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Abstract

Regulatory policy in telecommunications must balance short-term efficiency (low prices) against the firms' incentives to innovate, which have longer reaching impacts on economic welfare. Historically, policy tended to sacrifice dynamic efficiency for the sake of competitive prices and static efficiency. In the last few decades, economists and other researchers have begun to document the large welfare costs of ignoring dynamic efficiency. We analyze the impact regulation has on innovation in a simple theoretical framework. We then turn to the empirical evidence that regulation dampens firms' incentive to innovate in the telecommunications industry in general and the market for broadband Internet access in particular. Both product and process (cost reducing) innovation are discussed. The chapter forms a compendium of available research on the intersection of telecommunications regulation and innovation. The lesson for policy makers provided by the consensus of the literature is that *lighter regulation spurs process and product innovation*. We conclude with a discussion of future regulatory trends.

INTRODUCTION

For much of the 20th century, regulatory policy directed toward the telecommunications market was concerned with "getting the prices right". Regulators took the set of existing firms and products as given and sought prices that maximized consumer surplus, subject to the constraint that the regulated firm cover its costs of providing the current set of services. Although other regulatory objectives such as universal service played a role, regulation was framed within an essentially static view of the market. In the latter part of the century, however, as the pace of technological change increased in the telecommunications industry, it became clear that regulation could hinder innovation. In this chapter, we consider the evidence that regulation dampens firms' incentive to innovate. We begin by laying out the theoretical reasons underpinning this notion. In the main section of the chapter, we review the empirical studies in the literature, focusing on the U.S. market. In so doing, we find remarkably consistent evidence from numerous institutional and geographic settings that lighter forms of regulation encourage innovation.

Before proceeding, we must ask what innovation is. The term is used in the economics literature to refer to everything from basic invention to new product introduction to diffusion of existing technology. We use the term in a broad sense to refer to the making available of something new in a given market. It is useful, however, to distinguish between process and product innovation. Process innovations are advancements in the methods of creating existing products, and may not be directly apparent to consumers. Process innovation lowers the cost of producing goods or services currently available to consumers. Product innovation is the creation (or diffusion to new markets, in our expansive definition) of new goods previously unavailable to consumers.

Regulation affects firms in many ways. Regulators historically deemed regulation justifiable, to reap the economies of scale and scope created by a single service provider and to further social goals such as universal service, while avoiding the inefficiency due to monopoly pricing. Regulatory control over prices and profits was chosen instead of reliance on competition or antitrust policy, which is generally not designed to prevent market expansion by firms with legitimate cost advantages over rivals. Competition law, at least in the U.S., furthermore does not outlaw the unilateral exercise of market power in setting prices.

The economic inefficiency created by prices above their competitive level is illustrated in Figure 1, which depicts the demand and marginal cost curves for a telecommunications service. Total economic benefits from the service are the entire area between the demand and the marginal cost curves. Benefits are maximized when quantity Q^* is provided (as would happen if the competitive price P^* is charged). These social benefits, shared between the consumers and the firm, arise because one part of society (consumers) consumes units for which it is willing to pay more than it costs another part of society (the firm) to produce. If a carrier with monopoly power charges a higher price, such as P^m, then a lower quantity Q^m of the service is purchased and the market loses benefits in the amount of area DWL in Figure 1. This deadweight loss, also known as the "Harberger triangle", represents the dollar value of the economic benefits lost to consumers and the firm from units between Q^m and Q^* that are not consumed at the higher price. Deadweight loss is a static loss in welfare, because it is calculated given the service is already available.

The Harberger triangle is not the end of the story, because a regulatory regime that attempts to squeeze static inefficiency out of market prices may create dynamic inefficiency. Dynamic efficiency stems from the additional net surplus created by new products and services. In Figure 1, the surplus obtained by consumers each period from the existence of the service is triangle CS, sometimes called the "Dupuit triangle".[1] The firm gains producer surplus, the unshaded area PS. If regulated prices are too low to encourage innovation, so that the product is never introduced, then consumers and producers miss both benefits (although the firm saves the cost of innovating). Thus, as Bourreau and Doğan (2001) and many other authors point out, regulatory policy is a balancing act that often trades increased static efficiency for decreased dynamic efficiency. The focus of this chapter, the dynamic costs of regulation, has received much less attention than have the static effects (Joskow and Rose, 1989).

In the next section, we present a simple model to provide a framework for analyzing the impact regulation has on innovation. We then turn to the empirical evidence on the interplay between regulation and innovation in the telecommunications industry in general, and the market for broadband Internet access in particular. In these sections, we include every relevant formal econometric study pertaining to the U.S. case that we could find, as well as representative studies using data from other countries or

[1] Areas under the demand curve, such as the Harberger and Dupuit triangles, are only approximations of consumer welfare when there are income effects in demand. However, as long as the income effects are not too strong, they are good approximations in many cases (Willig, 1976).

international comparisons.[2] Thus, the meat of this chapter—and our main objective—is a compendium of the available research on how innovation depends on regulation in the telecommunications industry.[3] We conclude with lessons the literature provides to policy makers and a discussion of future regulatory trends.

HOW DOES REGULATION AFFECT INNOVATION?

The likely impact of a market intervention can be analyzed by studying how the regulation changes firms' incentives. While some regulatory schemes such as price caps are known as "incentive regulation" in particular, it is important to realize that *any* regulation, if it affects the actions of the market participants at all, does so by changing their incentives. The economic study of regulation thus entails looking at how regulation changes the profit function of the firm. When the profit function changes, the actions the firm takes to maximize profit also change. Take the case of product innovation. Regulation can affect firm's incentives to product innovate through three channels. There are direct effects through mandates, indirect effects stemming from changes in the cost of bringing a new product to market, and indirect effects stemming from changes in operating profits gained by new products. Although we draw the examples in this section from the telecommunications industry, the model is generic and would apply as well to other industries.

Most visible are the direct effects of regulation on innovation. For example, a line of business restriction placed on the U.S. Bell Operating Companies (BOCs) after the

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[2] Given the paucity of formally peer-reviewed, published research, we cast a wider net than is often seen in such literature reviews. The reader is cautioned that some of the working papers and other unpublished studies we cite may not have undergone rigorous peer review. This is particularly true of the section on the broadband market below.

[3] We have undoubtedly missed some research, and welcome readers bringing omissions to the attention of the first author.

breakup of the AT&T Bell System in 1984 prevented the BOCs from manufacturing telecommunications equipment. The incentive to introduce a new manufactured product, therefore, was dwarfed by the cost to the firm of the legal difficulties that would have ensued. Other examples of direct impacts of regulation include social contracts between the regulator and the firm, which are often the outcome of a public utility commission's review of a merger case or renewal of a regulatory regime. In such contracts with the regulator, the firms often commit to putting new services on the market or making existing services available in more service areas. The merger of Ameritech and SBC in 1999 provides an example of the latter. Ameritech, the incumbent local exchange carrier (ILEC) in five Middle Western states, had (in the eyes of the federal and state regulators) dragged its feet in making digital subscriber line (DSL) services available to customers. Before approving the merger, the Federal Communications Commission (FCC) extracted commitments from the companies to promote advanced services such as broadband Internet access. In particular, SBC was required to locate at least 10% of their advanced service facilities in low-income areas. The requirement had teeth: penalty payments of more than $2 billion were specified. Subsequent to the merger, SBC deployed DSL more rapidly in the area (Hu and Prieger, 2008).

In contrast to the obvious effect that direct regulatory prohibitions and deployment mandates have on product introduction, many (indeed, most) effects of regulatory policy are indirect. To see how, we introduce a simple model of the firm's decision problem.[4] Consider the panoply of new goods that a regulated firm could

[4] For more sophisticated modeling of a regulated firm's incentives to innovate, see Riordan (1992), Lyon and Huang (1995), and Prieger (2007,2008).

potentially offer. Some would provide higher operating profit, others lower.[5] Let the density *m* of operating profits *R* describe the distribution of potential outcomes, so that $M(x) = \int_x^\infty m(R)dR$ is the number of projects that earn more than *x*. Assume in our simple model that the innovation cost *c*, which includes everything from basic research through development and product launch costs, is the same for all projects. Then the amount of innovation in which the firm chooses to engage is *M*(*c*), for only projects to the right of *c* are profitable (see Figure 2). We can now use this model to consider some indirect impacts of regulation on innovation.

The first type of indirect regulatory effect is on the cost side. Regulations that affect the cost of innovation *c* include mandated regulatory filings and hearings before a public utility commission before introducing a new service. Cost studies that a firm must perform before a state commission approves rates for a new service are an example of the indirect costs of regulation. Hearings and cases in the legal and regulatory arena can also be expensive for the firm. For example, before (and even after) the BOCs could introduce information services there was a drawn-out string of federal court cases revolving around the FCC's *Computer III* series of orders, stretching from the late 1980's (the *California I* decision) into the mid 1990s (when *Computer III* was remanded) (Prieger, 2002).

Such regulatory costs increase *c*. The effect on the amount of innovative activity in which the firm engages is clear: as *c* shifts to the right in Figure 2, there are fewer worthwhile projects to pursue, *M*(*c*) decreases, and there is less product innovation.

[5] We treats costs and revenue as known quantities here. If they are uncertain, there is no change needed in our discussion if the firm is risk neutral. If the firm is risk averse, regulation has additional effects on the firm's decision problem (see, e.g., Prieger, 2007).

However, it is important to note that if regulation induces only a small change in c, then there will be only a small effect on innovation. It is only those products that were barely profitable that are lost because of regulatory costs. How many such projects are not pursued depends on the density of projects in the vicinity of c.[6] However, highly profitable projects (which are typically so because they provide sizable benefits to consumers) are pursued in either case. Unless the additional costs created by regulation are large, or the mass of projects just to the right of c is large, the number of new products lost because of these cost effects of regulation may be minimal.

The second type of indirect regulatory effect is on the benefit side. Regulations that effectively increase the time to market of a new product reduce the present value of the project by delaying the accrual of service revenue. Examples from telephone regulation abound. Many states and the FCC traditionally required hearings or minimum approval delays of tariffs for new services, designed to protect consumers from the "deleterious consequences of innovation," as one regulatory official put it (Oppenheim, 1991). The studies by Prieger (2001, 2002) cover examples from state and federal jurisdiction.

Regulation can also limit revenue from a new product through other means. One avenue is through competition. Under the unbundling regime instituted by the Telecommunications Act of 1996 in the U.S., incumbent telecommunications carriers must unbundle and lease to rivals certain parts of their network. The return on deploying the infrastructure is risky, and the carrier cannot fully recover the cost of investment after it is sunk. Thus, unbundling creates an asymmetry between incumbents (which bear the

[6] In mathematical terms, the effect on the amount of innovation of a(n infinitesimally) small increase in c is $M'(c) = -m(c)$.

risk) and competitors (which, because they can stop renting at any time, do not). Renting unbundled network elements (UNEs) thus grants competitors a "free option", and the extra competition reduces the return on the incumbent's investment.[7] Gayle and Weisman (2007) note that while unbundling may readily increase competition in telecommunications, it comes at the expense of investment that is vital for future innovation.

Regulation can affect the competitive environment and the benefits a firm expects from introducing new products in other ways, as well. Regulatory policy can encourage competition through means other than mandating resale and unbundling, such as by requiring interconnection between competing networks. Regulation can also create legal monopoly (e.g., the Bell System in the U.S. until 1984), which enhances the incumbent's ability to appropriate the social benefit created by innovation. Monopolies, however, may cannibalize demand for one of their existing products by introducing a new one, which increases the opportunity cost of innovation (Arrow, 1962).

Other features of the general regulatory regime a carrier operates under can reduce the benefits from innovation. For example, "prudency reviews" were a common feature of rate of return regulation (RORR), the most common form of utility regulation in the U.S. for much of the 20th century (Kolbe and Tye, 1990). If the regulator deemed a failed investment to be imprudent, it would be stricken from the rate base upon which the firm's allowed rate of return was calculated, reducing the firm's revenue. RORR also attenuates incentives for process innovation, since excess returns gained thereby last only

[7] The term "option" comes from the real options literature, in which the option value of delaying risky investment is priced into the firm decision problem (Dixit and Pindyck, 1994). The adjective "free" does not mean that the competitors bear no costs of entry using UNEs, but instead that they are not required to pay for the risk reduction that UNEs offer them. See Hausman (2002) for the argument applied to DSL infrastructure.

until the next regulatory review (Cabral and Riordan, 1989).[8] Alternative regulation, which includes price caps, earnings sharing plans, rate freezes, and other schemes may provide greater incentives for innovation. We discuss alternative forms of regulation more in the next section. For example, tariffs for new services require no cost studies or prior approval under the FCC's price cap regulation. Also, under price caps a dollar saved on cost (through process innovation) is retained by the firm, in contrast to RORR. However, even under alternative regulation the present value of the anticipated revenue from a new product is typically lessened, unless the regulation has no impact on the firm's activity at all.

Regardless of how regulation affects the costs and benefits of introducing new products, the net effect is shown in Figure 3. As regulation increases costs from c_0 to c_1, the mass of innovation that becomes unprofitable is depicted by the horizontally striped area. The vertically striped area is the mass of new products that become unprofitable due to the leftward shift of the revenue curve. It can be seen that changes in the revenue of potential services may have a larger effect on the amount of innovative activity of the firm than changes in cost. Changes in cost affect only the marginally profitable services, whereas changes in revenue affect the mass of all formerly profitable services.

In contrast to the usual view that regulation sacrifices dynamic efficiency on the altar of static efficiency, proponents of regulation sometimes claim that regulation encourages innovation. In the context of our simple framework above, this could happen only if regulation lowered costs or increased revenue. It is difficult but not impossible to imagine cases where regulation accomplishes such changes. One oft-cited role for the

[8] Kahn, Tardiff, and Weisman (1999) argue, to the contrary, that RORR encourages innovation by reducing the risks involved, since the firm is guaranteed a specified return on R&D.

regulator is to set technological standards in markets such as mobile telephony where coordination among firms, perhaps due to network effects in demand, is important. A standard imposed by the regulator that speeds consumer acceptance of a product can therefore increase revenue (or lower the cost of coordination). However, for every example of successful regulatory standard setting (e.g., perhaps, the GSM standard for European mobile telephony), one can find examples of failure. For example, the FCC's delayed approval of a standard and spectrum allocation rules for mobile telephony for about 14 years during the nascence of the industry in the U.S. Furthermore, industry-led efforts to coordinate are often successful absent regulatory intervention (e.g., the International Telecommunications Union (ITU) standards for Group 3 fax transmission).

Regulatory rules affecting competition, similarly, can also have conflicting effects on the rate of innovation. Increasing incentives for entrants to bring new services to market may diminish incentives for incumbents to do the same, and the net effect on innovation is ultimately an empirical matter in each market studied. We take up the empirical evidence in the next section.

EMPIRICAL EVIDENCE FROM TELECOMMUNICATIONS

Economic theory thus suggests that regulation may hamper innovation, at least by incumbents, but theory alone cannot accurately measure the impact in any given market. The numerous regulatory reforms in the U.S. telecommunications industry over the past few decades give researchers a unique opportunity to quantify the consequences of various types of regulation. Compared to the vast number of papers related to the static effects of various regulatory schemes, there has been only limited effort directed toward quantifying the impact of regulation on innovation. Joskow and Rose (1989) find this “distressing” given that the “static gains and losses from regulation are probably small compared to the historical gains in welfare resulting from innovation and productivity growth.”

Nevertheless, some researchers have compared the amount of innovation under the traditional RORR and incentive regulation. In the following section, we outline the empirical findings concerning the amount of innovation under divergent regulatory schemes. We also examine attempts to quantify the effects of regulatory delay on innovation. In addition, we review empirical findings on how unbundled network elements (UNEs) affect innovation. Finally, we explore endeavors to measure the value of the loss to society from the postponement of product introductions due to regulation. Process and product innovation are covered in separate subsections, and a final subsection reviews the literature on the broadband Internet access market as an in-depth case study. We summarize the literature for reference in Tables 1-3.

Before delving into the empirical literature, it is important to point out several possible pitfalls for researcher. Kridel et al. (1996) discuss the problems posed by demonstration effects, sequencing effects, and before-and-after study designs. The demonstration effect pitfall occurs when regulated firms, in an attempt to encourage favorable regulatory reforms, artificially “demonstrate” the success of these regulations. Thus, any positive action a firm takes after regulatory reform may not result from better incentives to innovate. On the contrary, the actions of the firm may merely be a strategic (and temporary) decision to encourage permanent regulatory changes that are favorable to the firm. If the demonstration effect is substantial, then the positive effects of incentive regulation that many researchers find may persist only in the short term.

A related hazard is the sequencing pitfall, in which firms hold off investment or innovation until the anticipated introduction of more favorable regulations. If the sequencing pitfall occurs, then innovations attributed to newly adopted regulations may also reflect only a short-term change in the firm's behavior. A third pitfall occurs with before-and-after empirical models (Sappington and Weisman, 1996), in which performance in a period before the new regulation is contrasted with a period after. Since regulatory change is not conducted under conditions of a controlled experiment, such models can confuse the effects of regulation with trends in innovation that are exogenous to the regulatory reform. With these potential pitfalls in mind, we can review the conclusions found in the empirical literature.

Process Innovation

Process innovation occurs when a firm, operating efficiently given its current technology, lowers its operating costs further by implementing new technology. Hence, researchers, when examining process innovation, often focus on changes in a firm's costs.[9] Stimulating process innovation is often a goal of regulatory reform. For example, one of the intentions behind the transition from RORR to incentive regulation was to provide firms with better incentives to reduce costs and deploy digital infrastructure.

The empirical literature on regulation's impact of firms' performance categorizes regulatory regimes differently, although generally a distinction is made between traditional RORR and alternatives. Ai and Sappington (2002) provide a good example of regulatory classification. They distinguish between RORR and three types of incentive

[9] Incentive regulation may reduce costs by means other than process innovation, however. The famous Averch-Johnson effect, for example, maintains that a firm choosing its input mix under RORR will not minimize costs given the output produced and its current technology.

regulations: rate case moratoria, earnings sharing regulations, and price cap regulations. Earnings sharing regulations give the firms greater control over which rates and services to offer, but require firms to return to consumers a percentage of their earnings above certain thresholds. Under most earnings sharing regulations, the firm is prohibited from increasing its earnings above a certain point. Firms regulated by earnings sharing regulations will thus not have an incentive to lower costs beyond a certain level. Earnings sharing regulation is thus similar to RORR, in that both regulatory schemes focus on the profit being made by the firm rather than the prices of the services in question. Rate case moratoria are typically an intermediate regulatory scheme in which regulated firms are freed from traditional RORR and given greater control over setting rates. Under price cap regulation, there are no direct constraints on profit and the firm instead faces a limit on how high it can raise its prices. Greenstein, McMaster, and Spiller (1995) note that firms under most price-cap regulations have greater control over prices than have firms regulated by traditional profit regulation like RORR.

Kridel et al. (1996) review a variety of earlier papers related to incentive regulation and find mixed evidence concerning reductions in operating costs.[10] Ai and Sappington (2002) perform a careful study and test empirically whether the introduction of incentive regulation did in fact lower the cost of producing existing services. They observe that rate case moratoria do indeed lower production costs compared to RORR in their sample of ILECs in the period 1986-1999. Surprisingly, other forms of incentive regulation do not produce significantly lower production costs than RORR, holding all else constant. The authors suggest that this finding may be due to the regulated firms'

[10] See also work by Resende (2000), who estimates a yearly "efficiency score" (a measure of how productively a firm uses inputs) for U.S. ILECs. He then regresses the scores on regulatory variables to find that alternative regulation is robustly and significantly correlated with better efficiency.

fear that lower production costs will cause regulators to "ratchet" the standards for the firm's performance upwards, thereby making any gains temporary. When local competition is present, regulation does indeed reduce production costs relative to RORR. This finding supports the notion that incentive regulation should be complemented by increased competition to realize the theorized gains of incentive regulation.

The deployment of digital infrastructure under various regulatory schemes is an important aspect of process innovation since it lowers the cost of providing services. Moreover, increases in digital infrastructure enable new services that require greater digital capacity. Ai and Sappington (2002), Greenstein et al. (1995), Tardiff and Taylor (1993), and Taylor et al. (1992) find that incentive regulation leads to increased deployment of digital infrastructure, such as fiber optic cables and digital switches, when compared to RORR. Greenstein et al. (1995) conclude that if all states had adopted some form of pricing regulation ILECs would have installed at least 75 percent more fiber optic cables than under the status quo. They do not find, however, find evidence that earnings sharing would have produced results drastically dissimilar to those under RORR. Ai and Sappington (2002), in contrast, find that deployment of digital infrastructure is more extensive under all types of incentive regulation—including earnings sharing—than under RORR. Unlike the other studies, Ai and Sappington (2002) correct for the endogeneity of the regulatory regimes[11] in their econometric modeling, and thus have the strongest claim to finding true causal effects of regulation. They also find that the

[11] Endogeneity of an explanatory variable occurs when it is correlated with the econometric error term, which violates a fundamental assumption of ordinary least squares regression. For example, if incentive regulation is more likely to be adopted in poorer performing areas, then incentive regulation may be correlated with worse outcomes in a regression, even though the true causal impact is in the other direction. Ai and Sappington (2002) discuss the issue thoroughly and provide a solution.

amount of digital infrastructure added to a local area under earnings sharing regulation increases when local competition increases.

To sum up the literature on process innovation: incentive regulation appears to spur the deployment of next-generation infrastructure, and perhaps to lower operating costs. The latter result does not always hold empirically, in contrast to the predictions from theory. The divergence may be explained by the fact that regulators in practice are often not able to commit to adhering to the incentive regulation when the temptation to return excess profit to consumers arises. If firms look forward to only short term gains from reducing costs, then their incentive to process innovate is blunted.

Product Innovation

Despite the limited amount of research on regulation and process innovation, until recently there has been more work looking at process innovation than at product innovation. Given the difficulty of counting innovations not created due to regulation, the imbalance is not surprising. Recent years have witnessed more attempts to quantify differences in product innovation under varying regulatory schemes, but the literature is still sparse. In addition to the usual comparison between RORR and incentive regulation, questions of regulatory delay become especially important when examining product innovation. Regulatory delay occurs when regulators prevent new products from entering the market until significant regulatory review has occurred. Regulatory delay may enhance social welfare by ensuring that new products meet certain guidelines, but may also create a disincentive for firms to release new services.

In an early attempt to study product innovation in the telecommunications industry, Mueller (1993) examined the effects of extreme deregulation. In 1987, while other states were adopting earnings sharing or price-cap regulation, lawmakers in Nebraska opted to remove nearly all restrictions on the telecommunications industry. Firms were allowed to introduce new products and change rates with little regulatory oversight. Of 100 new services offered by U.S. West that Mueller (1993) randomly selects for the study, 37 were first introduced in Nebraska. The result of Nebraska's experiment supports the contention that deregulation spurs firms to create new services. However, U.S. West likely opted to release new services in Nebraska first in order to demonstrate the benefits of such extreme deregulation. This is an example of the demonstration effects pitfall (Kridel et al. 1996), and it likely explains a portion of the increase in new services in Nebraska. Mueller's findings may have limited validity in other settings, especially since no formal econometric model is used in measuring the impact of extreme deregulation.

More recent attempts to quantify the amount of product innovation under various regulatory schemes have used more formal econometric models. Regulators in Indiana replaced traditional RORR with a mixture of incentive regulation and deregulation. Firms were allowed to set prices and the long regulatory delays witnessed under RORR were significantly reduced. Prieger (2001) estimates that the dominant ILEC (Ameritech) created new services 2 to 4.5 times faster than it did under the previous regime. Moreover, Ameritech, would have introduced up to twelve times as many services had reform been enacted at the beginning of the observed period. The author cautions, however, that the model consists of only two periods, one before introduction of the new regulations and one after introduction, with no "control" state. Thus the pitfall cited by Sappington and Weisman (1995), in which trends in overall innovation rates are indistinguishable from the actual regulatory effects, cannot be avoided.

Prieger (2004) confronts the problem posed by before-and-after study designs by using unique data covering three periods of regulation for information services offered by dominant ILECs. The first and third period had extensive FCC regulation that created significant regulatory delay and forced firms to file extensive paper work before the approval of new services. The second, interim period had lighter regulation. The empirical evidence shows that firms introduced considerably more new services during the interim than during the first or third periods. In fact, the model predicts that the rate of product innovation was anywhere from 60% to 99% higher during the interim. Furthermore, these new services reached consumers much quicker during the interim since firms did not face any significant regulatory delays.

The author's data and study design minimizes the potential for the before-and-after problem, but the sequencing pitfall remains a possible problem. If firms withheld innovations near the end of the first period in order to release them during the more profitable interim, then the significant increase in new services during the interim is not the result of better incentives to innovate under less regulation. The author addresses the sequencing pitfall and ultimately concludes that it does not significantly affect the results.

Prieger (2007) presents a theoretical model that predicts that a reduction in average regulatory delay would result in introduction of new services more quickly. These theoretical predictions are tested empirically by examining the number of new services offered in four states that adopted reforms designed to significantly reduce regulatory delay. The evidence confirms that the theoretical prediction: shorter regulatory delays lead to quicker product innovation. Thus, Mueller (1993) and Prieger (2001,2004,2007) all consistently find that lighter regulation does indeed encourage greater product innovation.

Increases in social welfare due to the creation of new products is an important aspect of the study of regulation and product innovation. While it is unrealistic to expect a precise measurement of the gains and losses to society caused by telecommunications regulation,[12] some attempts have been made to determine the welfare losses or gains from certain regulations.

Hausman (1997) examines regulatory delay by the FCC in approving the widespread availability of cellular telephones. He finds that the loss to consumer welfare in 1983 from regulatory delay was somewhere between $16.7 and $24.3 billion in 1983 dollars. Total losses were much higher, given that mobile telephony could have been introduced a decade earlier than it was in the U.S. In similar fashion, Hausman (1997) estimates that regulation preventing AT&T (before divestiture) and the BOCs (after) from offering voice mail services cost consumers $1.2 billion per year.

Prieger (2004), who examines the regulatory regime (CEI) put into place once the BOCs were allowed to offer information services, uses Hausman's (1997) calculations to estimate the effect of regulatory delay on voice mail services. The potential cost to consumers in delayed availability of voice mail services due to the CEI regime ranges from $690 to $910 million. Prieger (2004) notes that voice mail is merely one of dozens of information services delayed by regulatory action. However, Hausman's figures for voice mail cannot be extrapolated to other services, because many of the others were much less subscribed than voice mail services. Moreover, some of the services held up

[12] Nevertheless, see WEFA Group (1995) for a bold attempt.

by regulatory delay were substitutes for a service already available. The introduction of such services would probably increase consumer surplus far less than would truly novel services. We have not found other attempts to quantify the loss in consumer welfare caused by regulation.

A Case Study of the Broadband Internet Access Market

We turn now to one specific sector of the telecommunications industry: the market for broadband Internet access. The spread of Internet access—first narrowband, and now broadband—is one of the most studied phenomena in the literature on regulation of telecommunications. As in the rest of the chapter, we focus mainly on the U.S., but also draw international studies into the discussion at times. Growth in broadband Internet access (hereafter, "broadband" for short) has been rapid in the U.S., especially compared to the spread of other recent services such as mobile telephony (Faulhaber, 2002). The growing importance of broadband in the national economy is large but difficult to quantify. The benefits of broadband that accrue to consumers are worth hundreds of billions of dollars per year in the U.S. (Crandall and Jackson, 2003). Total benefits are even higher, since business' profits are not included in the estimate. Such rapid growth raises questions related to policy. Did good regulatory policy in the U.S. encourage the spread of broadband? Or, as some claim (e.g., Hausman, 2002), could broadband have diffused even faster in the U.S. (as it did in other countries such as Japan and Korea) if regulatory roadblocks had been removed? In this section, we look at the evidence available.

As in other segments of the telecommunications industry in the U.S., regulatory policy toward broadband is a welter of partly coordinated (at best) state and federal efforts.[13] State level direct subsidies for broadband are relatively rare: one survey found that only three states targeted tax incentives toward broadband deployment in 2001 (Lee, 2001). However, not all states were included in the survey, and a later study found 15 states with broadband tax incentives (Wallsten, 2005). Wallsten (2005) estimates the impact of other state policies directed at broadband, including private-sector grants and loans targeted to deployment in underserved or rural areas and use of universal service mechanisms to stimulate investment. None of these is positively correlated with the per capita broadband rate in the state,[14] except for rural-targeted grants, and some even have negative correlation.

Federal subsidies for carriers are not available for broadband specifically, although rural and high-cost areas receive general support for infrastructure, some of which may enable advanced services. Federal demand-side subsidies include the "e-rate" for schools and libraries. Although billions have been spent on the subsidies, Flamm (2005) finds no measurable effect on broadband availability. In sum, while it is not hard to find case studies of this or that neighborhood, organization, or school that benefited from being brought online by a subsidy program, there is scant evidence that the state and federal money spent has had large enough impacts to be measurable by econometric studies. Some of the programs are relatively recent, however, and the conclusion may change as time elapses and more data become available.

Lee (2001) reports that at least 14 public utility commissions hold rate hearings for broadband rates, but Wallsten (2005) states that nowhere do states set rates for broadband, a discrepancy not easily reconciled. There is no federal rate regulation. In

[13] This section draws on Prieger and Lee (2008).

[14] Subscription rates reflect both innovation (in the sense of diffusion: where the service is available) and other factors, such as the usual supply and demand considerations for existing markets.

any event, we know of no study examining whether direct rate regulation of broadband affected its deployment by providers or take-up among consumers.

The likeliest places to look for the impact of state policy on broadband are the general regulatory scheme for telecommunications and the prices it allows incumbents to charge competitors for access to the local network. Both impacts occur through indirect channels. As described above, RORR and price cap regulation lead to differing incentives to deploy new products—in this case, digital subscriber line (DSL). While the cable companies' decisions to offer broadband is not directly affected by public utility regulation in the U.S., any regulation affecting the deployment of DSL will indirectly affect the market for cable modem service, because they are substitutable to some degree.

Prieger and Lee (2008) examine broadband deployment data for the entire U.S. and find that areas under RORR have a lower probability of broadband availability than areas under price caps or rate moratoria. The impact of the form of regulation is not large, however. After controlling for which firm is the local incumbent, the presence of competition, and a host of demographic and economic characteristics of the area, price caps and rate freezes are each associated with an increase in the probability of broadband deployment in the postal code area of about one percentage point. Compare the increase with an average deployment of broadband in the ZIP code of 75% in 2000, the vintage of the data used. Broadband services are often not subject to either price caps or rate freezes even when basic telecommunications services are. So, it is perhaps not surprising that the evidence is consistent with rate of return regulation (in which revenue from all sources is typically regulated) dampening the incentive to deploy new services compared to alternative regulation. The correlation found in Prieger and Lee (2008) may not be causal for a host of the usual reasons, as they discuss. Regulatory regimes are not randomly assigned, alternative regulation may be offered to companies in exchange for commitments to roll out advanced services, and companies favored with alternative regulation may wish to "demonstrate" its beneficial effect to the regulator by speeding broadband deployment.

The other way states may indirectly affect broadband is through policy toward UNE rates for the parts of the local network. States do not set UNE rates unless negotiations between the private parties break down, but the threat of state rate setting affects the relative negotiating positions of the players. Pindyck (2007) notes that competitive local exchange carriers (CLECs) have a significant advantage in bargaining. If the parties are unable to agree on a rate, then the state regulator will typically impose a relatively low price to ensure CLECs can effectively compete in the market. The effect of UNE rates on broadband is indirect, because an ILEC's DSL packet-switching facilities are not subject to unbundling. However, competitors wishing to offer DSL to subscribers without duplicating the local network could also purchase the "last mile" segment between the incumbent's wire center and the subscriber's premises as a UNE. Since DSL does not require the whole line, until 2003 competitors could "line share" with the incumbent by renting just the high-frequency part of the local loop as a UNE to offer DSL. These various forms of unbundling enable competition in DSL. Cable companies, in contrast, have never been required to open their networks to competitors.

The empirical literature on the impact of unbundling on performance and competition is sizable, and here we cover only those empirical studies examining broadband innovation.[15] The impact of unbundling policies directed toward a subset of the industry may not be as important in general as competition itself between cable and telephone companies. Howell (2002) and Maldoom, Marsden, Sidak, and Singer (2003) use sets of national case studies to find that unbundling is less successful than intermodal competition at speeding broadband deployment in developed nations.[16] In another international comparison, Wallsten (2006) finds no relationship between full-loop unbundling requirements and broadband penetration, but that sub-loop unbundling is correlated with lower penetration.[17] García-Murillo and Gabel (2003) likewise find no impact of unbundling requirements on broadband availability within a country or on the percentage of population with broadband access. Relying solely on data from the U.S., Wallsten (2005) concludes that where more UNEs are rented, lower broadband penetration results. Curiously, he finds the opposite correlation for lines that are resold instead of purchased as unbundled elements, which casts doubt upon a purely causal explanation for either result.[18] The sole study we found that associates unbundling with increased broadband access is García-Murillo (2005), which uses a small international cross-section of countries.[19]

[15] Much of the literature on UNEs looks at whether unbundling leads to investment in infrastructure by incumbents and facilities-based entry by competitors. See also Hausman and Sidak (2005), who discuss arguments for whether unbundling leads to more innovation. They conclude unbundling did not lead to innovation in the five cases they study.

[16] See also Distaso et al. (2006) for further evidence that intermodal competition is an important driver of broadband penetration.

[17] In full loop unbundling, the entire "last mile" of copper between the wire center and the subscriber is rented to the competitor. Sub-loop unbundling entails renting access to only the last part of the "last mile," which in the case of DSL can allow superior transmission performance.

[18] Federal regulations require that any service that the incumbent local exchange company offers to retail customers has to be offered to CLECs at wholesale prices. These rules are distinct from the unbundling regime and UNE rates.

[19] In the estimation where García-Murillo (2005) finds a statistically significant positive effect of unbundling on broadband usage, there are 12 variables in the regression nearly span the 18 observations, resulting in a near-perfect fit (R^2 = 0.98). In the other estimation finding a positive effect of unbundling,

Should we expect high or low UNE rates to stimulate broadband? Hausman (2002) argues forcefully that allowing competitors to rent facilities after they are deployed by the incumbents causes the incumbents to invest less in infrastructure. He attributes the early lead of cable modem service over DSL to the former's closed networks. In Hausman's (2002) view, low UNE rates retard the spread of broadband, at least among incumbent carriers. In accord with this notion, the rate of DSL subscription growth rose markedly after the FCC's line-sharing rule was lifted in 2003 (Hazlett and Bazelon, 2005), although it is impossible to assess from a simple before-and-after comparison whether the change is entirely causal. Burnstein and Aron (2003) use state broadband subscription rates to indicate that lower UNE rates discourage broadband, although their estimate is not statistically significant.

On the other hand, lower UNE rates encourage entry by competitors, thus spurring competition that may spill over to the broadband market as well (García-Murillo and Gabel, 2003; Ford and Spiwak, 2004). Partially supporting this conclusion, Distaso et al. (2006), using data from Europe, and Prieger and Lee (2008), using U.S. data, find that areas with lower UNE rates are correlated with more broadband availability, but the sizes of the effects are small (although statistically significant). The latter study has the largest sample size and number of control variables of any, and furthermore controls for any state-level variables that do not vary over time by the inclusion of fixed effects in the econometric model. Further investigation reveals that the effects of UNE rates on broadband are greatest in states with alternative regulation. Thus, although the evidence

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this time on broadband availability in the country, the data used are the same as in García-Murillo and Gabel (2003), which found no effect when more controls are included in the regression.

in the literature is mixed, perhaps the tentative conclusion at this date is that UNE rates have little measurable impact on broadband deployment.

CONCLUSIONS AND OUTLOOK

For policymakers attempting to improve current regulatory schemes, the limited research available on innovation presents a problem. Each regulatory setting is unique, and thus presents unique incentives to participating firms. The external validity of the case studies is unknown, and not all instances of regulation have been thoroughly studied. What then can we conclude? Fortunately, a consensus exists in the economic literature and some general lessons are clear. In short, heavier regulation does place roadblocks on the information highway.

Incentive regulation appears to spur process and product innovation. Whether examining total deregulation (Mueller 1993), incentive regulation (Prieger 2001), or regulatory delay (Hausman, 1997; Prieger 2001, 2002, 2007), studies typically find a negative relationship between the number of roadblocks created by government regulation and the amount of product innovation. While some studies may be picking up a demonstration effect in part, as long as the regulator periodically reviews the firms' performance under the lighter regulatory regime and maintains the threat of re-instituting heavier-handed regulation (as was done in Indiana a few years past, for example), the improved innovation should continue. However, the regulator must avoid the temptation to use periodic reviews to confiscate excess returns created by process innovation, for then dynamic efficiency is lost in the name of short-term, static welfare gains.

Innovation and dynamic efficiency, however, are not the only goals of regulators. On the contrary, regulators are often instructed by legislation to strive toward competing goals, such as efficiency and universal service, and must find a balance. Rather than reading our review as necessarily calling for complete deregulation, policymakers should instead treat it as pointing out some of the dynamic costs of regulation of which they may not have been adequately aware.

As regulators attempt to balance competing factors, however, they will find that the large potential costs from lost innovation often tip the scales in the direction of lighter regulation. These costs are higher in times of rapid technological change, such as the industry now finds itself in. The trend in telecommunications is toward convergence of voice, data, and video communication. Regulatory schemes that discriminate between the types of information communicated (e.g., FCC distinctions between information and telephone services) or the mode of carriage (e.g., cable systems vs. the telephone network vs. the Internet) based on the arbitrary historical accretion of rules are sure to fail to promote dynamic efficiency to its greatest extent. For example, when voice communication via VoIP (voice over Internet protocol) is carried over the cable system's network on one end to the Internet and terminated on the telephone network on the other end, is it a telephone call? Or is it just transmission of data? A more appropriate question: why should it matter? Rules that force regulators to split increasingly fine hairs to categorize services and providers are bound to hamper investment in new technology and services and to favor less efficient technology or carriers over more efficient in some cases.

Banerjee et al. (2007) discuss principles for future regulation to be guided toward the goal of dynamic efficiency. In the era of rapid technological change and convergence, good regulation consists of reversing the regulator's past emphasis on static efficiency to the detriment of dynamic efficiency. Instead of trying to force prices down to their long-run competitive levels immediately, or attempting to pick (and thus artificially creating) technological winners through asymmetric regulation, dynamically efficient regulation seeks to remove entry barriers wherever possible to allow unhindered intermodal competition. As technology such as the Internet erodes the monopoly bottlenecks remaining in the telecommunications network, intermodal competition becomes ever more feasible. However, removal of barriers need not be carried forward into creating "negative entry barriers" by providing artificial advantages to intramodal competitors (as some claim the unbundling rules have done for wireline telephony in the U.S. [Hausman, 2002]). Promoting inefficient entry at the expense of incumbents does not enhance dynamic efficiency and innovation. The challenge for regulators in the future will be to "do no harm" as they seek to level the playing field to let all participants compete, without imposing *a priori* notions of neutrality of outcomes that stifle innovation. Without entry barriers in the market, dynamic efficiency will help solve the problem of static efficiency as competition moves prices toward their efficient level.

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Table 1: Empirical Literature on Process Innovation in Telecommunications

Study	Peer Reviewed Publication?	Data and Period	Major Findings Regarding Regulation and Innovation
Ai and Sappington (2002)	Yes	U.S. ILECs 1986-1999	Examines deployment of digital switching and fiber optic cable, and operating cost, *inter alia*. Regulatory variables: price cap regulation, earnings sharing regulation, and price freezes. General finding: "We find that network modernization is more pronounced under … incentive regulation than under rate of return regulation." (p.135). Specific findings: price caps, rate freezes, and earnings sharing regulation are correlated with greater deployment of fiber optic cable. Rate freezes and earnings sharing regulation are correlated with greater deployment of digital switches. Operating costs are lower under rate freezes that under RORR. Costs are also lower under earnings sharing and price caps in states where local competition is relatively strong.
Greenstein, McMaster, and Spiller (1995)	Yes	U.S. ILECs 1986-1991 (some estimations use fewer years)	Examines deployment of fiber optic cable, ISDN, SS7 signaling, and digital switching. Regulatory variables: price regulation, earnings sharing, and their interaction. General finding: "We find that, in general, more liberal regulatory environments lead to great incentives to deploy modern equipment, and that LECs respond to these incentives" (p.189). Specific findings: simulate that if states that had no incentive regulation had price cap regulation, those ILECs would have installed 77-127% more fiber optic cables than under the status quo. Similar figures (albeit smaller but statistically significant) apply to ISDN and SS7, but no impact of incentive regulation is found for digital switching.
Kridel, Sappington, and Weisman (1996)	Yes	various	Reviews several studies from the early 1990's on incentive regulation and operating costs. Results are various and mixed.
Resende (2000)	Yes	U.S. ILECs 1988-1994	Examines the efficiency scores of LECs estimated by data envelopment analysis (DEA), measures of how productively firms use inputs. Regulatory variables: separate indicators for alternative (to RORR) regulation and price caps. General finding: the analysis "concluded that alternative forms of regulation induce a higher level of productive efficiency as contrasted with traditional ROR" (pp.464-5). An anomalous finding: price caps are significantly associated with lower efficiency, which the author suggests is due to factors not directly related to the incentives provided by price cap plans.

Study	Peer Reviewed Publication?	Data and Period	Major Findings Regarding Regulation and Innovation
Tardiff and Taylor (1993)	No	U.S. ILECs 1980-1994	Examines deployment of digital switching, fiber transport, ISDN, and SS7 signaling. Regulatory variables: state-level separate indicators for regulatory reform and incentive regulation. General finding: "the rate of diffusion of new technology tends to be greater for companies that have experienced some type of regulatory reform" (p.45). Specific findings: regulatory reform (an indicator variable for any type) is correlated with increased diffusion of digital switching. Flexible pricing and banded ROR regulation have the positive significant impacts on digital switching, fiber transport, and SS7 (flexible pricing only) when the regulatory variable is disaggregated. There are a few anomalous findings not discussed: deregulation is significantly negatively correlated with ISDN and price caps with digital switching and SS7.
Taylor, Zarkadas, and Zona (1992)	No	U.S. ILECs 1980-1991	Method and variables are similar to Tardiff and Taylor (1993), which is (*inter alia*) an update of these findings. Specific findings: regulatory reform is significantly correlated with increased diffusion of digital switching, fiber transport, and SS7.

Notes: Although some of the studies examine many outcomes from regulation, we include only the effect on process innovation in our summaries here. All quotations are from the study in column one. Book chapters may be less stringently peer reviewed than are journal articles.

Table 2: Empirical Literature on Product Innovation in Telecommunications

Study	Peer Reviewed Publication?	Data and Period	Major Findings Regarding Regulation and Innovation
Hausman (1997)	No*	18 US states 1991-1994 (voice mail); 30 US MSAs 1989-1993 (cellular phone service)	General finding: "this paper demonstrates that regulators should be quite careful in causing the delay of new telecommunications services because of the potential for quite large losses in consumer welfare." Specific finding: The lost consumer surplus from voice messaging service from the BOCs, prevented because of a line-of-business restriction, was $1.27 billion in 1994. Regulatory delay in approving cellular telephone service cost consumers about $100 billion in lost benefits.
Mueller (1993)	No	US WEST after deregulation in 1987	Compares performance of US WEST in Nebraska, where telecom was deregulated in 1987, to its operations in other states. General finding: deregulation was "successful at encouraging new service introductions by US West in Nebraska." Specific findings: of 100 randomly selected new service offerings by US WEST in its territory, 37% of the time Nebraska saw the first introduction.
Prieger (2001)	Yes	Ameritech Indiana 1991-1997	Compares the number of new services introduced in the state tariff and the regulatory delay before and after alternative regulation imposed. Regulatory variable: an indicator variable for the period of alternative regulation. General finding: "When the firm is released from RORR, the rate of service creation triples and expected approval delays nearly disappear. The firm may have introduced up to 12 times as many services to consumers if the alternative regulation had been in place the entire time" (p.285).
Prieger (2002)	Yes	Ameritech 1984-1999	Compares the number of new services introduced in the federal access tariff and the regulatory delay before and after price caps imposed. Regulatory variable: an indicator variable for the price cap period. General finding: "More services were created under price caps than under RORR" (p.625). Specific findings: after controlling for other factors, only high capacity services show a significant increase (301%) in innovation under price caps.
Prieger (2004)	Yes	U.S. ILECs and AT&T 1987-1997	Examines the number of new information services introduced and the regulatory delay during three periods of the Comparably Efficient Interconnection regime. Regulatory variable: an indicator variable for the periods at the start and the end of the time frame when the CEI rules were in effect, period of heavier regulation than the interim. General finding: "some otherwise profitable services are not financially viable under the CEI regime" (p.705). Specific findings: the number of services the firms created during the relatively unregulated interim is 60-99% larger than if the CEI regime had been in effect. Simulates that over the entire study period, firms would have introduced 62% more services if the regulation had not been in place compared to it being in effect the entire time.

Study	Peer Reviewed Publication?	Data and Period	Major Findings Regarding Regulation and Innovation
Prieger (2007)	Yes	Ameritech in Illinois, Indiana, Ohio, and Wisconsin 1991-1997	Examines the impact of regulatory delay on the time to introduction of a new service in the state tariffs. Regulatory variables: average regulatory delay for new product approvals, regulatory uncertainty in time to approval, and indicator variables for implementation of alternative regulation in the state. General finding: "the reduction in average regulatory delay in the Ameritech states contributed toward the speedier product introductions by the firm observed in the latter half of the 1990's." With the possible exception of Illinois, longer regulatory delay is significantly associated with a decrease in how fast Ameritech tries to introduce a new service.

* The article is published with commentary by other academics, but the paper itself need not have been revised to reflect any criticism.
Notes: All quotations are from the study in column one. Book chapters may be less stringently peer reviewed than are journal articles.

Table 3: Empirical Literature on the Diffusion of Broadband Internet Access

Study	Peer Reviewed Publication?	Data and Period	Major Findings Regarding Regulation and Broadband Diffusion
Burnstein and Aron (2003)	Yes	U.S. states Dec. 2000	Dependent variable: broadband subscribers. Regulatory variable: UNE prices. Specific finding: UNE prices have no effect on broadband subscription.
Distaso, Lupi, and Manenti (2006)	Yes	14 European countries 2000-2004	Dependent variable: broadband penetration rate (BPR). Regulatory variables: UNE prices, right of way delay, extent of competition. General finding: "while inter-platform competition drives broadband adoption, competition in the market for DSL services does not play a significant role" (p.87). Specific findings: the prices of local loop unbundling and leased lines are negatively associated with the BPR. The impact of rights of way delay isn't significant. Intermodal (e.g. cable modem vs. DSL) competition is positively associated with BPR.
Flamm (2005)	No	US ZIP codes 2000-2003	Dependent variable: availability of at least one broadband subscriber in ZIP code. Regulatory variables: eRates, rural health care grants, state indicator variables. General findings: the "analysis shows that state policies may play an important role" (p.36). Specific findings: the conclusion about state policies comes from significant differences among state indicator variables, which reflect not just state policy but all non-time-varying differences among states. The eRate and rural health care grants have no impact on broadband availability.
Ford and Spiwak (2004)	No	US states 2002-2003	Dependent variables: percentage of ZIP codes in state that have at least 1 broadband provider; same with at least 4 providers. Regulatory variable: average UNE prices. General finding: "the coefficient on loop price is consistently negative meaning that higher loop prices, holding costs and other factors constant, reduce both the universal and competitive availability of broadband services" (p.11).
García-Murillo (2005)	Yes	100 countries* 2001	Dependent variables: availability of broadband within country (AB), percent of Internet users subscribing to broadband (%IUB). Regulatory variables: unbundling requirements, broadband competition, privatization. General finding: "Of the factors that governments can control, competition and unbundling show a positive relationship to the availability of the service" (p.102). Broadband competition and unbundling are significantly positively associated with AB, but these results are from separate regressions. Broadband competition and unbundling are significantly positively associated with %IUB, although evidence is inconsistent for the latter. Privatization has no effect on AB or %IUB. Caution should be used when interpreting the results with the %IUB regression: there are 12 variables included in the regression and only 18 observations.

Study	Peer Reviewed Publication?	Data and Period	Major Findings Regarding Regulation and Broadband Diffusion
García-Murillo and Gabel (2003)	No	135 countries* 2001	Dependent variables: availability of broadband within country (AB), percent of population with broadband access (%PBA). Regulatory variables: unbundling requirements, telecom competition, privatization. Competition is weakly positively associated with AB, but unbundling and privatization have no effect. Privatization is significantly positively associated with %PBA. Unbundling and competition have no effect on %PBA.
Hausman and Sidak (2005)	Yes	Five countries, various years	Case studies of broadband uptake. General finding: the empirical case studies of "the unbundling experience in United States, the United Kingdom, New Zealand, Canada, and Germany suggests that none of the four rationales [that telecommunications regulators offer for mandatory unbundling] are supported in practice."
Howell (2002)	No	OECD countries, various years	Quantitative study but no regressions. General findings: the paper provides "some empirical evidence from the OECD countries that the … local loop unbundling has had negligible effect in instigating the uptake of DSL services….Rather,…it is competition between technology platforms which is driving uptake of high-speed Internet access." (p.25).
Maldoom, Marsden, Sidak, and Singer (2003)	No	Seven countries, various years	Case studies of competition in Germany, the Netherlands, Republic of Ireland, South Korea, Sweden, the United Kingdom and the U.S. General finding: "the current policy framework leads to a situation where incentives to invest in infrastructure…are suboptimal…. [C]urrent policy could be reformed … to provide a coherent approach that provides appropriate incentives for investment, promotes facilities-based competition and better achieves the public interest." (p.122).
Prieger and Lee (2008)	Yes	US ZIP codes 2000-2003	Dependent variables: availability of at least one broadband subscriber in ZIP code. Regulatory variables: indicator variables for price caps, rate freezes, deregulation, and hybrid schemes, and UNE prices. General finding: "alternative regulation at the state level generally increases the probability of broadband availability, particularly for price caps." Specific findings: Alternative regulation is generally significantly associated with higher probability that broadband is available (PBA), with some exceptions in some specifications. Excluding outliers, areas with lower UNE rates have a significantly (but small) higher PBA. The effects of UNE rates on broadband are largest where there is alternative regulation.
Wallsten (2005)	No	U.S. states 2000-2004**	Dependent variables: number of broadband connections, share of rural population with broadband access. Regulatory variables: indicator variables for state policy toward rights of way, municipal broadband, universal service, grant and loans, and tax incentives; telephone competition. General findings: "the analysis reveals that most state-level policies are ineffective" (from abstract). Specific findings: guaranteed access to right-of-way and resold local loops are significantly positively correlated with statewide broadband penetration (SBP). Unbundling is significantly nagatively correlated with SBP. No other state policies affect SBP, except possible state grants. Regarding rural broadband access: no state policies are effective; neither is the USDA broadband program. The USDA rural telecom development program does stimulate rural broadband access.

Study	Peer Reviewed Publication?	Data and Period	Major Findings Regarding Regulation and Broadband Diffusion
Wallsten (2006)	No	30 OECD countries 1999-2003	Dependent variables: broadband subscribers per capita. Regulatory variables: indicator variables for various unbundling, collocation, and price regulation schemes. General findings: “one general interpretation of these empirical results is that regulations that can reduce returns to investment (more extensive unbundling) or increase costs to entrants (allowing incumbents to insist on off-site collocation) reduce broadband investment” (p.17). Specific findings: subloop unbundling, virtual collocation, and regulatory approval for collocation charges are significantly negatively correlated with broadband penetration. Commingling collocation is significantly negatively correlated with broadband penetration. The effect of full local loop unbundling is inconclusive.

Notes: All quotations are from the study in column one. Book chapters may be less stringently peer reviewed than are journal articles.
* Actual number of countries varies across specifications and in some is quite small.
** Vintage of data used in the regressions is not explicitly stated in the paper, but other references appear to identify this time period.

Figure 1: Static versus Dynamic Efficiency

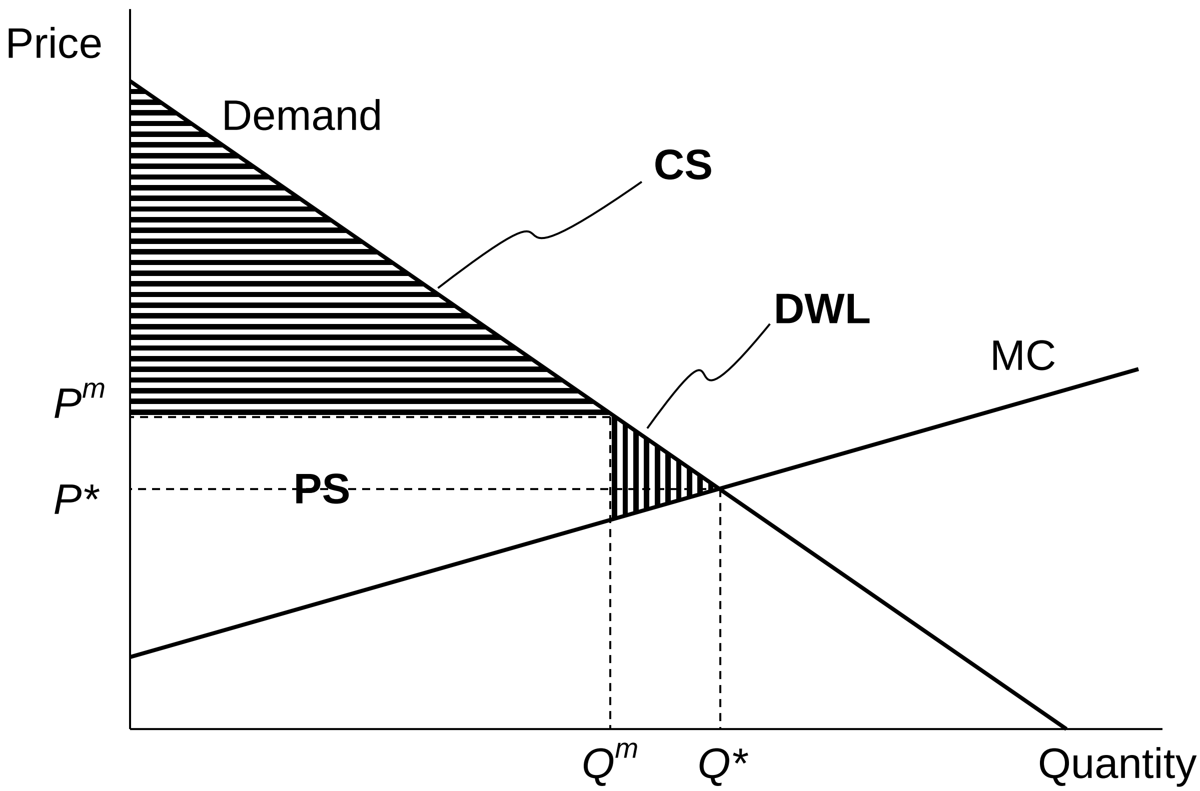

Figure 2: The determination of the amount of innovation

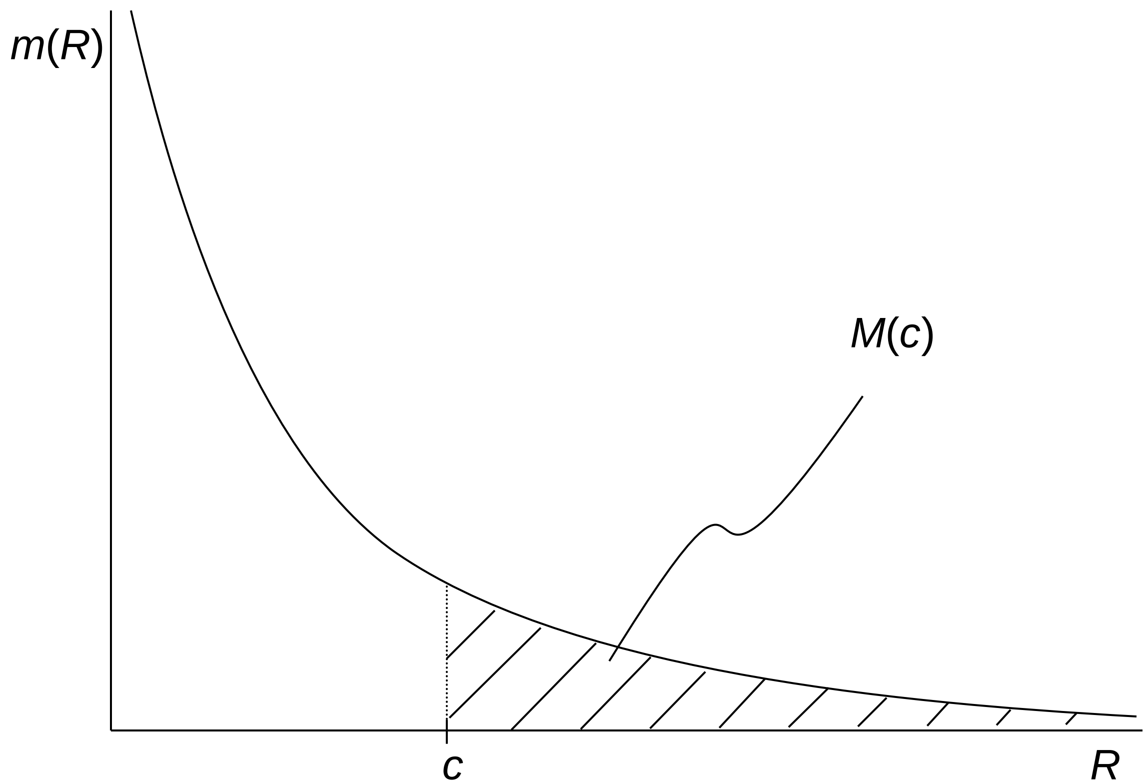

Figure 3: Changes in amount of innovation due to regulation