a method by which a regulatory commission justifies its approval of price increases or major changes in rate structures. Without such triggering mechanisms the rate of return constraint is essentially inoperative.’ When the cost-of-service regulatory process operates it sets a price that allows the public utility an opportunity to recover its operating costs and the regulated rate of return on its capital stock through prudent operation.

If the firm earns a higher rate of return at this price because of superior management, then it is allowed to keep the revenue. If the firm earns a lower rate of return because of poor management, then shareholders must accept a lower rate of return. Only when the regulatory commission has overwhelming evidence that the higher or lower rate of return is due to extraordinary events beyond the control of the firm and not anticipated at the time the regulatory commission set the price will it make *ex post* adjustments to alter the public utility's regulated rate of return. A well-known example of an extraordinary event is a price change for fossil fuels used to produce electricity. The extreme volatility in oil, natural gas and coal prices since 1977 has led many regulatory commissions in the United States to implement fuel price adjustment clauses that automatically pass through in any input fuel price changes in the price of electricity. Baron and De Bondt (1979) discuss the impact of these fuel adjustment mechanisms on the investment and operating decisions of regulated electricity and natural gas utilities.

The terms and conditions surrounding this promise of full cost recovery through prudent operation is often referred to as the ‘regulatory contract’ between the regulatory commission and the public utility. This implicit contract requires the utility to serve all demand at the price set by the commission in exchange for a price that allows the utility the opportunity to recover its operating costs and a reasonable return to its capital stock. A major challenge to this regulatory contract is determining when imprudent operation is the cause of a failure to achieve full cost recovery.

For a number of reasons, unexpected events outside the control of the regulatory commission or utility and *ex post* opportunism by the regulator are often very difficult to distinguish from valid reasons for the regulatory commission to disallow price increases. Utilities typically require substantial investments in a network infrastructure that has limited alternative uses. The future demand for the public utility's services is uncertain, so there is a substantial risk that investments in network infrastructure will not be needed to serve the demand that exists when the investment is completed. Several aspects of the regulatory process in the United States are designed to address the problem of the regulator setting a price that is insufficient to provide a reasonable return on past investments. The concept of a ratebase and the requirement that the regulatory commission sets a price that recovers operating costs and a reasonable return on the entire ratebase limits opportunistic behaviour on the part of the regulatory commission. To a first approximation, the ratebase is the sum of all past investments judged as prudent and therefore worthy of cost recovery by the regulatory commission. Phillips (1993, ch. 8) provides a detailed discussion of this concept. The requirement that the entire ratebase earns the regulated rate of return ensures that the current regulatory commission compensates the utility for investments that previous commissions have deemed prudent. Gilbert and Newbery (1994) construct a dynamic model of the regulatory price-setting process where the commitment to allow the firm to earn a reasonable rate of return on a ratebase composed of past prudent investments results in a socially efficient level of investment by the regulated firm. Lyon and Mayo (2005) investigate the empirical relevance of regulators’ opportunistic behaviour by examining the investment behaviour of regulated electric utilities and the propensity of the relevant state regulatory commissions to disallow investments by these utilities from entering the ratebase. Lyon and Mayo (2005) find little evidence that these cost allowances by the state regulatory commissions were due to opportunistic behaviour, and instead argue they were motivated by a desire to punish poorly managed firms.

Optimal pricing of public utility services with full information

Prices that adhere to the implicit regulatory contract of allowing full cost recovery only impose one restriction on the set of possible prices. For the case of a single-product utility that must set the same price for all customers, this restriction implies that the regulated price is equal to average total cost. However, virtually no public utilities sell a single product or are required to set a single price for all customers, so that regulatory commissions are free to pursue additional goals, besides the promise of cost recovery, in setting regulated prices.

This section discusses methods for setting economically efficient prices – those that maximize some social welfare function – under the simplifying assumption that the utility and the regulatory commission have the same amount of information about the utility's production process and demand. The remainder of this section assumes symmetric information between the regulated utility and the regulatory commission, so the commission can credibly set a price that only recovers the firm's minimum cost of serving its demand. Although the assumption of symmetric information about the production process and nature of demand between the utility and regulatory commission is unrealistic, the literature on optimal pricing for public utilities described in this section relies on this assumption.

Two-part tariffs relax the assumption that a single uniform price is charged to all customers for each unit of output. If the production of the good or service is subject to increasing returns to scale, setting price equal to the marginal cost of the last unit sold violates the legal requirement that the firm has an opportunity to recover total production costs. Coase (1946) addresses this problem by considering a regulated public utility producing a homogenous product with a monthly fixed cost of production, F, and a constant marginal cost, c. Coase (1946) argues that the total surplus maximizing two-part tariff sets the price of each unit consumed, p, equal to c and the fixed charge for each customer equal to F/N, where N is the number of customers served by the public utility.

If consumers differ in their willingness to pay for the product, then the surplus accruing to some consumers can be increased by the commission setting multi-part tariffs that charge different marginal prices for different ranges of monthly consumption. If the level of the monthly fixed charge necessary to recover total monthly fixed costs causes some consumers not to purchase the product, then a multi-part tariff can increase total consumer surplus. Assuming the marginal cost of a minute of telephone service is two cents per minute, setting a low monthly fixed charge and charging two cents per minute for the first 200 minutes of phone calls in the month and four cents per minute for all minutes above 200 minutes per month can allow the phone company to increase the number of consumers that benefit from having a telephone service without violating the promise of cost recovery. In this way, those consumers with the highest willingness will select through their consumption choice the higher marginal price, while those with the lowest willingness will select the lower marginal price, and virtually all consumers will pay a monthly fixed charge that does not cause them to disconnect from the telephone network. Brown and Sibley (1986, ch. 4) discuss consumer and producer welfare properties of multi-part tariffs.

The nature of the goods and services sold by public utilities often allows them to segment customers and to charge different prices for the same product. In addition, virtually all public utilities are multi-product firms, which implies that the regulatory process involves setting prices for all goods sold by the firm. Both of these circumstances provide opportunities for regulatory commissions to pursue objectives beyond the promise of cost recovery.

Consider the case of a homogenous product with increasing returns to scale in production that is sold to M different sets of consumers and a regulatory commission that can set a single price for each set of customers. Deriving the total surplus maximizing prices for all customer types subject to the constraint on cost recovery fits into the framework considered by Ramsey (1927). Let $CS_i(p_i)$ equal the consumer surplus accruing to consumers of type i and when they face price p_i, and $PS_i(p_i)$ equal the producer surplus from serving consumers of type i. Ramsey prices maximize the objective function $TS=\Sigma_{i=1}^{M}[CS_i(p_i)+PS_i(p_i)]$ subject to the cost recovery constraint, $F\leq\Sigma_{i=1}^{M}PS_i(p_i)$, where F is the firm's fixed cost. Let c equal the marginal cost of production and $\varepsilon_i(p_i)$ the own-price elasticity of the demand by customers of type i at price p_i. The solution to this constrained optimization problem yields the inverse elasticity pricing rule:

$$\frac{(p_i^*-c)}{p_i^*}=-\frac{k}{\varepsilon_i(p_i^*)},\ i=1,2,\ldots,M$$

where k is some positive constant and the p_i^*, i=1,2,…,M, are called Ramsey prices. These prices raise the revenue necessary to achieve full cost recovery with the smallest total surplus loss. Those consumer types with relatively more inelastic demands for the goods pay higher markups above marginal cost than other consumer types.

This same Ramsey-pricing logic can be applied to the case of multi-product public utilities. However, the simplicity of inverse elasticity pricing rule is complicated by the fact that customers can substitute across the products that the public utility offers. For example, in the pricing of postal delivery services, a business mailer has the option to use different US postal service products to communicate with its customers. To set Ramsey prices, the regulatory commission must know the multi-product cost function for postal products and the consumers' surplus associated with each postal product, which depends on the price charged for other postal products that the consumer can use as a substitute. As shown in Brown and Sibley (1986, ch. 3), both own-price and cross-price elasticities of demand now determine the total surplus maximizing markups that solve the Ramsey-pricing problem.

The properties of the regulatory pricing mechanisms described in this section rely on the assumption that the public utility's cost function is the minimum cost way to produce each vector of outputs. Specifically, let T equal the public utility's technology set, the pairs of vectors of input quantities, x, and output quantities, q, such that q can be produced using x. If w is the vector of input prices, then the minimum cost function is equal to

$$C(q)=\min_{x\geq 0}w'x\ \text{ subject to }\ (x,q)\in T.$$

Although a price-taking profit-maximizing firm would like to produce along its minimum cost function, the structure of the regulatory process could cause a privately owned profit-maximizing regulated utility not to produce along its minimum cost function. Averch and Johnson (1962) present an example of a regulatory mechanism that causes a profit-maximizing firm not to produce in a least-cost manner. This work led to a massive theoretical and empirical literature exploring the distortions from minimum cost behaviour caused by regulatory price-setting processes.

State-owned utilities are likely to have even less incentive to produce in a least-cost manner. Besides the incentives provided by the regulatory price-setting process, earning revenues in excess of operating costs is just one of the many objectives that managers of state-owned companies must balance. As Waterson (1988, ch. 4) notes, state-owned utilities are often asked to pursue political or social goals that conflict with maximizing profits and therefore minimizing production costs.

Economists have begun to recognize the distinction between a public utility's observed cost function and its minimum cost function. The observed cost function, $CO(q)$, gives the firm's actual cost of producing output vector q given the incentives provided by the regulatory process. For example, in the case of a state-owned utility, political constraints could require a firm's management to hire a certain number of workers for each level of output despite the fact that it is technologically feasible to produce using fewer workers at each output level. In general, the value of the firm's observed cost function is greater than the value of its minimum cost function for the same level of output, and this difference can be substantial.

There is a vast empirical literature documenting violations of the assumption of cost-minimizing behaviour by public utilities. Christensen and Greene (1976) is a well-known example in the electricity supply industry and Evans and Heckman (1984) is one for the telecommunications industry. There are few empirical studies of regulated utility behaviour where the assumption of cost-minimizing behaviour is not rejected.

Optimal pricing of public utility services with asymmetric information

Public utility regulation has long been recognized as an example of agency relationship where the regulator (the principal) attempts to provide incentives for the public utility (the agent) to serve its demand in a least-cost manner at a price that only recovers observed costs. This link between the utility's production costs and the price it is allowed to charge creates the opportunity for the public utility to exploit its superior information about the production process and the demand it faces. This recognition has led researchers and regulatory policymakers to consider ways to either break this link between the price charged and the firm's observed cost or to design incentive mechanisms that exploit the link between the regulated price and the firm's observed cost.

Price-cap regulation attempts to break this link by committing to change the price the utility is allowed to charge according to a formula that cannot be altered for a sustained period of time. For a profit-maximizing firm, the price-cap mechanism creates the same incentive to minimize cost as the assumption of price-taking behaviour. In the United Kingdom (UK) this form of regulation is also called RPI minus X price-cap regulation because the rate at which prices are allowed to change on an annual basis is equal to rate of change in the retail price index (RPI) minus an X-factor chosen by the regulatory commission. Armstrong, Cowan and Vickers (1994, ch. 3) describe the details of choosing an X-factor for a specific firm and extensions of this basic regulatory framework.

The major challenge associated with price-cap regulation is balancing the desire to commit to a pre-specified pattern for the X-factors for as long as possible against the fact that the longer duration of the commitment to this pattern of X-factors the greater the likelihood that the commitment will run afoul of the regulatory contract or political concerns. The experience of many public utilities in the UK privatized during the 1990s provides an instructive example of this phenomenon. According to Armstrong, Cowan and Vickers (1994), the regulator for the water industry and the regulator for the electricity distribution sector initially committed to a five-year initial duration for values of the X-factors. However, in both these industries the regulator was forced to abandon these commitments before the end of the five-year period because of what was argued to by the water utilities to be inadequate revenues and what was argued by many consumers as excessive revenues in the case of the electricity distribution sector. Wolak (1998) discusses practical problems associated with implementing price-cap mechanisms and why they often evolve into an extremely ineffective form of cost-of-service regulation.

The development of game theoretical models of private information environments has led economists to derive optimal prices in this ‘second-best’ world. Baron and Myerson (1982) derive the total surplus maximizing prices when the public utility has private information about its production process not observable by the regulatory commission. The Baron–Myerson model assumes that the commission offers the firm a menu of prices and fixed fees that depend on the public utility's report of its private information. This report determines what price and fixed fee the firm is able to charge to its customers and therefore the revenues it is allowed to earn.

Recognition that informational asymmetries between the regulatory commission and utility can lead to significant distortions from minimum cost production and regulated prices that recover revenues substantially higher than these minimum costs has led to an explosion of theoretical work on the design of optimal regulated prices in this private information environment. Laffont and Tirole (1993) provide a comprehensive presentation of this literature.

Wolak (1994) attempts to quantify the cost of this private information in the regulatory process. Using a sample of California water distribution utilities, he estimates a full or symmetric information solution to the utility and regulatory commission interaction and a private or asymmetric information model of this interaction based on the Baron–Myerson (1982) model. Wolak (1994) finds that the asymmetric information model of the regulatory process provides a superior fit to observed data relative to the symmetric information model in addition to computing various estimates of the cost of the informational asymmetry between the firm and regulatory commission.

Concluding comments

The explicit recognition of the impact of the private information possessed by the firm on the price set by the regulatory commission has increased the realism of the assumptions underlying models of the public utility price-setting process. Unfortunately, the form of the optimal price-setting mechanism derived from these models depends crucially on the source of informational asymmetries between the firm and the regulatory commission, as well as many other details of the economic environment. This implies that much more empirical work on actual regulatory price-setting processes is needed to implement these theoretical advances in actual regulatory practice.

See Also

- Averch–Johnson effect
- mechanism design
- principal and agent (i)
- principal and agent (ii)
- price discrimination (theory)
- Ramsey pricing

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