

CHAPTER 12

Regulated costs and prices in telecommunications

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Introduction

Economic advice to regulators regarding the correct principles to set regulated prices has often been flawed in that it does not recognize the underlying technology of the industry. Economists recognized early on that in the situation of privately-owned utilities in the United States (US) that the first-best prescription of price set equal to marginal cost could not be used because of the substantial fixed (and common) costs that most regulated utilities needed to pay for (see Kahn, 1970). This realization typically accompanied the claim that the economies of scale of the regulated firm were so significant that competition could not take place because the regulated firm's cost function was significantly below that of new entrants. Nevertheless, the most common advice from economists was that prices should be set similar to the outcome of a competitive process. What the competitive process would be was never specified with any detail, which was to be expected since economic theory had no well-accepted model of competition with a technology exhibiting strong economies of scale, especially in the multi-product situation.

In the US regulators following legal principles adopted the position that the regulated firm should cover its costs. However, regulators also adopted prices for certain services to attempt to meet social goals for these given services. For other services, regulators used arbitrary means to set prices while balancing competing claims from increasingly well organized groups of consumers, all of whom claimed they should receive low prices with other groups paying for the fixed and common costs. This regulatory approach arguably did not do undue damage when no actual competition existed. So long as the regulated firm was (nearly) productively efficient, the losses were essentially second-order social welfare losses.¹ The regulated firm covered its total costs, at least approximately, although prices for individual services were often badly distorted from an economically efficient solution. However, when actual competition appeared and was allowed to exist by the regulators, the economists' advice of setting prices as if they were the outcome of a competitive process soon led to a regulatory morass. Regulators could no longer depend only on cost factors in setting regulated prices. The outcome of a competitive process would also need to take into account demand and competitive interaction (oligopoly) factors, with the first set of factors difficult to measure and the competitive interaction factors unlikely to be agreed upon. While regulators had some imperfect information about costs, they typically had little or no information about demand and no well-developed idea regarding the effects of competitive factors. In the following two sections the question of whether using costs to set regulated prices, while disregarding demand factors and competitive factors, is a reasonable economic policy are discussed.

A particularly difficult problem arises when a regulated firm wants to decrease its prices for services subject to entrant competition. Economists recognize that price set above incremental (marginal) cost should be permitted. New entrants want the

previously regulator-set prices be maintained. New entrants typically enter because regulated prices are well above efficient levels, and they do not want these prices reduced. Furthermore, from a social welfare viewpoint the argument became first-order since inefficient new firms could be productively inefficient causing a first-order loss of social welfare. Regulators found it difficult to permit the regulated firm to reduce its prices, since under cost of service regulation other prices would need to increase. Even when cost of service regulation was replaced by incentive (price-cap) regulation in the 1980s and 1990s, regulators found it extremely difficult to allow price reductions since they believed in 'regulated competition' (an oxymoron) where regulators could better manage competition than the market. Nevertheless, the regulated companies were not harmed too badly since competition did not proceed at such a rapid pace so as to cause extreme economic damage.

Cost-based regulation of telecommunications, e.g., rate-of-return (ROR) regulation in the US, had substantial negative effects on innovation while it was claimed that it led to excessive capital investment. Most economists conclude that cost-based regulation led to significant consumer harm. In the mid-1980s when the UK government privatized British Telecom, it decided not to use the historic approach of cost of service regulation to set regulated prices as the US and Canadians had. The UK government instead chose price caps a regulatory method proposed by Littlechild and discussed in Beesley and Littlechild (1989). Price caps are regulated prices based on inflation and a productivity factor instead of regulated profits as in the US cost of service based ROR regulation. Price caps have a number of advantages over ROR regulation in terms of incentives for cost minimization (productive efficiency), innovation, and the ability of the regulated firm to rebalance its prices. In particular, the regulated firm can reduce its prices to compete. In 1989-1990 the US Federal Communications Commission (FCC) adopted price caps. During the 1980s and 1990s price-cap regulation was implemented instead of cost-based regulation in most countries when telephone companies and other utilities were privatized. In the majority of the states of the US, ROR regulation has been replaced by price cap-regulation. The battle to banish cost-based regulation appeared to be largely over.²

During the late-1990s and the early-2000s cost based regulation has reappeared because of the necessity to set price for unbundled network elements sold by incumbent firms to their competitors. Several governments including the US, Australia and Canada adopted mandatory network unbundling for the incumbent local exchange carrier (ILEC). The most commonly used approach to set regulated network element prices based on total service long run incremental cost or TSLRIC. Unfortunately, the adoption of TSLRIC as a cost basis to set the prices for unbundled elements has negative economic incentive effects for innovation and for new investment in telecommunications networks. TSLRIC provides an incorrect basis to set regulated prices as it fails to recognize that a significant proportion of telecommunications networks are sunk costs. Instead, TSLRIC makes the assumption that costs are fixed but not sunk so that the capital assets could be redeployed in other uses if technology advances or other economics events decrease the return on the assets. Failure to recognize the sunk-cost character of much network investment leads to the granting of a free option to the regulated incumbent's competitors. This causes incumbent firm shareholders to fund the free option, as competition will lead to under-investment by both the incumbent and competitors. The incumbent under invests because it will not achieve (on average) a sufficient return to justify marginal investments due to the grant

of the free option to its competitors. New competitors, who receive the 'free option', will under invest in facilities because of the subsidy they receive with the grant of the free option. Uncertainty in a dynamic industry, with rapidly changing technology and economics, can have an especially large effect on investment incentives because the value of the option is high. Losers are consumers and business that do not have access to the most up to date services had the regulation not created disincentives to invest.

How did network unbundling and a return-to-cost based regulation become government policy? In 1996 the US Congress passed the Telecommunications Act. As trade-off for permitting local telephone companies to provide long distance, they agreed to unbundle their networks.³ The FCC adopted cost-of-service regulation to set the unbundled network element prices. Thus, the well-known problems of cost-of-service regulation with its inability to correctly treat economies of scale and scope, and its use of arbitrary allocations of fixed and common costs to prices all reappeared. Even worse, the FCC adopted the approach of total element long run incremental cost (TELRIC) that assumes that all investments in telecommunications networks are fixed, but not sunk. This assumption is, of course, directly contradicted by the actual technology of telecommunications networks. Perhaps an even more troubling development is that a number of countries such as the UK and Australia have adopted a similar incorrect regulatory cost-based approach called total service long run incremental cost (TSLRIC). It appears likely that the European Union will adopt a similarly incorrect approach. What is particularly troublesome is that the inventor of TSLRIC has now stated that the failure to account for sunk costs is a mistake.

Below I discuss why the cost-based approach to regulation, which ignores demand factors and competitive factors, is wrong except under a very special set of assumptions. The assumptions, used in the 'non-substitution theorem' are closely connected to Marx's labor theory of value, and never hold true, even approximately in real-world telecommunications networks. Thus, the regulatory attempt to set prices independent of demand does not make economic sense. However, even within this approach why the failure to take account of sunk costs, lead to a large downward bias in setting regulated prices is discussed.⁴ The assumption that network investments are fixed, but not sunk, leads to a large error. Also, by giving a 'free option' to new entrants the policy creates an economic disincentive for facilities based investment by the new entrants. Instead, they find it better to accept the below cost use of the incumbent providers network. Thus, regulators' attempt to set price that would occur in a competitive market is very far removed from the real world technology and competition that would exist in a competitive telecommunications market. FCC-type regulation is leading to reductions in economic efficiency and decreased consumer welfare. Instead, regulators should permit actual competition to occur rather than trying to choose the form of regulated competition they think should take place.

In the final section of this review chapter I consider the question of which elements of the incumbents network should be subject to mandatory unbundling.⁵ The goal of the 1996 Telecommunications Act is increased consumer welfare and competition. Thus, a consumer welfare approach to mandatory unbundling is discussed. The approach is in contrast to the US regulators' approach of a competitive welfare standard. A competitor welfare approach leads to reduced investment and innovation compared to a consumer welfare approach. The likely outcome of government policy in the US, in contrast to the approach taken in Canada and Australia, will be to harm US consumers.

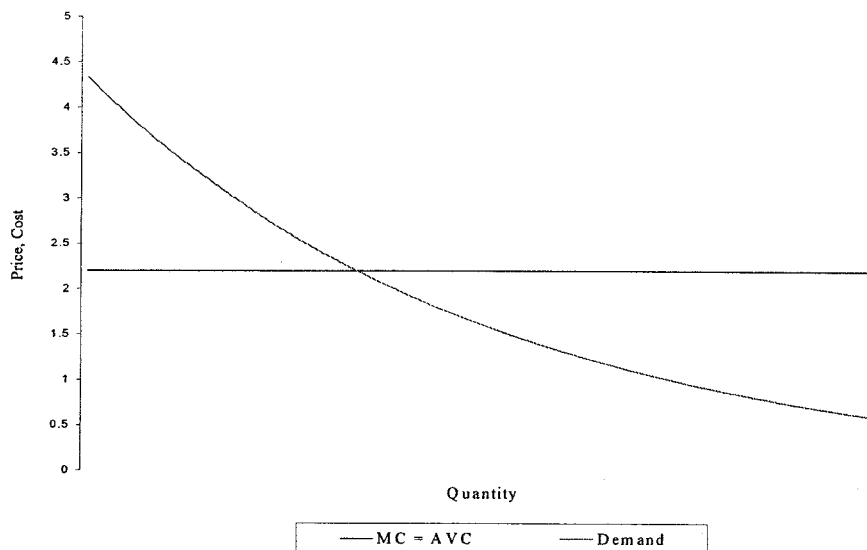
A simple model of cost-based regulation

The model of cost based regulation is to use costs of production to set prices that would be the result of a 'competitive' situation. These costs of production are used to set prices independent of demand factors. A very simple one-good one-period Marshallian partial equilibrium model leads to the result, where competitive price is independent of demand.

Conditions for prices independent of demand

Assume that a regulated telecommunications service is produced by one or more inputs. No multi-period capital goods are present. The production technology exhibits constant returns to scale. In Figure 1 it follows that competitive price equal marginal cost, which in turns equals average cost, because of the constant returns to scale assumption. The position and shape of the demand curve does not matter in setting the competitive price. Under these conditions, cost determines price, independent of demand. This interesting result depends very much on the assumptions of the economic model: partial equilibrium so that demand for the product does not affect input factor prices, constant returns to scale so there are no economies of scale, a single product so there is no joint production and no economies of scope, and a single period so there are no durable capital goods. When any of the assumptions fails to hold, competitive price cannot be based on cost, independent of demand. Thus, the price independent of demand result turns out to be a very special result not applicable to real-world telecommunications.

Figure 1. Cost and Price with Constant Returns to Scale



The role of fixed costs and economies of scale

Now suppose that marginal cost remains constant but that fixed costs of production are introduced. However, a single service continues being produced. The cost function is written as:

$$C(q; w) = F + wq \quad (1)$$

where F is the fixed cost, q is output quantity, and w is the constant marginal cost per unit of output. A regulator might conclude that in a competitive, free entry situation that price would equal average cost, so that $p = (C/q) = (F/q) + w$. Since quantity demanded is a function of price, price is no longer independent of demand. However, setting price equal to average cost, AVC , seems to be the correct outcome if the regulated utility is to recover its costs.

The role of common costs and economies of scope

A common cost arises when more than one service arises from a production process, but some of the cost is incremental to neither product. The term 'fixed and common costs' arises often in discussion of regulated costs and prices because of the common occurrence of this type of cost. In terms of the cost function again assume constant marginal costs for both outputs:

$$C(q_1, q_2; w_1, w_2) = G + w_1q_1 + w_2q_2 \quad (2)$$

Note in (2) the fixed cost G cannot be uniquely assigned to either output. Indeed, no measure of average cost for either output exists. Here regulators typically choose to use an allocation of the fixed cost G to each service. However, allocations such as fully allocated cost, equal allocation of cost and so on are inherently arbitrary.⁶ Nevertheless, the results of such allocations have very important consequences for regulated prices. These regulated prices in turn have important effects on competition, economic efficiency and consumer welfare. In competitive markets, firms set price based on cost, demand and competitive conditions. Regulators attempt to base prices only on the first of these factors. Thus, regulators do not meet their goal of setting regulated prices in a similar manner that competitive markets do. Furthermore, they cause billions of dollars annually in losses in economic efficiency and consumer welfare.⁷ Instead of using inherently arbitrary allocation procedures, regulators should either take account of demand and competitive conditions in setting regulated prices or adopt procedures such as global price caps which will lead the regulated utility to take account of demand and competitive conditions.⁸

The role of sunk costs

The model is generalized further by considering sunk costs in addition to fixed costs. Sunk costs are costs that cannot be recovered when the economic activity ceases. Sunk costs are prevalent in telecommunications networks consider an investment in a (copper) loop to a residential customer. The customer has a unique loop that connects the residence to the central office switch. When a customer decides to use a competitive

service, e.g., local access service offered by a competitive cable company or a wireless company, the copper loop cannot be redeployed. The investment in the loop is sunk. When a regulated telephone company faces no uncertainty over the future use of the loop and the cost and prices for the associated services provided with the loop, the distinction between a fixed cost which arises from an asset which can be economically redeployed and a sunk cost is not that important. Indeed, in the 'old days' of cost-based regulation for a monopoly provider if an investment was deemed to be 'used and useful' by the regulator, the asset entered the regulatory cost base. Once the asset entered the regulatory cost base, the regulator, in principle, allowed the utility to recover the cost of the investment.⁹

However, in a situation of competition, where the utilities' competitors are allowed to use the incumbent's network at regulated prices, the distinction between fixed and sunk costs can be quite important. The competitor typically pays for the facility it uses on a monthly basis. As regulators assume investment costs are fixed but not sunk, competitors receive a free option to use the incumbent's network at a price that fails to take account of the sunk cost nature of much of the investment. The regulators thus subsidize competitors at the expense of the incumbent and create an economic disincentive for competitors to invest in their own facilities.¹⁰ Furthermore, the regulators reduce the incentive for new services to be offered by the incumbent. New services often fail. Yet if successful new services must be resold to competitors at cost, the incentive to undertake the required risky investment is diminished.¹¹

Cost-based regulation: Economic analysis with cost but not demand

In a simple one-period and one-good production model with constant returns to scale a partial equilibrium Marshallian analysis demonstrates that the competitive price does not depend on demand. Marginal and average costs are independent of the quantity produced, so the position of the demand curve does not affect the price. However, the required description of technology does not depict accurately the telecommunications industry. For example, telephone and wireless networks have a very large proportion of fixed and sunk costs. Whether the 'price independence of demand' type result holds in a broader context is considered next to see if this result is (approximately) applicable to telecommunications. To do so non-substitution theorems, which demonstrate that under certain conditions an economy will have a unique price structure determined by the costs of production and independent of the structure of final demand are considered. These results are referred to as Samuelson-Mirrlees non-substitution theorems (see Samuelson, 1961 and Mirrlees, 1969).¹² Initially consider only the simplest situation where labor is the only non-produced factor in the economy. Here a set of necessary conditions that would lead to a Samuelson-Mirrlees non-substitution theorem result:

Necessary conditions for a non-substitution theorem are:

- (a) *Only one non-produced good exist.* The good is usually assumed to be labor so that land or minerals do not exist.
- (b) *The technology has constant returns to scale.* A constant per unit requirement of inputs occurs regardless of the amount of output. This condition rules out economies of scale.

- (c) *No joint production.* A single production process cannot lead to two or more different outputs. This condition rules out economies of scope.
- (d) *The economy is productive.* The economy can produce a positive net vector of outputs where net output is gross output minus inputs.

With these (plus some additional technical) conditions product prices are independent of final demand. Product prices equal the cost of production, denominated in terms of the *numeraire* that can be units the non-produced good. Thus, in a Samuelson-Mirrlees non-substitution model, prices of the many products in the economy are independent of demand as in the simple partial equilibrium single-product Marshallian model.

Enter the Marxian theory of value

Since labor is the only primary input in an economy described by the non-substitution theorems and prices are independent of demand, what sets this price? Prices are set by the cost of production, as in the Marshallian example, and the cost of production is the sum of direct plus indirect labor costs in a one-period economy.¹³ Actually, solving the dual problem to the linear programming problem which minimizes the cost for a given final output vector that yields the non-substitution theorem result leads to the conclusion that the labor costs will be minimized in the problem. These minimized costs establish the prices in the non-substitution theorem economy and are independent of final demand. This result is similar to the Marxian labor theory of value (see Morishima, 1973). When the situation is generalized to more than one period and durable capital goods are present, the cost of production remains direct plus indirect labor costs. However, the labor costs embedded in the durable capital goods increase at the economy-wide rate of interest, connected to the steady-state growth rate of the economy, each period.

It is worth noting that the 'Marxian theory of value' terminology is not a 'Marxian theory of price'. The Marxian theory of value arises from the labor cost of production theory as discussed above in a particular multi-sector economic model. A huge literature exists that attempts to go from this labor theory of value to the competitive price in the context of Marxian analysis — the so-called transformation problem between values and competitive prices (see Samuelson, 1971 and Morishima, 1973). Marx understood that market determined competitive prices could differ greatly from those of the labor theory of value.¹⁴ Furthermore, Marx and his followers were unsuccessful in solving the transformation problem except under very restrictive and uninteresting assumptions. Thus, both Marx and his followers were unable to go from a cost basis in terms of labor costs to observed competitive prices (independent of demand). Cost-based regulation is involved in a similar exercise to this 'crude' Marxian economics of determining prices that would result in a competitive economy solely from some measure of cost, which is an impossible task under realistic economic conditions. But regulators attempt to set competitive prices while disregarding demand has some interesting connections with Marxian economic analysis. Regulators and some Marxian economists have attempted a remarkably similar yet mistaken approach to determine competitive prices from a basis determined solely by the costs of production.

Necessary assumptions and economic reality: The 'regulatory fallacy'

Could the regulatory goal of setting competitive prices independent of demand hold approximately true in a realistic economic situation? Since the assumptions for the Samuelson-Mirrlees non-substitution theorems are necessary assumptions, no weaker assumptions will do. Thus, to correctly set prices independent of demand the four necessary assumptions must hold true. The first assumption of only a single non-produced factor cannot be correct in a modern economy. If labor and land (minerals) are both non-produced factors their relative prices will affect input costs and final product prices. But their relative prices will depend on the pattern of demand for products that use both labor and land (silicon, copper and silver). Since products will use in direct and indirect form different proportions of the non-produced products, the relative prices cannot be independent of demand.¹⁵ Then neither the cost of production nor final product prices can be independent of demand. How important this departure from the necessary assumption is cannot be resolved easily. It may not be that important since should it be considered telecommunications is a separable sector of the economy, similar to partial equilibrium analysis, it might be claimed that the sector is small enough compared to a given regional economy for service and the world economy for capital goods that it does not have a significant effect on the relative prices of primary factors. The price of the Hicksian composite economy for the non-telecommunications sector might be used as a *numeraire* without too much departure from reality. The last assumption, that the economy is productive, is disposed of with the remark that as an approximation its likely departure is unimportant.

The most important necessary assumptions for the current application are no economies of scale and scope. The presence of substantial economies of scale has traditionally been given as one of the primary reasons for regulation (see Kahn, 1988, II, pp. 119ff). The old question of a natural monopoly is based on large economies of scale. Whether or not the claim of a natural monopoly is correct, modern telecommunications network regulation in the US, UK, Australia and Canada is based on the importance of economies of scale.¹⁶ The idea is that a new entrant cannot duplicate the telecommunications network so the incumbent provider is required to sell the use of its network to the entrant at regulated cost. The common terminology of fixed and common costs in telecommunications denotes the importance of economies of scale that arise from fixed costs in modern telecommunications networks. The regulated price typically ignores demand factors that are inconsistent with the notion of economies of scale. The higher is demand the lower is per unit cost, especially when fixed costs are taken into account.¹⁷

The no economies of scope assumption of the Samuelson-Mirrlees non-substitution theorems is violated by all modern telecommunications networks. An example of joint production arises with modern telecommunications switches, which are combinations of computers and switch blocks.¹⁸ Switches route calls but they also provide other services such as voice mail. The same computer is used to provide both services in a less costly manner than if switching and voice mail were provided separately. Again economies of scope are one of the stated reasons for required resale of network functions by incumbent telephone companies to their competitors. Another indication of the importance of economies of scope is the concern with common costs in debates over regulated prices. Common costs are typically defined to be costs that arise from two (or more) services but the costs are not incrementally caused by either service

alone. The FCC, the Canadian CRTC, and some state regulatory bodies have arbitrarily set a markup to the direct cost of 20%-25% to take account of common costs.

Yet economists know that most modern competitive companies have joint production and common costs for the production of their outputs. These competitive companies base their prices on competitive conditions for their products. Competitive conditions take account of demand conditions that arise from overall market demand for the product as well as firm demand conditions that arise as a result of competition. While regulators often say they want to replicate the outcome of a competitive process, they miss the obvious point that a competitive process involves cost factors as well as demand factors. Regulators, to the contrary, ignore the effect of demand factors on competitive outcomes. Instead, regulators use arbitrary mark-ups over some measure of incremental (or variable) cost to account of economies of scale and scope. These arbitrary mark-ups decrease economic efficiency and consumer welfare substantially.

H An additional necessary assumption for a non-substitution theorem to hold is that the economy is on a steady-state growth path. This assumption allows for durable capital goods to enter the model. This assumption for an economy may be a reasonable approximation in certain circumstances, but for the telecommunications sector it departs from an approximation to economic reality.¹⁹ Economists agree the telecommunications sector is among the most dynamic in the economy. And since the durable capital goods used in the telecommunications sector are closely connected to semi-conductors and optical transmission, innovations in these sectors will directly affect investment in capital goods in telecommunications. Thus, the steady-state growth assumption is not a good assumption for telecommunications.

Thus, my overall evaluation is that modern telecommunications differ in many significant and quantitatively important ways from the necessary conditions for price to be independent of demand. Economies of scale and scope are universally recognized to be important economic characteristics of modern telecommunications networks. The regulatory attempt to set prices as if they were the outcome of a competitive process but to ignore the importance of demand factors leads to the 'regulatory fallacy'. No serious student of economics would claim that the necessary conditions for the non-substitution theorem hold in a telecommunication network environment. Yet the regulatory assumption that price would be based on cost alone in a competitive market is wrong. Economic theory has developed precise conditions when price is independent of demand, and they do not hold, even as an approximation, in telecommunications. Thus regulators are acting on an erroneous belief that with competition that price equals cost, independent of demand. This erroneous belief leads directly to the resulting regulatory fallacy. The regulatory fallacy leads to the consequent use of arbitrary allocations and mark-ups to regulated prices to take account of fixed and common costs. These costs are exactly the costs that arise from economies of scale and scope. The regulatory approach leads to significant consumer harm. If regulators instead took account of demand factors in setting regulated prices, economic efficiency and consumer welfare could be increased significantly.²⁰

Fixed and sunk costs in cost-based regulation

Current FCC approach to regulation of unbundled elements

The US Congress passed the Telecommunications Act of 1996, which called for less regulation, more competition and the most modern up to date telecommunications infrastructure: ‘...[T]o provide for a pro-competitive, de-regulatory national policy framework designed to accelerate rapidly private sector deployment of advanced telecommunications and information technologies and services to all Americans by opening all telecommunications markets to competition’.²¹ The FCC instituted numerous regulatory rulemakings to implement the 1996 Telecommunication Act. The most important regulations so far have been the Local Competition and Interconnection Order of August 1996.²² If implemented in its current form the Order will likely have serious negative effects on innovation and new investment in the local telephone network.²³

Most economists agree that regulation should be used only when significant market power can lead to unregulated prices well above competitive levels.²⁴ The goal of regulators is then to set prices at ‘competitive levels’. However, economists are much less explicit about how these competitive price levels can be estimated. Most economists would agree that perfect competition cannot yield the appropriate standard since prices set at marginal cost will not allow a privately-owned utility to earn a sufficient return on capital to survive. The large fixed costs of telecommunications networks thus do not allow the price equal marginal cost standard of perfect competition to be used.²⁵ Baumol and Sidak (1994) propose the perfect contestability standard as an alternative. They proposed that regulators should require firms to set prices as if ‘the competitive pressures generated by fully unimpeded and costless entry and exit, contrary to fact, were to prevail’.²⁶ However, costless entry and exit presumes that no sunk costs exist, i.e., costs that cannot be recovered upon exit by a firm.²⁷ This assumption of no sunk costs is extremely far from economic and technological reality in telecommunications where the essence of most investments is an extremely high proportion of sunk costs. Consider the investment by an ILEC in a new local fiber optic network that can provide broadband services and high speed Internet access to residential customers. Most of the investment is sunk since if the broadband network does not succeed, the investment cannot be recovered. Thus, when either technological or economic uncertainty exists ‘perfect contestability as a generalization of perfect competition’ cannot provide the correct competitive standard.

In a perfectly contestable market, if the return to an investment is below the competitive return, the investment is immediately removed from the market and used elsewhere. This costless exit strategy is always available in a perfectly contestable market.²⁸ However, the actual economics of telecommunications investment could not be further from a perfectly contestable market. When fiber optic networks are constructed, they are in large part sunk investments.²⁹ If their economic return falls below competitive levels, the firm cannot shift them to other uses because of their sunk and irreversible nature.³⁰ Thus, the use of a perfectly contestable market standard fails to recognize the important feature of sunk and irreversible investments — they eliminate costless exit. Because of its failure to take into account the sunk and irreversible nature of much telecommunications investment, the contestable market model has nothing of interest to say about competition in telecommunications.³¹ An industry cannot be

expected to behave in a manner that is fundamentally inconsistent with its underlying technological and economic characteristics.

One way to consider the problem is the situation of a new investment by an ILEC. Suppose a competitor wants to buy the unbundled elements associated with the investment. The ILEC could offer the new competitor a contract for the economic life of the investment — say 10 years for investment in the local loop. The price of the unbundled element would be the total investment cost plus the annual operating costs for the unbundled element. Should demand not materialize or prices fall, the new entrant would bear the economic risk of this outcome.³² However, regulation by TSLRIC typically allows the entrant to buy the use of the unbundled element on a month-by-month basis. Thus if demand does not materialize or prices fall, the ILEC has to bear the risk for the business case of the new competitor. Accordingly, the ILEC has been required by regulation to give a free option to the new entrant, where an option is the right but not the obligation to purchase the use of the unbundled elements. The monthly price of the unbundled element should be significantly higher than the ten year price of the element to reflect the risk inherent in the sunk investments, or equivalently the value of the option given to the new entrant.³³ Regulators to date, including the FCC, the ACCC in Australia and the EU have not incorporated the value of the option, which arises from the sunk cost nature of much telecommunication investment, into their price setting.

Another way to consider the problem of regulation set prices is to allow for the existence of the (all-knowing) social planner. Suppose the social planner were considering a new investment in a telecommunications network where the features of sunk and irreversible investments are important. The social planner wants to maximize the value of the social welfare integral over time subject to uncertainty. However, the investment is subject to both technological and economic uncertainty so that the cost of the investment may (randomly) decrease in the future and because of demand uncertainty the social planner does not know whether the investment will be economic. In making an optimal decision the social planner will take into account the sunk and irreversible nature of the investment since should the new service fail, the investment cannot be shifted to another use. Thus, incorrectly assuming that sunk costs do not exist, which is the perfect contestability standard, when sunk costs are an extremely important part of the economic problem will lead to incorrect decisions and decreased economic efficiency. The economy will not reach its production possibility frontier.

Regulation set prices for unbundled elements

Under the 1996 Telecommunication Act the FCC mandated forward looking cost based prices for competitors to use unbundled LEC facilities.³⁴ The FCC did not permit any mark-up over cost to allow for the risk associated with investment in sunk assets; instead, it used a TSLRIC-type approach that attempts to estimate the total service long run incremental cost on a forward looking basis.³⁵ Australian and European regulators have chosen a similar approach. TSLRIC attempts to solve the perfect competition problem that price cannot equal marginal cost by allowing for the fixed costs of a given service to be recovered. TSLRIC allows for the recovery of the cost of investment and variable costs of providing the service over the economic lifetime of the investment. However, TSLRIC makes no allowance for the sunk and irreversible nature of telecommunications investment, so that it adopts the perfect contestability standard. The

perfect contestability standard provides the incorrect economic incentives for efficient investment once technological and economic uncertainty exist. The FCC and other regulators have chosen the incorrect standard for setting regulated prices. TSLRIC will lead to less innovation and decreased investment below economically efficient levels.³⁶

The TSLRIC standard and harm to innovation

Many new telecommunications services do not succeed. Recent failures include Picturephone services (AT&T and MCI within the past ten years) and information service gateway services offered by many ILECs. These new gateway services require substantial sunk development costs because creation of the large databases to provide information service gateways is substantial. Now when a new service is successful, under TSLRIC regulation, an ILEC competitor can purchase the service at TSLRIC. Thus, for a successful new service the ILEC recovers at most its cost. For unsuccessful services, the ILEC recovers nothing and loses its sunk investment. Thus, the TSLRIC regulation is the analogue of a rule that would require pharmaceutical companies to sell their successful products to their generic competitors at incremental cost and would allow the pharmaceutical companies to recover their R&D and production costs on their successful new drugs, but to recover nothing on their unsuccessful attempts. This truncation of returns where a successful new telecommunications service recovers its cost (but no more), and unsuccessful new services recover nothing decreases economic incentives for innovative new services from regulated telecommunications companies. By eliminating the right tail of the distribution of returns as demonstrated in Figure 2, TSLRIC regulation decreases the mean of the expected return of a new project. For example, consider a project with returns, y , which follow a normal distribution with mean μ and standard deviation σ , the expected value of the return when it is truncated at cost c is:

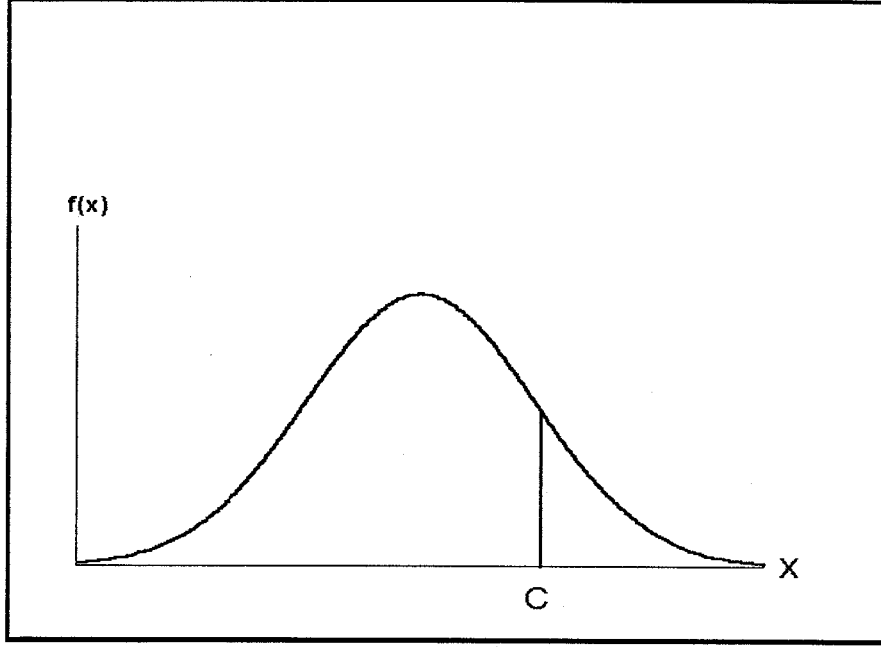
$$E(y | y < c) = \mu - \sigma M(c) \quad (3)$$

where $M(c)$ is the inverse Mills ratio evaluated at c .³⁷ Thus, the tighter is the cost standard the lower are the incentives to innovate. More importantly, as the returns to innovation become more uncertain, the expected return and the incentives to innovate decrease. Thus, in the absence of sunk and irreversible investment, a TSLRIC pricing policy decreases the economic incentives for investment in innovative services, and a TSLRIC policy may eliminate these economic incentives to invest altogether.

Regulators could allow for something similar to patent protection for new services to provide economic incentives for ILECs to innovate.³⁸ However, this policy option is a recipe to delay new telecommunications services for ten years or more with enormous consumer welfare losses as occurred with voice messaging and cellular telephone.³⁹ Currently, it takes the US Patent Office over two years to grant a patent with longer time periods not uncommon. However, no opponent of the patent is allowed to be part of the process. In a regulatory setting where competitors would attempt to delay the introduction of new services as happened with both voice messaging and cellular telephone, one would expect much longer delays. A better approach would be not to regulate new services. Given the large welfare gains from new services and price cap regulation for existing services, ILECs should be permitted to offer new services

with no prior approval or price regulation. The gains in consumer welfare from successful new services would lead to significant gains for consumers. Attempting to fine tune prices of new services through cost based regulation will lead to overall consumer losses. However, regulators find it extremely difficult not to regulate any new service of a regulated company.⁴⁰

Figure 2. Truncated Returns Caused by TSLRIC



The effect of sunk and irreversible investments

TSLRIC assumes all capital invested now is used over the economic life of the new investment and that prices for the capital goods or the service being offered also not decrease over time.⁴¹ With changing demand conditions, changing prices, or changing technology, these assumptions are not necessarily true. Thus, TSLRIC assumes a world of certainty where the actual world is one of uncertainty in the future. Substantial economic effects can arise from the effects that the sunk nature of investment has on the calculation of TSLRIC.

Consider the value of a project under no demand uncertainty with a risk adjusted discount rate of r and assumed known exponential economic depreciation at rate δ . This assumption on depreciation can be thought of as the price of the capital decreasing over time at this rate due to technological progress. Assume that price, net of the effect of economic depreciation of the capital goods, is expected to decrease with growth rate $-\alpha$.⁴² The initial price of output is P . The value of the project is:

$$V(P) = \int_0^{\infty} \lambda \exp(-\lambda t) P \frac{1 - \exp(-\delta t)}{\delta} dt = P/(\lambda + \delta) \tag{4}$$

where $\lambda = r + \alpha$. Note δ is added to expression to account for the decreasing price of capital goods. This term, omitted from TSLRIC calculations, accounts for technological progress in equipment prices, which is one economic factor that leads to lower prices over time. Suppose that the cost of the investment is I . The rule for a competitive firm is to invest if $V(P) > I$. Equivalently from (4), $P > (\lambda + \delta) I$. The economic interpretation of this expression is that the price (or price minus variable cost) must exceed the cost of capital, which includes the change in price of the capital good to make the investment worthwhile.⁴³ Note the net change in the output price and the price of the capital good both enter the efficient investment rule. TSLRIC calculations ignore the basic economic fact that when technological change is present, (quality adjusted) capital goods prices tend to decline over time. This economic factor needs to be taken into account or economic inefficiency will result.

A simplified example demonstrates the potential importance of changing prices of capital goods when competition exists. Suppose an investment is considered which uses computer technology in a significant manner. Because computer technology is advancing rapidly the price of the capital good used in the investment decreases over time. Now consider a competitive firm priced according to (4), but it did not take account of changing prices of capital goods due to technological progress, i.e., $\delta = 0$ is assumed. A company 'New Telecom' decides to enter the Internet access business. The company purchases a switch (router) which costs USD10,000. It expects to serve 100 customers annually with variable costs at USD500 per annum. The firm's cost of capital is 10% and it expects to use the router for five years at which time the resale (scrap) value of the router will be zero.⁴⁴ The discounted cost of the project over five years is USD11,895 which is the TSLRIC. On a per customer basis the cost is USD118.95 so that if the price were set at USD31.38 per annum the net present value (NPV) of the project is zero. Thus, the price based on TSLRIC is USD31.38 per annum. Unfortunately, the company will make losses at this price and so the investment will not be made.

The reasons for this conclusion are that the price of routers, switches, fiber optic electronics and other telecommunications equipment is decreasing with technological progress, e.g., Moore's law for microprocessors. Assume the price of the router declines by USD1,000 annually, but all other costs remain the same. For a market entrant in year 2, the TSLRIC calculation leads to a discounted cost of USD10,895 (exactly USD1,000 less if no further price reductions occurred) so that the TSLRIC set price is USD28.74 per annum. Now the initial entrant, New Telecom, will be forced to decrease its price by USD2.64 and it will make a loss on every customer (taking the original cost of capital into account). Indeed, as expected, New Telecom will lose USD760 on the project. This will continue in the next year when the router price falls to USD8,000. Thus, TSLRIC-based prices cause the initial entrant to lose money even in a world of complete certainty because of decreasing capital costs. Instead, of charging USD31.38 for each year as TSLRIC implies, New Telecom must charge decreasing prices of (\$USD36.65, USD33.75, USD30.85, USD27.95 and USD25.04) due to competition. Where does TSLRIC go wrong?⁴⁵ TSLRIC fails to recognize that the change in the price of the equipment needs to be included in the cost of capital. Indeed, the competitive price would not be the TSLRIC answer of USD31.38, but the correct answer is New Telecom must charge USD36.65 the first year and then decrease its price to USD33.75 the next year, and so on, because of the decreased price of the router. Thus, the TSLRIC set price

is too low by about 17% for the first year because it ignores the falling price of capital goods.

The usual TSLRIC calculation does not include δ , but it instead assumes that both the prices of capital goods and output do not change over time. This assumption is extremely inaccurate. Take a Class 5 Central Office Switch (COS) for example. Ten years ago an AT&T Class 5 switch (5-ESS) was sold to an ILEC for approximately USD200 per line (Hausman and Kohlberg, 1989: 204). Today, the price of Lucent 5-ESS switches and similar NTI switches are in the USD70 per line or lower range. A TSLRIC calculation would be based on the USD70 price. An ILEC who paid USD200 per line made the efficient investment decision when it purchased its COS. But TSLRIC, by omitting economic depreciation due to technological progress, leads to a systematically downward biased estimate of costs. Indeed the economic depreciation of COS is estimated to be near 8% per annum over the past five years, while the cost of fiber optic carrier systems has decreased at approximately 7% per year over the same period.⁴⁶ The omitted economic factor δ can be quite large relative to r for telecommunications switching or transmission equipment due to technological progress.

TSLRIC calculations makes the further assumptions that: the investment is always used at full capacity; the demand curve does not shift inwards over time; and a new or improved technology does not appear that leads to lower cost of production. Of course, these conditions are unlikely to hold for the life of the sunk investment. Thus uncertainty needs to be added to the calculation because of the sunk nature of the investment. To account for the sunk nature of the investment and its interaction with fundamental economic and technological uncertainty, assume a reward for waiting occurs because over time as some uncertainty is resolved.⁴⁷ The uncertainty can arise from at several factors: demand uncertainty; price uncertainty; technological progress (input price) uncertainty; and interest rate uncertainty.⁴⁸ Under these conditions the fundamental decision rule for investment changes to:

$$P^s > \frac{\beta_1}{\beta_1 - 1} (\delta + \lambda)I \quad (5)$$

where $\beta_1 > 1$ so that $m = \beta_1 / (\beta_1 - 1) > 1$. β_1 takes into account the sunk cost nature of the investment coupled with inherent economic uncertainty.⁴⁹ m is the mark-up factor required to account for the effect of uncertain economic factors on the cost of sunk and irreversible investments. Thus, the critical cut-off point for investment is $P^s > P$ from (2). Note that $m=1$ for fixed but not sunk investments. Thus, rearranging (5) gives:

$$\frac{P^s}{m} > (\delta + \lambda)I \quad (6)$$

Equation (6) demonstrates that the value of the investment is discounted by the factor m to take account of the sunk costs, compared to the fixed (but not sunk) cost case of $m = 1$. Sunk cost investment must have higher values than fixed costs investments, other things equal, to be economical to undertake. To see how important this consideration of sunk costs can be, next evaluate the mark-up factor m . The parameters β_1 and m depend on a number of economic factors. It can be demonstrated that as uncertainty increases, i.e.,

the variance of the underlying stochastic process, β_1 decreases and the m factor increases (see Dixit and Pindyck, 1994, p153). Also, as δ increases, β_1 increases which means that the m factor decreases. As r increases β_1 decreases so that the m factor increases. MacDonald and Siegel (1986), and Dixit and Pindyck (1994, p.153) calculate $m = 2$ so that, for instance, $V^S = 2I$. A TSLRIC calculation that ignores the sunk cost feature of telecommunications network investments would thus be off by a factor of two.

Using parameters for ILECs and taking account of the decrease in capital prices due to technological progress (which Dixit and Pindyck assume to be zero) and because the expected change in (real) prices of most telecommunications services is negative given the decreasing capital prices, the value of m is around 3.2 to 3.4.⁵⁰ Thus, a mark-up factor must be applied to the investment cost component of TSLRIC to account for the interaction of uncertainty with sunk and irreversible costs of investment.⁵¹ Depending on the ratio of sunk to fixed and variable costs the overall mark-up on TSLRIC will vary, but the mark-up will be substantial given the importance of sunk costs in most telecommunications investments. This mark-up would be used by a (hypothetical) social planner determine the optimal telecommunications network investment as the social planner faces the same inherent economic and technological uncertainty over future demand and costs.

Now when the mark-up for sunk and irreversible investment is applied, it should only be used for assets that are sunk, e.g., potentially stranded. Other investments that are fixed, but not sunk, would not have the mark-up. The proportion for transport links sunk costs is 0.59 so that the mark-up factor of $m = 3.3$ is approximately 2.35 times TSLRIC. By contrast, the proportion of sunk costs for ports is about 0.10 so that the mark-up factor becomes 1.23 times TSLRIC. The mark-up over TSLRIC that takes account of sunk costs and uncertainty is the value of the free option that regulators force incumbent providers to grant to new entrants; e.g., 1.35 times TSLRIC for links and 0.23 times TSLRIC for ports. Thus, the proportion of sunk costs has an important effect on the correct value of regulated prices when sunk costs are taken into account. Regulators, by failing to apply a mark-up to TSLRIC, set too low a regulated price for telecommunications services from new investment. The result decreases new investment in telecommunications below economically efficient levels, contrary to the stated purpose of the 1996 Telecommunications Act and enabling legislation in other countries. Thus, through its focus on static cost efficiency considerations in setting regulated prices equal to TSLRIC, the regulators miss the negative effect on dynamic efficiency that TSLRIC-based prices cause. Since the examples of voice messaging, cellular telephone, and the Internet demonstrate that the dynamic efficiency effects are quite large in telecommunications, use of TSLRIC to set regulated prices will likely cause substantial welfare losses to consumers similar to past FCC regulatory policy in the US.

Professor William Baumol, an inventor of contestability theory and a supporter of the TSLRIC approach to regulation, has now recognized that sunk costs must be considered in a proper regulatory approach owing to the 'profound implications for both theory and practice' (see Baumol, 1999). Because Baumol was an inventor of TSLRIC (which mutated into the TELRIC approach currently in use at the FCC) and supported the use of TSLRIC and TELRIC when the FCC decided on its current form of regulation in 1996, his recognition that sunk costs are an important economic factor that cannot be ignored is potentially quite significant.⁵² Baumol now states that a cost

component in the investment decision has been overlooked, so that the total costs of such decisions and hence their appropriate prices are normally underestimated. This recognition is equivalent to the granting of the free option to competitors by failing to take account of the sunk costs. Thus, Baumol agrees that the options value of investment is a real cost that regulators must take account of if they are to make the correct decisions. Baumol agrees that the application of real options theory to the regulation of ILECs is potentially important, given the presence of sunk and irreversible investments. Regulators should take note of these considerations because their current TSLRIC approach assumes that sunk and irreversible investments are not present. Otherwise, regulators will be an example of Lord Keynes' (1936) observation, paraphrased in Samuelson and Nordhaus (1986), that:

“The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood, indeed the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influences are usually the slaves of some defunct [economic theory]”.

Hopefully, regulators will realize the mistake they are making sooner rather than later.

What elements should be unbundled?

Up to this point the choice of regulator-mandated unbundled elements, whose prices are regulated, is given exogenously. The focus has been the correct economic method of how regulators should set prices for the elements once they are chosen. In this section the question of what elements should be unbundled is considered. If the goal is to have actual, not subsidized, competition, this choice is potentially quite important. Should regulators require essentially the entire local network to be unbundled, as the FCC has done in the US, with the likely outcome of less competition. In what follows the unbundling question in the framework of the goal of consumer welfare is considered.⁵³ Thus, the goal is not a competitor welfare goal, as regulators often seem to believe, but a consumer welfare goal. The Australian regulator, the ACCC, has explicitly established a consumer welfare goal for their approach to telecommunications regulation. The ACCC refers to the goal as the long-term interests of end-users (LTIE). The FCC regulates under a public interest rule that in my view should be a consumer welfare rule, but the FCC has used the public interest rule to give it wide latitude in its decisions, which often have caused consumer losses of tens of billions of dollars per annum.⁵⁴

The 1996 Telecommunications Act established basic principles for unbundling network elements. Section 251 and Section 252 provide a framework for the pricing of interconnection, resale and unbundling. Section 251(c)(3) requires any ILEC, other than certain rural carriers, to offer competitors access to the ILEC's network elements on an unbundled basis. In turn, Section 251(d)(2) requires the FCC to consider, when determining whether to mandate the unbundling of an ILEC's network elements under Section 251(c)(3), 'at a minimum, whether — access to such network elements as are proprietary in nature is necessary; and the failure to provide access to such network elements would impair the ability of the telecommunications carrier seeking access to provide the services that it seeks to offer'. Together, those subsections are known as the

'necessary' and 'impair' requirements. One cannot construe necessary and impair for purposes of Section 251(d)(2) without first identifying the larger objective of the 1996 Telecommunications Act. The statute's preamble states that its purpose is to 'promote competition and reduce regulation in order to secure lower prices and higher quality services for US telecommunications consumers and encourage the rapid deployment of new telecommunications technologies'.⁵⁵ In the legislative history, Congress reiterated that the objectives of the Telecommunications Act are 'to provide for a pro-competitive, deregulatory national policy framework designed to accelerate rapidly private sector deployment of advanced telecommunications and information technologies and services to all Americans by opening all telecommunications markets to competition'.⁵⁶

Consumer welfare: Competition rather than competitor protection

The definitions of necessary and impair should seek to further overall competition and not merely the economic interests of individual competitors. When overall competition is increased, consumer welfare and economic efficiency will also increase. In its Local Competition First Report and Order, the FCC failed to make that distinction. Consumers benefit from competition because it leads to greater innovation and lower prices. Thus, the public interest is consistent with increased competition and innovation. However, the public-interest standard, although central to interpretation of telecommunications regulation, has not always received so precise a definition in its implementation by the FCC. The primacy that economists ascribe to economic efficiency and to the maximization of consumer welfare has a related benefit. It harmonizes economic regulation and antitrust (competition) law. In 1996, Congress endorsed this view when it emphasized in the Telecommunications Act that the improvement of consumer welfare was the new legislation's overarching purpose.

A standard that looks to the effect on competition, rather than the interests of a given CLEC comports with the US Supreme Court's command that the Commission must take into account the availability of substitutes for ILEC network elements outside the ILEC's network. When substitutes outside the ILEC's network are available, that availability occurs because some firms have made the rational economic decision that they can efficiently provide services that employ those non-ILEC elements. Two conclusions necessarily follow. The element provided by the incumbent ILEC are not essential for competition because competition is already occurring without ILEC provision. Thus, the network element, unbundled by government decree at TELRIC prices, cannot be labeled an essential facility or necessary for competition, or an element for which the decision not to mandate unbundling at a TELRIC price would impair the competitive supply of telecommunications services. Further, competition will not be adversely affected if a given CLEC cannot procure the unbundled element from the ILEC. Other firms are providing substitutes outside the ILEC's network, and so, in the absence of diminishing returns to scale, increased demand for the element outside the ILEC's network can be met at the same or lower economic cost.

The FCC's failure to advance consumer welfare

In its Local Competition First Report and Order, which it issued in 1996, the Commission determined that a requesting carrier's ability to offer service is impaired (diminished in value) if 'the quality of the service the entrant can offer absent access to

the requested element, declines' or if 'the cost of providing the service rises.' That impairment standard, much like the rest of the FCC's approach to network unbundling, reflects a competitor-based standard, not a competition-based standard. The economic welfare of a single CLEC will not affect consumer welfare, because consumer welfare depends on the overall competitive supply of telecommunications services. If, under the FCC's interpretation of the necessary and impair standards, any single CLEC can claim that a given element is necessary to its business strategy, then it is likely that all elements of the network will be subjected to mandatory unbundling at TELRIC prices. Such a standard would harm consumers and diminish consumer welfare. The correct approach is for the FCC is to determine whether competition will be impaired by analyzing whether prices for telecommunications services will be higher or quality (innovation) will be lower as a result of the agency's necessary and impair policy. This approach is consistent with the ACCC LTIE standard, but is not the approach the FCC has taken.⁵⁷ Thus, individual competitors' profits are not relevant to a competition standard or a public interest standard.

A consumer welfare implementation of the necessary and impair standard

Hausman and Sidak (1999) have proposed an approach to the necessary and impair standard of the 1996 Telecommunications Act within a consumer welfare framework. The definitions of necessary and impair rely on the competitive analysis of demand and supply substitution that provides the primary basis for other areas of regulatory economics and, more particularly, that provides the analytical basis for modern antitrust and competition law.

(a) The essential facilities doctrine of antitrust law

The essential facilities doctrine addresses scenarios in which a company owns a resource that other firms absolutely need to provide their own services. Properly understood, the doctrine is a rule concerning the obligation (if any) of a vertically integrated firm to sell an input to competitors in the downstream market. Federal courts applied the essential facilities doctrine to telecommunications networks in *MCI Communications Corporation v. American Telephone & Telegraph Company*.⁵⁸ In that case, the Seventh Circuit refined the essential facilities doctrines into a four-part test that requires the plaintiff to show: control of the essential facility by a monopolist; a competitor's inability practically or reasonably to duplicate the essential facility; the denial of the use of the facility to a competitor; and the feasibility of providing the facility. Inherent in the concept of an essential facility is the premise that the owner of that facility possesses monopoly power. The first two elements of the doctrine incorporate that recognition in a variety of ways. Some degree of uniqueness and market control is inherent in the term 'essential'. Further, the inquiry regarding the impracticability of duplication ensures that the doctrine will apply only to facilities for which no feasible alternative exists or that cannot be reasonably reproduced. Finally, the term facility itself connotes an integrated physical structure or large capital asset with the degree of cost advantage or unique character that usually confers monopoly power and market control by virtue of its superiority. This approach is applied to demonstrate the technical feasibility of access is a necessary but not sufficient condition for mandatory unbundling to advance consumer welfare.

If a given unbundled element (the facility) competes for users with other products or services that are effective substitutes for access to the facility, the discipline imposed by such competition will suffice to control the conduct of the facility owner. There will, of course, be instances in which the facility in question will be somewhat better than the alternatives, but not so much better as to preclude the continued survival of excluded parties. It may be difficult in practice to determine whether exclusion from the use of a particular facility will mean inconvenience, extinction, or some intermediate degree of harm to the excluded competitor. The point is not that the judgment as to the magnitude of the competitive disadvantage of exclusion is simpler in principle with one test instead of another. Rather, the point is that the question of essentiality and ease of duplication — measured by either the potential harm of exclusion or the potential benefit of inclusion — is no different from the issue of whether monopoly power is present in the market for the service produced with the allegedly essential facility. The focus of courts and regulators should be on whether mandatory access to the facility enhances the long-term welfare of consumers, regardless of the effect on individual competitors. Because a finding of monopoly power should be a prerequisite to any further inquiry, any market characteristic that prevents the exercise of market power should preclude the application of the essential facilities doctrine.

(b) Deriving the necessary and impair standards from the essential facilities doctrine

Whether the FCC should mandate unbundling of a particular network element in a particular geographic location at a particular time should depend on whether such unbundling is necessary to permit the competitive supply of telecommunications service. The correct meaning of impair for purposes of Section 251(d)(2) is whether an ILEC fails to unbundle a particular network element, at a TELRIC price, in a particular geographic location at a particular time would produce an equilibrium supply of telecommunications services that was, relative to the competitive equilibrium, significantly inferior for consumers. Although a particular network element may be essential to producing a bundle of services in a particular manner, the existence of competition among bundles of services limits the extent to which that element is essential to the competitive supply of telecommunications services. More specifically, the development of wireless voice, data and vertical services has served to increase the availability of substitutes for wireline access. This insight about competition at the service level is analogous to the economic concept of derived demand. In the context of § 251(d)(2) of the Telecommunications Act, the relevant question is whether competition among bundles of services produces, for a particular network element, a sufficiently low level of derived demand such that the element is inessential to producing a competitive equilibrium.

In the language of economics, necessity and competitive impairment are given rigorous economic meaning by computing the price elasticity of derived demand for any given unbundled network element. The elasticity of derived demand for an input varies directly with Marshall's rules of derived demand: the elasticity of demand for the product that the factor produces; the share of the factor in the cost of production; 3 the elasticity of supply of the other factors; and the elasticity of substitution between the factor in question and the other factors. The application of Marshall's rules can illuminate whether the demand for a given network element is so inelastic, i.e., the quantity demanded is not sensitive to changes in price, that it could not be considered a

necessary element. The availability of close substitutes to traditional wireline service such as wireless applications serves to increase the elasticity of demand for wireline service and hence, by Marshall's first rule, tends to increase the elasticity of demand for all of the ILEC's network elements used to produce voice telephony. As wireless prices approach wireline prices, fixed (as opposed to mobile) customers begin to substitute wireless telephones for landline telephones. As an example, the remaining rules of derived demand are applied to loops in particular. According to Marshall's second rule, the price elasticity of derived demand for a network element should rise as the share of the element in the network costs rises. The intuition is: suppose the price of a network element, which represents a large portion of the total costs, doubles. Because the price of total network costs would rise substantially, the demand for additional network services would fall, and hence the demand for unbundled access to that particular network element would fall. An example of a network element that represents a large portion of the ILEC's total network costs is the loop. Thus, Marshall's second rule implies that the price elasticity of derived demand for loops would be larger than for other network elements, *ceteris paribus*, and hence unbundled loops would be less likely to be considered necessary for competition.

According to Marshall's third rule, the price elasticity of derived demand for a loop should increase with the elasticity of supply of another network element, such as a switch. Intuitively, the more price elastic the supply of switches, the less the price of switches will fall with a given reduction in the quantity of switches employed, and hence the greater must be the reduction in the quantity of loops employed. As other network elements such as switches have become increasingly competitively supplied, Marshall's third rule of derived demand implies that the price elasticity of derived demand for loops should be rising.

Finally, according to Marshall's fourth rule, the price elasticity of derived demand for a loop should increase with an increase in the cross-price elasticity of substitution between a loop and other network elements. When network elements are used in fixed proportion, then the cross-price elasticity of substitution between a loop and another network element would be small. In that case, Marshall's fourth rule of derived demand would be the only one of the four rules that does not imply a large price elasticity of derived demand for loops. On the other hand, if technological change permits network elements to be used in variable proportions, substitution will occur across network elements, and Marshall's fourth rule of derived demand will have relevance.

(c) The relevant product market and critical share

The 1992 US Merger Guidelines specify that relevant markets for merger analysis may be defined for classes of customers on whom a hypothetical monopolist of the merging firms' products would likely impose a discriminatory price increase.⁵⁹ According to the Merger Guidelines, the task of defining the relevant product market when price discrimination is not feasible involves identifying the smallest set of products for which a hypothetical monopolist could profitably raise price a significant amount (typically 5%) above the competitive level for a non-transitory period of time (normally assumed to be two years).⁶⁰ Thus, under the Merger Guidelines, a potential market definition is too narrow if, in the face of a five percent price increase, the number of customers who would switch to products outside the market is sufficiently large to make the price

increase unprofitable. Customers who decide not to purchase the product (or to purchase less of the product) at the increased price are marginal consumers. For small price increases, they switch from the products inside the putative market. Not all customers, however, are marginal customers. Indeed, in the typical case, most customers would continue to purchase the product despite the higher price because their willingness to pay for the product exceeds the raised price. These customers are infra-marginal consumers.

In the presence of high demand elasticity and high supply elasticity, a firm cannot exercise unilateral monopoly power by attempting to decrease its supply. Demand elasticity is captured by customer willingness to switch to competing suppliers as relative prices change. Thus, a broad range of available substitutes would imply a high own-price elasticity of demand. Following the same logic as the market definition criteria, the Merger Guidelines provide a concrete test for evaluating the competitiveness of a market as captured in the idea of market power, which is the ability of a firm unilaterally to increase price above the competitive level for a non-transitory period.⁶¹ Because competition takes place at the margin, only a small proportion of the ILEC's customers need to defect to defeat its attempted price increase. In a simple example, it is possible to calculate that necessary proportion. Suppose that an ILEC attempted to increase prices on end-user access by 5%. How much traffic would that ILEC need to lose before the increase would be unprofitable? The formula to calculate that critical share is:

$$(1 - MC/P) q_1 < (1.05 - MC/P) q_2. \quad (7)$$

An important empirical fact for network elements is that fixed costs are a very large component of the overall cost, so that marginal cost is a relatively small component. Assume, for example, that the ratio of marginal cost to price, MC/P , is 0.2. Then q_2 would be $0.94q_1$, so that the critical share is 6%. Thus, if the ILEC were to attempt to raise its price by 5%, and if, as a result, it were to lose more than 6% of its traffic, the attempted price increase would be unprofitable and thus unilaterally rescinded.⁶²

(d) The Hausman-Sidak test for the impairment standard

The existing essential facilities doctrine sets forth necessary but not sufficient conditions for defining impairment under §251(d)(2). The complete set of necessary and sufficient conditions includes a fifth requirement, responsive to the Telecommunications Act, to address whether the denial of access to that network element at TELRIC prices would impair competition at the end-user level. The Hausman-Sidak five-part test is as follows.

The FCC should mandate unbundling of a network element if, and only if: it is technically feasible for the ILEC to provide the CLEC unbundled access to the requested network element in the relevant geographic market; the ILEC has denied the CLEC use of the network element at a regulated price; it is impractical and unreasonable for the CLEC to duplicate the requested network element through any alternative source of supply; the requested network element is controlled by an ILEC that is a monopolist in the supply of a telecommunications service to end-users that employs the network element in question in the relevant geographic market; and the

ILEC can exercise market power in the provision of telecommunications services to end-users in the relevant geographic market by restricting access to the requested network element.

To implement the fifth element of the Hausman-Sidak test, one modifies the Merger Guideline's test for unilateral market power only slightly: whether it would impair competition for an ILEC not to sell a particular unbundled network element to a CLEC at a regulated price. Intuitively, our impairment test asks whether the ILEC can exercise market power when restricting access to a particular network element to the CLEC in a particular geographic market. If the ILEC cannot exercise market power, in the output market, when declining to offer a particular network element at a TELRIC price; then all of the consumer benefits associated with a competitive outcome have already been secured. Therefore, the regulator should not order the network element in question unbundled. In contrast to the method employed by the FCC, the Hausman-Sidak test is focused on protecting competition as opposed to competitors. Where market forces can protect consumers from the harms of monopolization, then the regulators should not impose mandatory unbundling.

Thus, the answer to the question of when a network element should be unbundled has the answer when the incumbent can exercise monopoly power in the absence of unbundling. In this situation competition is harmed and consumer welfare is decreased because consumers will pay a supra-competitive price for the final service, barring further regulatory distortions. This conclusion is very closely related to the essential insight of the economic approach to regulation. Regulation should only be used in the situation of market failure, which here would be the exercise of unilateral monopoly power. Note that the approach does not use competitor welfare as the standard rather consumer welfare is the appropriate standard. The approach concludes that network elements should not be unbundled nor mandatory access required when monopoly power cannot be exercised. Competitive market forces will set the price of the elements, not regulators. Thus, the economists' advice that regulated prices should be like the prices set by a competitive market leads to the conclusion that the market prices should be used, absent monopoly power. While regulators typically have a difficult time of letting go despite their avowals to the contrary, the market should be used to determine prices. Only when unilateral monopoly power could be exercised should unbundling be required. The presence of sunk costs is then likely to be important because it is the presence of significant sunk costs that typically is an element of barriers to entry. Thus, the approach of the last section should be used. Lastly, demand conditions should be taken into account when setting the regulated prices to cover the fixed and common costs. This approach will lead to increase consumer welfare, which should be the goal of regulatory policy.

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Notes

1. However, the approach did harm consumers to a significant degree by retarding new product innovation, which is a first-order loss to economic efficiency. See Hausman (1997) for estimates of the consumer welfare loss.
2. State regulatory agencies in the US set local prices for telecommunications. California adopted price cap in 1989 and by the mid-1990s the majority of states had adopted some form of incentive regulation.
3. The Bell Operating Companies had been not allowed to provide interLATA long-distance service since the breakup of AT&T in 1984.
4. This section is based on Hausman (1997, 1999a, 1999b).
5. This section is based on Hausman and Sidak (1999).
6. Indeed, the results of such allocations depend in important ways on the units the outputs q_1 and q_2 are measured in.
7. For an example of regulators causing massive losses see Hausman (1998), and Hausman and Shelanski (1999).
8. See Laffont and Tirole (2000) for a discussion of global price caps.
9. In practice, because of incorrect depreciation schedules and inflation, utilities often did not recover the true cost of their investments.
10. Justice Stephen Breyer of the US Supreme Court in a recent decision, *AT&T Corp. v. Iowa Utilities Board*, 119 S. Ct. 721 (1999), described how this outcome distorts and diminishes the actual amount of competition. Regulators are actually causing decreased competition when one of their stated goals is to increase competition.
11. For estimates of the extremely large gain to consumer welfare that can arise from new telecommunications services see Hausman (1997).
12. An early version of this type of result is in Georgescu-Roegen (1951). A

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- textbook treatment is found in Bliss (1975, Ch. 11).
13. Indirect labor costs are embedded in the other commodity inputs used to produce a given output.
 14. I do not mean to initiate or bring back hoary, and now unimportant, debates about what Marx really meant. For the reader, please do not contact me about these interpretations for I will not answer.
 15. Even if labor were the only primary factor, different qualities of labor would receive different wages depending on demand conditions for the different human capital that different types of labor possess. Again the necessary conditions for the non-substitution theorems would be violated. For a further discussion see Morishima (1973).
 16. Economies of scale often appear as economies of density in telecommunications, but the basic notion is the same.
 17. This statement may not hold in the US in the future. The 8th Circuit Court of Appeals recently (July 2000) invalidated the FCC's approach to setting regulated prices for network elements. The Court said that in the future regulated prices must depend on actual, not hypothetical, costs. Actual costs will depend on demand. The FCC will likely attempt to evade this requirement as they have done with prior Supreme Court and Appeals Court rulings, but the FCC's future success in evasion of court directions remains uncertain.
 18. For a further discussion of economies of scope with switches see Hausman and Kohlberg (1989).
 19. Burmesiter (1980) emphasizes the unreality of the steady-state growth assumption within labor theory of value models.
 20. For a recent situation where the FCC disregarded demand conditions and caused billions of dollars in efficiency losses to the economy see Hausman (1998a). This paper demonstrates that if demand conditions had been taken into account, the efficiency losses to the economy could be reduced to approximately zero.
 21. Conference Report to the Telecommunications Act of 1996, Pub. L. No. 104-104, 110 Stat. 56.
 22. FCC, 'First Report and Order, CC docket No. 96-98 and 95-185', August 1, 1996.
 23. The FCC is being challenged by the ILECs in Federal Court. The US Supreme Court reversed and remanded for further consideration the FCC's regulatory approach in January 1999. See *AT&T Corp. v. Iowa Utils. Bd.*, 119 S. Ct. 721 (1999). The key issue remanded to the FCC was what network elements should be unbundled. Justice Breyer in his separate opinion discussed the effect of the FCC approach to prices of unbundled elements and the likely negative effect on new investment and innovation in local networks, which is the subject of this chapter. In July 2000 the 8th Circuit Court of Appeals invalidated the FCC approach of basing cost estimates on a hypothetical network, rather the actual network in use. See *Iowa Utils. Bd. v. FCC*, No. 96-3321 (2000). The Court decision requires the FCC to modify its approach to cost estimation.
 24. In considering the regulation of unbundled elements, the FCC has failed to consider whether in the absence of regulation market power could be exercised by the ILECs. Instead, the FCC has adopted a competitor welfare standard, which is inconsistent with the economic analysis of competition and the modern

antitrust law. In contrast, Canadian regulators have taken competitive considerations into account in their decision on which elements should be unbundled. Hausman and Tardiff (1995) discuss competitive considerations in unbundling.

25. Economists have long agreed on this point. See Kahn (1988) for a discussion.
26. Baumol and Sidak (1994), p. 28 and pp. 31 ff.
27. The FTC and DOJ Horizontal Merger Guidelines (1992) define a sunk cost as an 'asset that cannot be recovered through the redeployment of the asset outside the relevant market, i.e., costs uniquely incurred to supply the relevant product and geographic market' (1.32).
28. To the extent that some network elements are fixed, but not sunk, investments should not be unbundled by regulators since new entrants can enter and exit markets using these elements without undergoing sunk investments, which can create entry (and exit) barriers.
29. The electronic used in the networks need not be sunk, but much of the actual dark fiber will be a sunk investment.
30. This feature of sunk and irreversible investment has been widely recognized by economic research for over a decade (see MacDonald and Siegel, 1986). For a recent comprehensive textbook treatment see Dixit and Pindyck (1994).
31. The contestable model of competition has been highly criticized as not relating to telecommunications. Critics include Armstrong and Vickers (1995), 'In fact, of course, the industry does not remotely resemble a contestable market...'
32. The contract (or regulation) could allow the new entrant to sell the use of the unbundled element to another firm if it decided to exit the industry.
33. In contracts between unregulated telecommunications companies, e.g., long-distance carriers, and their customers, significant discounts are given for multi-year contracts.
34. The FCC decision is currently under court appeal by the ILECs. In the FCC proceeding I provided testimony on behalf of the ILECs (see Hausman, 1996).
35. The FCC chose a variant of TSLRIC, called TELRIC for total element LRIC. However, the essential economic problem of TSLRIC also exists in TELRIC. The FCC is currently constructing a TELRIC model to be used in future regulatory proceedings.
36. TSLRIC provides the correct approach in a world with no uncertainty so long as economic depreciation is known. However, given the dynamic technological advances in telecommunications, considerable uncertainty exists, especially over the long economic lifetimes of much investment in telecommunications.
37. The inverse Mills ratio is the ratio of the density function and distribution function of the standard normal distribution evaluated at $(c - \mu)/\sigma$. The ratio increases monotonically as c decreases for given μ and σ (Greene, 1990, p. 718).
38. The FCC chief economist, Joseph Farrell (1997) considered this option.
39. See Hausman (1997) for a discussion for consumer losses from this policy.
40. The FCC, remarkably enough, has proposed to regulate new services under TSLRIC-type regulation, even when the FCC itself has found that significant competition currently exists for these services. Thus, the FCC is proposing to regulate new services even when no regulation is required since no market failure exists. This unnecessary regulation is potentially extremely harmful to

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- consumers (the public interest). See Hausman (1998), Hausman and Shelanski (1999), and Hausman and Sidak (1999) for discussions of why regulation should consider consumer welfare to be the primary factor in public interest regulation not the competitor welfare standard that the FCC has adopted.
41. This discussion follows Hausman (1996, 1997, 1999a, 1999b, 1999c). For papers that consider the options approach to investment in telecommunications see Alleman and Noam (1999), and Laffont and Tirole (2000).
 42. This factor arises due to changes in demand and total factor productivity.
 43. For simplicity assume only capital and no variable costs. Variable costs are included by interpreting P as price minus variable costs that lead to the same solution.
 44. The terminal value assumption can be changed with no alteration to the conclusions.
 45. TSLRIC-type formulae can be corrected by using (2) with δ not equal to zero to account for decreasing capital prices. However, regulators have not adopted these corrections.
 46. Testimony of Prof. Jerry Hausman before the CPUC, April 1998.
 47. Salinger (1999) attempts to generalize the approach of (4) to allow for uncertainty by appending various ad hoc assumptions on randomness to the equation. However, his approach has severe limitations. He avoids the effect of lumpy investment by assuming that investment occurs continuously while the technological nature of much investment in telecommunications depends on its lumpiness. He also assumes that regulators update their depreciation formulae in continuous time so that the option value decreases in importance. These assumptions bear a similarity to the contestability assumptions (instantaneous free entry and exit) that bear no relationship to the actual technology of much investment in telecommunications networks.
 48. The FCC incorrectly assumed that taking account of expected price changes in capital goods and economic depreciation is sufficient to estimate the effect of changing technology and demand conditions, see the FCC 'First Report and Order', para. 686. Thus, the FCC implicitly assumes that the variances of the stochastic processes that determine the uncertainty are zero, e.g., that no uncertainty exists. Under the FCC approach the values of all traded options should be zero (contrary to stock market fact), since the expected price change of the underlying stock does not enter the option value formula. It is the uncertainty related to the stochastic process, as well as, the time to expiration that gives value to the option as all option-pricing formulae demonstrate, e.g., the Black-Scholes formula.
 49. This equation is the solution to a differential equation. For a derivation see e.g., Dixit and Pindyck (1994), pp. 254-256, pp. 279-280 and p. 369. The parameter β_1 depends on the expected risk adjusted discount rate of r , expected exponential economic depreciation δ , and the net expected price $-\alpha$, and the amount of uncertainty in the underlying stochastic process. Note that this result holds under imperfect competition and other types of market structure, not just under monopoly, as some critics have claimed incorrectly. See e.g., Dixit and Pindyck (1994), Ch. 8, 'Dynamic Equilibrium in a Competitive Industry'. Imperfect competition is the expected competitive outcome in telecommunications because

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- of the significant fixed and common costs that exist.
50. Because of the expected decrease in the price of capital goods, even if the standard deviation of the underlying stochastic process were 0.25, as high as a typical stock, the mark-up factor is 2.1. For a standard deviation 0.5, the mark-up factor is 2.4. I have also explored the effect of the finite expected economic lifetimes of the capital investments in telecommunications infrastructure. Using expected lifetimes of 10-15 years leads to only small changes in the option value formulas, e.g., for a project with a 12 year economic life the mark-up factor of 2.0 changes to 1.9.
 51. It is the advent of competition that requires correct regulatory policy to apply the mark-up. Previously, when regulatory policy did not allow for competition, regulators could (incorrectly) set prices based on historic capital costs. Given the onset of competition arising from the 1996 Telecommunications Act and regulatory removal of barriers to competition, regulators must now account for changes in prices over time. Otherwise, ILECs will decrease their investment below economically efficient levels because their expected returns, adjusted for risk, will be too low to justify the new investment.
 52. See Affidavit of Baumol, Ordoover and Willig on behalf of AT&T in FCC CC Docket No. 96-98, July 1996. Also see Baumol and Gregory Sidak (1994), Ch. 6.
 53. See Hausman (1998b), Hausman and Shelanski (1999), and Hausman and Sidak (1999).
 54. See Hausman (1997), Hausman (1998a) and Hausman and Shelanski (1999).
 55. Telecommunications Act of 1996, Pub. L. No. 104-104, pmb., 110 Stat. 56, 56.
 56. H.R. REP. NO. 104-458, p. 1 (1996).
 57. In May 1997, the CRTC adopted an unbundling policy that in contrast to the FCC's approach, the CRTC ordered that Canadian ILECs 'should generally not be required to make available facilities for which there are alternative sources of supply or which (competitive local exchange carriers) can reasonably supply on their own.' Mandatory unbundling in Canada extends only to the ILEC's essential facilities.
 58. 708 F.2d 1081 (7th Cir. 1983).
 59. See 1992 DOJ and FTC Horizontal Merger Guidelines. The Australian 1999 Merger Guidelines take a similar approach.
 60. 1992 Horizontal Merger Guidelines. For convenience, the 5%, although for some purposes a 10% level may be more appropriate.
 61. See 1992 Horizontal Merger Guidelines. The Merger Guidelines emphasize the own-price elasticity of demand, while other analyses focus on the cross-price elasticity of demand. But the two elasticity measures are closely related.
 62. For a more extensive discussion of critical share see Hausman *et al* (1996).