Innovation Matters

Competition Policy for the High-Technology Economy

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6 Competition and Innovation: Empirical Evidence

> The most important common feature of the few R&D and innovation analyses that have sought to control for the underlying technological environment is a dramatic reduction in the observed impact of the Schumpeterian size and market power variables.
> —William L. Baldwin and John T. Scott, "Market Structure and Technological Change" (1987)

1 Introduction

Researchers have attempted to identify and measure a causal relationship between firm and industry characteristics and the pace of innovation for decades. Wesley Cohen and others provide comprehensive surveys of the historical record.[1] Rather than repeat these surveys, I focus in this chapter on several recent empirical studies that reflect the current state of the art for the econometric analysis of the relationship between competition and innovation and highlight studies that are relevant to mergers, a key antitrust policy lever.

The economic incentive to innovate depends on technological opportunities and the nature of the innovations as well as on industry and firm characteristics. Section 2 describes the many factors that complicate attempts to determine a causal relationship between competition and innovation. Section 3 summarizes the results from several studies that compare the effects of competition in different industries on investment in research and development (R&D) or the output of innovations and best attempt to control for these confounding factors.

Section 4 examines empirical studies of R&D competition in selected industries with a focus on markets for personal computer (PC) hard disk drives (HDDs) and microprocessors. The microprocessor study highlights the influence of product durability on investment incentives and shows that even a monopolist has an incentive to innovate to sell upgrades to customers that have already purchased its product. This section also reviews empirical evidence related to whether incumbent firms tend to invest in product and process improvements or more radical innovations.

Section 5 surveys empirical studies of the effects of mergers on innovation. These studies are particularly relevant to the theme of this book because merger policy is the most common way that antitrust enforcers regulate competition. Furthermore, as noted in chapter 5, the effects of a merger on incentives to invest in R&D are not equivalent to the effects from a reduction in competition, which underscores the policy significance of empirical results from studies of actual mergers.

Section 6 offers some case studies of policy interventions that have had consequences for innovation and future price competition. These include the breakup of AT&T and several case studies and related research that examine the effects of compulsory licensing of intellectual property (IP) on innovation. Antitrust agencies have settled numerous merger challenges with requirements that IP owners license their intellectual property either without royalties or at reasonable terms. In the more distant past, courts and antitrust authorities have compelled dominant firms to license their intellectual property, often with positive consequences for industry innovation and price competition. The final section concludes with a brief summary of the empirical evidence relating to competition and innovation.

2 Unraveling the Industry-Innovation Connection

Early econometric studies found a relationship between industry concentration and innovation measures that displayed the shape of an inverted U.[2] The result was greeted with enthusiasm because it was consistent with both the teachings of the Arrow replacement effect, which implies that monopoly power discourages innovation, and Schumpeterian notions that highly competitive markets can be inimical to innovation by limiting the ability of innovators to appropriate value from their discoveries. However, these early studies failed to account for many factors that confound the relationship between competition and innovation. More recent studies that correct for these deficiencies demonstrate a more nuanced relationship between innovation and firm and industry characteristics.

The measurement of innovation

Empirical studies have used R&D expenditures, counts of patents and innovations, and revenues as alternative measures for the output of innovation. R&D is a flawed measure because it is an input to innovation rather than a measure of the output of innovation. R&D expenditures can increase with no corresponding benefit for innovation, and efficiencies can allow firms to decrease their R&D spending without harming innovation. Patents are also imperfect measures of innovation, even when adjusted for quality, which is often done by using citations from other patent applications. Patent values are highly skewed, and in industries such as semiconductors, firms often patent to defend against the threat of costly litigation and to negotiate access to external technologies on more favorable terms. These factors make patent counts a weak indicator of the progress of technology in these industries.[3] Revenues reflect the importance of innovations but also include the confounding effects of market power.

The measurement of innovation is also complicated by the fact that it is often difficult to trace its source. Innovations often come from unexpected directions, including from firms in unrelated industries or individual inventors. An example is the semiconductor manufacturing industry, where photolithography technologies that enabled the miniaturization of semiconductor circuitry had their origins in a different industry, optical instruments.[4] For many industries, the sources of invention and its economic benefits are numerous, scattered, and varied.

Innovation, firm size, and competition are codetermined

Studies that attempt to identify a causal relationship between firm and industry characteristics and the output of innovations must contend with the circular relationship between innovation, firm size, and competition. They are codetermined. Larger firms may invest more in R&D, but size is also a consequence of past success. Innovation confounds measures of competition because market dominance can reflect successful innovation by a firm with better products or superior production technologies. It is also possible that innovation can open the gate to new entry into an industry or expansion of smaller incumbents, leading to a decrease in market concentration and an increase in apparent rivalry. Successful innovation by a firm that is far from the technological frontier can create new competition by narrowing the gap in quality or production costs relative to the market leader, but empirical studies may fail to account for changes in competitive pressure from firms' relative technological capabilities.[5]

In the language of econometrics, firm size, market concentration, and market power are endogenous to the variable—innovation—that the econometrician is attempting to explain. Early studies made little or no attempt to control for this endogeneity, which led to erroneous conclusions about the causal relationship between firm and industry characteristics and innovation. More recent studies recognize the problem and use various techniques to attempt to control for these interdependent effects.

Controlling for technological opportunity and appropriation

The relationship between industry and firm characteristics and the output of innovations depends on the available technological opportunities, which also tend to be correlated with firm and industry characteristics. The significance of competition or industry concentration as an independent determinant of R&D expenditures or innovation faded when researchers repeated early studies with variables that accounted for industry differences.[6]

Investments in R&D have economies of scale for many technological opportunities, which can cause observed investments to be correlated with firm size and market concentration.[7] An observation that scale or concentration is correlated with innovation may be nothing more than an observation that firms tend to be larger when R&D is a significant expense. That point, by itself, does not imply that firm size causally determines innovation.

Incentives for investment in R&D depend on the ability of a firm to profit from the value of inventions that may emerge from those investments, which are related to many factors, including patent rights, opportunities for trade secrecy, benefits from lead time, and complementary factors of production and marketing that can serve as barriers to competition from firms that may want to imitate an invention. These appropriation factors depend on the technology and the industry in which the firm resides and can change over time. In addition, they may differ significantly for process inventions that offer the opportunity to achieve lower production costs and for new products that can expand a firm's sales.[8]

Data limitations

The available data to test these relationships is often lacking. Innovation is difficult to measure. Some researchers, such as the Science Policy

Research Unit (SPRU) in the UK, have produced databases of innovation counts, but the counts do not cover all innovations and only allow crude classifications of their significance.

Accounting for R&D expenditures is often imprecise, and R&D data is frequently absent for small firms and for private firms that are not required to report their expenditures. This can lead to comparative underreporting by smaller firms, which are disproportionally private. Firms often in-license technology rights, which may or may not be recorded as an R&D expense. Most firms comprise many business units that operate in different industries. The relevant technological opportunities and industry effects exist at the level of the business unit but, with a few exceptions, data is at the firm level. It is important to recognize that R&D expenditure is an input to innovation and is not a measure of the output of innovations.

A related data concern is the measurement of market power. Studies often use market concentration or firm share as an index of market power. Market concentration and firm share depend on the definition of the market, which often bears little relation to the relevant competition. Often data is only available at a level that aggregates over many distinct products, which undermines its value as an indicator of actual competition, or markets are defined too narrowly and consequently fail to account for important sources of competition. High market concentration or firm share does not necessarily indicate market power if consumers would easily switch suppliers in response to higher prices, and low concentration or firm share does not necessarily indicate a lack of market power if consumers are reluctant or unable to switch suppliers.

Statistical limitations

Modern statistical methods often rely on differences between separate but otherwise similar populations to measure relevant effects. For example, studies of the effects of competition on market prices can exploit differences in competition across local geographies. That is difficult to do for innovation because innovation often has a global, or at least national, geographic dimension. Hence, empirical studies of competition and innovation have to resort to other, generally less satisfying, ways to control for the effects of confounding factors in the competition-innovation relationship. The difficulties of constructing valid tests of the relationships among innovation, firm characteristics, market structure, and competition warrant caution in interpreting empirical results despite numerous attempts to test these relationships.[9]

Productivity versus innovation

"Productivity" is a measure of the efficiency of production. "Labor productivity" is a measure of output per worker. "Total factor productivity" accounts for capital and other inputs in addition to labor.[10] Many empirical studies show a positive relationship between competition and labor or total factor productivity.[11] Although merging parties often claim that the merger will yield efficiency benefits, there is little empirical support for a presumption that mergers generally increase productivity.[12]

It is tempting to infer from this body of empirical research that competition promotes innovation and, conversely, that mergers harm innovation. However, most productivity studies do not support this conclusion, because an increase in productivity is not the same as an increase in innovation. Competition can increase productivity in two ways. One mechanism is a Darwinian selection effect, which forces inefficient plants to close and creates incentives for firms to allocate resources to more productive activities. A second mechanism operates through process innovations that lower production costs or new products that increase output. Only the second mechanism reflects innovation by the firms that survive competition, but few productivity studies distinguish between these two effects.

Some studies demonstrate a positive relationship between competition and the rate of growth in productivity.[13] Productivity growth is also a flawed measure of innovation because it measures the historical rate of change in a static measure of the efficiency of production. An increase in productivity could be caused by increases in competition that are unrelated to innovations and that cause the growth of more efficient firms and the exit of less efficient firms over time through the Darwinian selection mechanism. The relevant empirical research for the competition-innovation nexus relates competition, market structure, or mergers to a measure of innovative output or a surrogate measure, such as investment in R&D or counts of patents or new products. I focus on these studies.

3 Interindustry Econometric Studies

With these caveats in mind, I briefly summarize a few studies that utilize modern econometric methods to assess the relationship between industry structure and innovation. Richard Blundell, Rachel Griffith, and John Van Reenen employ a sample of 340 manufacturing firms listed on the London International Stock Exchange over the period 1972–1982 to explore the relationship between firm size, market concentration, and innovation.[14] They measure innovation using innovation counts from the SPRU, along with patent data. The SPRU counts an innovation if it is technologically significant and commercialized by a firm. The authors attempt to control for the importance of heterogeneity in firms' innovation capabilities by calculating a variable that measures the stock of the firm's innovations prior to the start of the sample period.

Their study finds that more-concentrated industries produced fewer innovations. Within industries, firms with large market shares introduced more innovations, but there is no correlation between absolute firm size and the significance of innovations, and no evidence that cash flow is a significant determinant of innovation.[15] This result undermines the Schumpeterian view that market power provides a stable platform that promotes investment in R&D. The authors find similar results when they use patents as a measure of technological performance, and when they examine a subset of data confined to the pharmaceutical industry, which is notable for its high R&D intensity and for the importance of patent protection.

The empirical analysis by Blundell and his coauthors covers a short time frame that preceded the internet age, and it is limited to UK firms. Furthermore, the authors assume a linear relationship between market concentration and innovation. They do not investigate whether there is a nonmonotonic relationship such as the inverted-U relationship from early studies that failed to control for industry and firm characteristics. A 2005 study by Philippe Aghion and coauthors specifically address this latter issue.[16] They follow patents issued to 311 firms listed on the London Stock Exchange over the period 1973–1994, weighting each patent by the number of times that it is cited by another patent.

Aghion and his coauthors use an industry average of firm-specific Lerner Indices to measure competition. The Lerner Index measures the extent to which a firm exercises market power by raising its price above its marginal production cost.[17] In this respect, the average Lerner Index can be a better measure of industry competition than a concentration index, although that depends on the firms that are included in the average. An additional concern is that the calculation relies on accounting data that may differ significantly from a firm's actual marginal cost, which makes the Lerner Index a less reliable measure of market power.

Adding controls for industry-specific innovation propensities, the authors find that innovation output, as measured by citation-weighted patents, displays an inverted-U relationship with the industry average Lerner Index. Although these results are intriguing, they should be interpreted with caution because the index calculations are for broad industry classifications, and it is debatable whether the authors' industry-specific controls fully account for differences among firms in their ability to innovate or the fact that competition and innovation are mutually determined.

The authors address some of these issues by repeating the analysis using a set of policy measures that caused unanticipated changes in competition. These are industry privatizations that occurred in the Margaret Thatcher era, the European Single Market Programme that liberalized trade across member nations in 1988, and investigations by the UK Monopolies and Mergers Commission that resulted in structural or behavioral remedies. Applying these policy instruments as controls in their empirical analysis does not change the inverted-U relationship between patenting and the industry average Lerner Index, but the controls do not erase concerns about the aggregation of indices in broad industry classifications.

In a subsequent paper, Philippe Aghion and several coauthors drill down further to explore the effects of new competition on innovation.[18] They measure new competition by the entry of new production facilities by foreign firms and measure innovation by patent counts for 174 UK firms over the period 1987–1993.[19] They also keep track of the distance of each industry from the technological frontier, which they measure as the gap between the average labor productivity of the incumbent UK industry and the labor productivity of its counterpart in the US (because UK productivity generally lagged productivity in the US over this time period).

The authors find an inverted-U dependence of patenting on industry competition measured by average profitability, but the effects differ dramatically for industries close to and far from the technological frontier. New competition spurs patenting for industries close to the frontier but has the opposite effect for industries far from the frontier. The authors argue that these differential effects are consistent with their theoretical model of stepwise innovation incentives. Firms that are close to the frontier have an incentive to invest in R&D to escape head-to-head competition from efficient new entrants, while the entry of efficient new competitors discourages investment by firms that are far from the technological frontier by lowering the return from catching up to industry leaders.

Richard Bloom, Mirko Draca, and John Van Reenen study the effects of competition on innovation by European firms that manufacture clothing and textiles.[20] While not generally branded as high-tech, firms in these sectors held over 30,000 European patents in the ten-year period, 1996–2005, covered by the study. They focus on import competition from China's entry into the World Trade Organization in 2001 and measure innovation by citation-weighted patents and investments in R&D and information technology.[21] The study finds that surviving firms exposed to Chinese import competition filed more patents and increased their investments in R&D and information technology. The authors do not find any statistically significant effects on patenting or other innovation-related measures in response to increased import competition from developed countries. One explanation is that Chinese imports were a wake-up call for firms that had the ability to differentiate themselves technologically from low-wage competition. Competition among technologically advanced firms offered less scope for differentiation.

German Gutiérrez and Thomas Philippon examine investment in R&D, as well as other measures, for forty-three groupings of US nonfinancial firms in response to import competition over the period 1995–2015. They find a positive relationship between competition and R&D investment. Consistent with results in other studies, they find that industry leaders (defined as the firms that account for the largest one-third of market value) responded more to the shock of Chinese import competition than industry laggards (firms in the bottom third of market value).[22]

However, a study that examined patenting activity and R&D by US manufacturing firms over the period 1991–2007 reports the opposite conclusion. David Autor and coauthors document a negative relationship between US firms' exposure to Chinese competition and their patent applications and investments in R&D. The authors conclude that "the innovation response of U.S. firms more exposed to rising market competition from China has been substantially and unambiguously negative."[23] The authors' explanation for their results is that firms scaled back their global operations in response to shrinking demand caused by global competition, and that contraction included a reduction in R&D expenditures and patenting.

This study includes patenting by textile manufacturers, yet reaches opposite conclusions from those reported by Bloom, Draca, and Van Reenen for European firms. Autor and his coauthors reconcile their contrasting findings by showing that the negative effects of import competition concentrate on firms that are initially less profitable and capital intensive. This is consistent with theoretical results about the relationship between competition and innovation and with the findings in other empirical studies, which show differential effects of competition on innovation by firms with different characteristics.[24]

Table 6.1 summarizes the conclusions from these interindustry studies for the effects of competition and industry structure on innovation. Unfortunately, these studies do not reach a consensus, other than to note that innovation effects can differ dramatically for firms that are at different levels of technological sophistication. Although some studies find a positive relationship between measures of innovation and competition (alternatively, a negative relationship between innovation and industry concentration), others find that the relationship exhibits an inverted-U, with the largest effects at moderate levels of industry concentration or competition, and at least one study reports a negative relationship between competition (measured by Chinese import penetration) and innovation (measured by citation-weighted patents and R&D investment). One consistent finding is that an increase in competition has less of a beneficial effect, and may have a negative effect, on innovation incentives for firms that are far behind the industry technological frontier.

The inconsistent findings from these studies reflect the difficulty of measuring competition and innovation and unraveling their codependence. Moreover, these studies have only limited relevance for competition policy. The sources of new competition in several of these studies arise from trade policies, which promote foreign direct investment and have possible additional effects by expanding markets for exporters, crowding out demand for domestic suppliers, and lowering the prices of intermediate inputs. Competition policies, such as merger enforcement, do not generally have similar trade-enhancing consequences.

Studies that focus on a particular industry can help to isolate determinants of the competition-innovation relationship that are specific to industry capabilities and technological opportunities. The next section reviews some of these studies. Section 5 describes studies that address the effects of mergers and acquisitions on measures of R&D investment and innovation. These studies have particular relevance to antitrust

Table 6.1
Summary of interindustry studies of competition and innovation.

Study	Firms and Time Frame	Innovation Measure	Competition Measure	Conclusions
Blundell et al. (1999)	340 UK manufacturing firms; 1972–1982	Innovation and patent counts	Industry concentration	Competition and firm share *positively* related to innovation and patenting
Aghion et al. (2005)	311 UK firms; 1973–1994	Citation-weighted patents	Lerner Index	*Inverted-U* relationship between competition and patenting
Aghion et al. (2009)	174 UK firms; 1987–1993	US registered patents	New entry by foreign firms	*Positive* relationship between competition and patenting for firms close to the technological frontier. *Negative* relationship for firms far from the technological frontier.
Bloom et al. (2016)	European manufacturers of clothing and textiles; 1996–2005	Citation-weighted patents, R&D and information technology (IT) investment	China entry into World Trade Organization; other entry	Competition *positively* related to patent counts and investment in R&D and IT. *No response* to entry from developed countries.
Gutiérrez and Philippon (2017)	43 groupings of US nonfinancial firms; 1995–2015	R&D investment	Industry concentration; China import penetration	*Positive* relationship between competition and patenting for industry leaders. *Negative* relationship for laggards.
Autor et al. (2020)	US firms in almost 400 industries; 1991–2007	Citation-weighted patents and R&D investment	Chinese import penetration	Competition *negatively* related to patenting and R&D investment. Larger negative impact for weaker firms.

policy because the decision to block a merger or condition approval on a behavioral or structural remedy is the most common tool used by enforcement agencies to address innovation effects.

4 Industry Studies

Empirical studies that mine data from many industries typically attempt to control for differences among broad industry classifications, but that can fail to capture differences in technological opportunities that exist at more of a microlevel. Single-industry studies avoid some of this variation, although technological opportunities within a single industry can and do change over time. Nonetheless, single-industry studies can provide a fertile field to test theoretical predictions about market structure and innovation.

R&D "races"

One candidate for testing is the relationship between market structure and patenting in industries that have characteristics of competition in which the winner takes all (or at least most) of the value from a discovery. An example is a race to patent the next important invention. Jennifer Reinganum argues that incumbents have less incentive to invest in R&D than new entrants because innovations replace their existing profits.[25] This Arrow replacement effect implies that incumbents are less likely than new entrants to patent the next important discovery. In contrast, Richard Gilbert and David Newbery show that a dominant firm has an incentive to invest to preserve its dominance and, in some circumstances, is more likely than an entrant to make the next discovery.[26] Clayton Christiansen claims that incumbents fail to sustain technological leadership because they focus too much on the needs of their immediate customers and ignore emerging technologies that ultimately displace established practices.[27]

Economists have applied econometric analysis to unravel these contrasting arguments. Josh Lerner examines competition between HDD manufacturers and the characteristics of firms that developed higher-density drives over nearly two decades. He concludes that firms in the HDD industry that lagged the current technological leader—and particularly those in the middle of the technological pack—had a greater propensity to innovate than the leader and were more likely to win the race for the next generation of disk drives. His results are consistent with both the replacement effect and Christiansen's theory of incumbent customer focus.[28]

Mitsuru Igami develops a dynamic model of HDD investment and applies the model to the transition from 5.25-inch to 3.5-inch HDDs, which were common formats in PCs over the relevant period of his analysis. Igami's model allows him to sort out three contrasting explanations for innovation by incumbents and new entrants: (1) the Arrow replacement effect, (2) preemption, and (3) differential investment costs. Igami finds some evidence to support preemptive investment by incumbents. Nonetheless, he confirms previous results that find that incumbents invested less in the new 3.5-inch format than new entrants. The dynamic model attributes this result to the Arrow replacement effect; incumbents were reluctant to invest in a new product that would cannibalize their existing products. The replacement effect is strong enough to more than offset his empirical conclusion that incumbents have a cost advantage for new product investments relative to entrants.

These results illustrate the relative importance of replacement effects and preemption incentives for innovation, but they are limited to the HDD industry; other industries need not evidence similar behavior.[29] Furthermore, the HDD industry is not a good candidate to test preemption incentives. More than twenty firms sold 5.25-inch HDDs when 3.5-inch HDDs first arrived in 1982 (although four to six firms accounted for more than 50 percent of sales by the late 1980s). Preemption incentives are weak in an oligopoly because a firm that engages in costly preemptive investment has to share the benefits of preemption with its rivals. It is significant that Igami identifies a role for preemption in the HDD industry, notwithstanding the relatively unconcentrated structure of the industry for most of the period spanned by the Igami study.

Durable goods

Many innovations create new or improved durable goods. A firm that sells (rather than rents)[30] a durable good has three ways to profit from additional sales: it can benefit from sales to new consumers that were not previously in the market; it can lower its price to induce purchases by existing consumers that did not want to buy the good at the higher price; or it can offer a new and improved product to attract new consumers and induce existing customers to upgrade their purchases. The first alternative is not available in a mature market with no consumer growth. The second alternative can result in an unprofitable downward price spiral if the firm cuts prices to attract more demand. That leaves innovation as an appealing strategy for producers of durable goods, even for firms that command a large share of the market.

As noted in chapter 3, the Arrow replacement effect does not have the same deterrence effect for a monopoly producer of a durable good because even a monopoly seller of a durable good has an incentive to innovate to increase its sales to consumers who choose to upgrade their purchases. Unfortunately, little empirical research has addressed the relationship between competition and innovation specifically for durable goods.

An exception is the study by Ronald Goettler and Brett Gordon of competition and innovation in the microprocessor industry. The microprocessor industry is an excellent candidate to explore the effects of competition and antitrust policy on innovation for durable goods. Microprocessors are durable goods; they can function without depreciation for many years. A consumer's incentive to replace a microprocessor is often the desire to upgrade to a more powerful processor. The industry has been a duopoly for decades, with Intel and Advanced Micro Devices (AMD) accounting for about 95 percent of desktop PC microprocessor sales. Innovation can be measured by the clock speed of the microprocessor. Both Intel and AMD have invested heavily in microprocessor R&D. Clock speeds for the newest microprocessors roughly doubled every seven quarters over the twelve-year period examined by Goettler and Gordon (1993–2004).

Intel has been the target of several antitrust actions related to conduct that allegedly excluded AMD from microprocessor sales. In 2009, Intel paid AMD $1.25 billion to settle charges that Intel violated antitrust laws by offering rebates to Japanese PC manufacturers who agreed to eliminate or limit purchases of rival microprocessors.[31] In the same year, the European Commission (EC) fined Intel 1.06 billion euros and ordered the company to end its rebate program.[32] In 2010, the US Federal Trade Commission (FTC) and Intel settled charges that Intel unlawfully maintained a monopoly in microprocessors and attempted to acquire a second monopoly in graphics processors using a variety of unfair methods of competition.[33]

Goettler and Gordon propose a dynamic model of microprocessor investment. After estimating the model parameters using data from 1993–2004, the authors pose counterfactuals to explore how different market structures would affect their conclusions regarding industry structure, R&D investment, and pricing.

One of their counterfactuals compares R&D investment and pricing in the actual market to investment and pricing for a hypothetical Intel monopolist. They reach the striking conclusion that microprocessor innovation would have been *greater* if competition from AMD had been eliminated over the study period. The reasons for this counterintuitive result can be traced to the demand for upgrades and investment incentives from higher prices. Most of the demand for PC microprocessors came from upgrades over the study period; for instance, 82 percent of PC sales in 2004 were replacements of existing units.

Intel's microprocessor prices would have been higher without competition from AMD. The Schumpeterian appropriation effect from higher prices increases the incentive to innovate, but this innovation benefit comes at a large consumer cost. The authors conclude that higher prices from a hypothetical Intel monopolist would more than offset the benefit from greater innovation; consumers would be worse off. This result repeats findings from theoretical models discussed in previous chapters. Higher prices can promote innovation, but often the higher prices imply that consumers fail to benefit from the innovations that they foster.

Incremental versus drastic innovation

Concerns about the effects of rising market concentration in the US economy on innovation are not limited to the effects of concentration on the level of R&D investment. An additional concern is that large firms in concentrated industries have a bias toward incremental improvements in existing products and technologies rather than transformative innovations.[34]

There are theoretical justifications for concern about the effects of firm size and market concentration on the direction of innovation. Chapter 3 explains why firms in concentrated industries can have incentives to invest in R&D to preempt rivals, but those incentives are absent if innovation is drastic. Furthermore, established firms can face large disruption costs for radical innovations that require the firms to change the internal architecture that defines their ways of doing business. This organizational effect, emphasized by Rebecca Henderson[35] and others, can bias large established firms in favor of incremental innovations.

Wesley Cohen surveys empirical studies that conclude that larger firms pursued more incremental innovations and more innovations related to process improvements.[36] The positive relationship between size and process innovation has a clear theoretical explanation because larger firms have more to gain by lowering their production costs. In a more recent study, Daniel Garcia-Macia, Chang-Tai Hsieh, and Peter Klenow use employment data to make inferences about the types of innovations pursued by incumbents and new entrants.[37] They equate large changes in employment to disruptive innovation (the "creative destruction" described by Schumpeter) and smaller changes to incremental innovation. With the qualification that employment changes can be explained by factors other than innovation, the authors conclude that incumbents tend to make incremental quality improvements rather than develop disruptive new products. Nonetheless, most growth comes from incumbents rather than entrants, primarily because entrants account for a small fraction of industry employment and innovation.

5 Mergers

Merger enforcement is the single most common policy lever employed by competition authorities, and nearly all merger challenges in high-tech industries include an allegation of harm to innovation.[38] Yet empirical evidence for the effect of mergers on innovation is sparse. The empirical literature on the relationship between competition and innovation, summarized in table 6.1, provides uncomfortably weak support for the conclusion that increased competition in concentrated markets promotes innovation for technologically advanced firms; however, a merger is not the same as a reduction in competition.

In addition to the factors that confound empirical studies of competition and innovation, a complication for empirical studies of mergers is that they take place in the shadow of antitrust enforcement. The Hart-Scott-Rodino (HSR) Act requires companies to notify the antitrust authorities about a planned merger or acquisition if the transaction exceeds modest thresholds, and the authorities will block a merger if they believe that it is likely to raise prices or harm innovation or condition the merger on remedies that are intended to eliminate anticompetitive effects. If they could do their job perfectly, no mergers would cause consumer harm. That is not possible, though, because merger enforcement is a prediction that is subject to error, and the antitrust authorities often miss mergers that fall below the HSR reporting thresholds.[39]

There are errors of underenforcement and overenforcement. Merely observing that *some* mergers harmed innovation is not enough to conclude that the agencies should be tougher on *all* proposed mergers.

Some bad mergers will escape challenge by antitrust authorities, and some good mergers will be blocked. Furthermore, the mere observation that merged firms invested less in R&D than firms that did not merge is not sufficient to conclude that mergers harm innovation. Firms that choose to merge are typically different from firms that do not merge. Firms may have an incentive to merge because, acting independently, they anticipate poor performance from their R&D activities and expect that a merger partner will improve their prospects. As discussed next, this is a critical issue for the evaluation of mergers in the pharmaceutical industries, for which the breadth of merging parties' R&D pipelines and their complementary clinical and marketing capabilities can be important determinants of merger decisions. Consequently, merely comparing the performance of merged firms against a sample of firms that did not merge is likely to introduce significant error. Moreover, some mergers may lower R&D expenditures by eliminating redundancies without harming the output of innovations.

With these and other caveats in mind, empirical research has followed different tracks to estimate the effects of mergers on innovation or related measures, such as R&D spending or patenting. These include interindustry studies of merger effects, dynamic models that predict innovation outcomes, and studies of merger activities in single industries, such as pharmaceuticals, that have experienced large merger waves.

In their study of merger activity across many industries, German Gutiérrez and Thomas Philippon report a negative relationship between merger activity and investment.[40] The authors assume that large merger waves are mostly exogenous events and use the occurrence of these discrete waves to estimate effects on investment. The study shows that, conditional on measures of current concentration and expected sales growth, industries with greater merger activity are associated with relatively lower investment. This result should be viewed with caution because the study does not eliminate the possibility that merger waves are the result of declining expectations of R&D performance rather than the cause of a reduction in R&D investment.

Respondents to a survey of mergers conducted by Bruno Cassiman and coauthors reported that they increased R&D expenditures when they had complementary technological capabilities and reduced R&D expenditures if they operated in similar markets.[41] Robust conclusions from this undertaking are elusive because the survey is not a random sample, includes only thirty-one deals, and relies on self-reported descriptions of deal outcomes. While many of the respondents reported that the transactions had positive outcomes for innovation, the survey includes no calibration mechanism to compare innovation-related outcomes against likely outcomes for the parties if they had not merged. Without such a comparison, a positive report for innovation could merely reflect general postmerger satisfaction rather than an actual innovation benefit from the transaction.

Within-industry studies of mergers and acquisitions have followed one of two approaches. One approach is to estimate a dynamic model of pricing and R&D investment and then use the estimated parameters to assess the consequences from hypothetical mergers. Goettler and Gordon use a variant of this approach to explore the consequences of different market structures in the PC microprocessor industry. Mitsuru Igami and Kosuke Uetake also follow this approach to investigate the effects of hypothetical mergers in the market for PC HDDs,[42] and conclude that mergers in the HDD industry would have had only modest effects when they occur with more than three firms in the industry. Of course, these predictions are only as reliable as the models used to generate them.

A second approach exploits data from actual mergers in an industry that has experienced many mergers. As noted previously, this approach suffers from truncation bias—the data is unlikely to include the most troubling mergers because antitrust authorities would likely prevent or modify them.

Isolating the effects of mergers on innovation requires a necessarily imprecise method to predict the output of innovation postmerger and to compare that prediction with the output of innovation that would be expected if the firms do not merge. A firm may anticipate having excess capacity to manufacture and market drugs because its current drugs are nearing the end of their patent exclusivity and it expects to lose sales to generic equivalents. Another firm may have promising molecular entities in its pipelines with little capacity in place to manufacture and market the new drugs that may emerge from its R&D. A merger of the firms would allow better utilization of complementary factors of production, marketing, and R&D. Failure to control for these firm-specific attributes can lead to an erroneous conclusion that mergers harm innovation when the correct interpretation is that mergers are responses to declining innovation expectations by one or both of the merging firms.

As for other studies, it is important to distinguish the output of innovation from the input of R&D expenditures. Although an increase in postmerger R&D suggests an increase in expected innovation (if the increase is not wasteful duplication), the opposite is not necessarily true because mergers can increase the output of innovation while rationalizing redundant R&D expenditures.

Data limitations plague these studies. They may have data on acquiring firms, but only limited data on acquired firms. Some firms engage in acquisition sprees that make it difficult to identify the consequences from individual transactions. Few studies observe merger outcomes over time horizons that are long enough to fully identify innovation effects, and those that do have to control for additional factors that are unrelated to the merger and confound their conclusions. Another limitation is that most evaluations of mergers only examine innovation-related effects on the parties. A merger can change competitive conditions in an industry, which can increase or decrease innovation incentives for nonmerging firms. These R&D responses by nonmerging firms can offset or magnify effects observed for the merging firms.

Subject to these limitations, the pharmaceutical industry is a good candidate to study the effects of mergers and acquisitions on innovation performance for several reasons. First, mergers and acquisitions have transformed the pharmaceutical and biotech industries. Figure 6.1 shows a selection of major pharmaceutical deals that occurred during

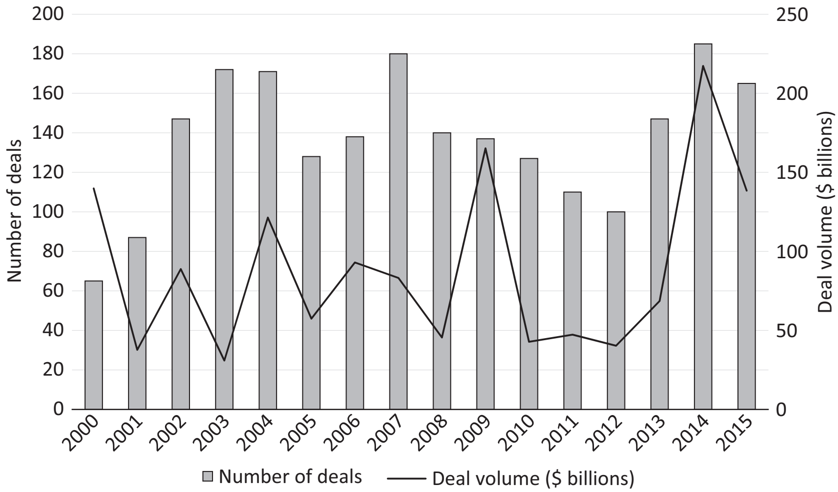

Figure 6.1
Selected merger and acquisition (M&A) activity in the pharmaceutical and biotech industries. Source: Visnji (2019).

the period 2000–2015. Second, the pharmaceutical and related biotech industries are among the most R&D-intensive sectors of the economy. Third, compared to some other industries, it is easier to measure the output of pharmaceutical innovations by counting either new drug applications or patents.[43] Fourth, compared to some other industries, it is easier to identify firm-specific innovation capabilities by examining projects in firms' clinical pipelines, for which there is public data.

Pharmaceutical R&D expenditures increased more than threefold over the period 1995–2015, while the production of new drugs hovered at around thirty per year over this interval. These statistics, in combination with the large measure of merger activity, suggest that pharmaceutical mergers have lowered R&D productivity; however, that confounds merger effects with a general industry trend of declining discoveries per R&D dollar as new drugs become more challenging to discover. The cost of developing a commercially successful new drug (including the opportunity costs of failures) increased from $271 million in 1987 to $2.6 billion in 2013 (unadjusted for inflation).[44] Other industries have also experienced large increases in the cost of R&D.[45]

A few empirical studies examine the effects of pharmaceutical mergers on drug discoveries and control for firm characteristics that might differentiate the innovation performance of firms that chose to merge from that of other firms in the industry. Carmine Ornaghi examines the performance of twenty-seven large pharmaceutical mergers and acquisitions over the period 1988–2004. To account for firm-specific differences between merging and nonmerging firms, the author creates a comparison set of firms using the merger propensity method. This approach estimates the likelihood that firms merge based on the percentage of their drugs approaching patent expiration, the percentage of newly launched drugs, and other observable characteristics. He finds that the merging firms did less R&D and produced fewer important drug patents in the three years following the merger, relative to his comparison set of firms.

Patricia Danzon, Andrew Epstein, and Sean Nicholson conduct a similar study that examines 165 transforming pharmaceutical mergers over the period 1988–2000. They define a transforming merger as a transaction valued at more than $500 million or representing more than 20 percent of a firm's premerger enterprise value. The study assigns firms to subpopulations of large and small firms. The large firms had an enterprise value of at least $1 billion in at least one year during the study period. Danzon and the coauthors also use the propensity method to match merging firms to a population of companies that had a similar likelihood of merging based on the number of the firm's marketed drugs, the fraction of drugs that are nearing the end of exclusivity, and other observable characteristics.

The study tracks the growth in enterprise value, sales, employees, and R&D expenses in the three years following mergers. The analysis demonstrates the importance of controlling for the characteristics of firms that are likely to choose to merge. Compared to the population as a whole, firms with a relatively high likelihood of merging in a particular year experienced relatively small growth in sales, employees, and R&D over the next three years regardless of whether they actually merged or not. This result shows that failure to control for conditions that lead firms to merge can result in overestimates of the negative effects of mergers on R&D investment and innovation.

Controlling for merger propensity, the authors report that the performance of large firms that merged was not significantly different from the performance of nonmerging firms. Small firms experienced some reduction in R&D in the first year following a merger, but the study also finds some beneficial effects from mergers for small firms that were likely to otherwise experience a reduction in performance due to adverse events such as the loss of drug exclusivity.

Justus Haucap, Alexander Rasch, and Joel Stiebale also conduct an empirical study of pharmaceutical mergers.[46] They examine sixty-five mergers reviewed by the EC between 1991 and 2007 and use patent applications as their measure of innovation. To estimate merger propensity scores, the authors use patent applications lagged one to three years before merger events, the presample average of the number of patents, the stock of citation-weighted patents, a variable indicating nonzero innovative activity prior to merger, sales, and the ratio of profits to sales. Unlike Ornaghi (2009) and Danzon, Epstein, and Nicholson (2007), this study does not include the percentage of a firm's drugs approaching patent expiration and the percentage of newly launched drugs in the calculation of merger propensity scores, which is a possible source of estimation error.

Haucap and his coauthors find a substantial decline in patenting postmerger. They estimate that three years after the merger, merging firms' patent stocks were more than 30 percent less than what they would have been if they had not merged. Furthermore, the authors report a knock-on effect from mergers: Averaging over their sample of mergers, the patent stocks of the merging firms' competitors were more than 15 percent less than what they would have predicted without the merger. Competitors followed reductions in patenting by the merging parties with reductions in their own levels of patenting. If the competitor responses that they observe hold more generally, this suggests that adverse effects on innovation by the merging parties underestimate the industrywide harm from a merger.

The results from these three studies are not consistent. Whereas Ornaghi and Haucap and his coauthors report significant declines in innovation-related activities following mergers, the study by Danzon and her coauthors finds no effect following mergers of large pharmaceutical firms. One explanation for the different conclusions is that the merger propensity method does not allow an exact comparison between merging and nonmerging firms in an industry, and the studies calculated merger propensity scores in different ways. Many relevant characteristics of firms are omitted or are not observable by an econometrician. The fact that some firms chose to merge and others did not, despite having similar merger propensity scores, suggests that the analysis overlooks key attributes that may be correlated with mergers and innovative performance. Nonetheless, these studies do not support a conclusion that mergers have promoted innovation in the pharmaceutical industry. This is an important empirical result, particularly in light of the fact that the observed transactions are those that did not raise sufficient competition concerns to be challenged by the antitrust authorities.

Henry Grabowski and Margaret Kyle follow a different approach to studying merger innovation effects by examining the progress of drug development projects following merger events. The authors utilize a database of more than 4,500 firms that were engaged in pharmaceutical R&D between 1990 and 2007. Their measure of R&D performance is the probability that a project in the R&D pipeline advances to the next stage of development (e.g., the probability that a project moves from phase II to phase III clinical trials). They find that for firms that experienced a merger during the 1985–2006 period, a higher fraction of their projects progressed to the next phase compared with nonmerging firms. The most substantial differences were in movements from phase III to the launch of a new drug. They observed this general trend for all size categories of firms.

The observations by Grabowski and Kyle do not indicate that mergers increase the output of pharmaceutical R&D. Their results could reflect greater commitment by merging firms to selected R&D projects, not necessarily greater allocation of R&D effort. The merged firms may have been better at advancing drugs through clinical trials because they abandoned less promising early-stage drug projects, which would indicate a decline in R&D effort. Furthermore, their analysis does not control for factors that lead pharmaceutical companies to pursue mergers.

A study by Colleen Cunningham, Florian Ederer, and Song Ma raises significant concerns about the effects of acquisitions in the pharmaceutical industry on the acquiring firms' allocation of R&D effort. In their aptly titled study, "Killer Acquisitions," they find that pharmaceutical companies are more likely to terminate drug research projects that they acquire from other companies compared to projects they originate themselves. The authors collected data on more than 60,000 drug projects. By 2017, companies had discontinued 85 percent of drug R&D projects that they had originated themselves in the period 1990–2011. This result reflects the well-known fact that most R&D projects fail to advance to commercial drugs. Over the same time period, they terminated 92.1 percent of R&D projects that they had acquired from other companies. Expressed differently, the companies advanced only about half as many R&D projects that they had acquired from others, compared to their internally generated R&D projects. The difference is statistically significant and implies that dozens of acquired pharmaceutical projects failed to become commercial drugs, compared to a hypothetical in which the projects have the same success rate as internally generated projects.

The authors conclude that technology and product overlaps explain most of the difference in termination rates for acquired pharmaceutical R&D projects. Technology overlaps are projects in the acquiring firm's R&D pipeline that have the same biological interaction as the acquired project. Product overlaps are acquired projects that target the same therapeutic class as a drug supplied by the acquiring firm. Product overlaps had a significant negative effect on the probability that the acquired firm continued to invest in the acquired project only when the product class was highly concentrated.

These results accord with the economic theory of R&D incentives. Product overlaps in concentrated therapeutic classes imply that the acquiring firm has profits that are at risk from the Arrow replacement effect, which has negative incentives for project continuation. Furthermore, preemption incentives imply that a firm with a product in a concentrated therapeutic class has an incentive to outbid rivals for acquisition targets that threaten the firm's existing business. Thus, incumbents are likely acquirers of promising R&D projects, but this research shows that they are less likely than other acquirers to move these acquired R&D projects to a commercial application. An implication is that dominant firms have incentives to use acquisitions to eliminate potential competition. Furthermore, Cunningham and the coauthors also conclude that the acquisitions observed in their study had a larger negative effect on R&D continuations than the benefits from diversification and synergies.[47]

These are important observations. Do they imply that antitrust policy should police acquisitions more aggressively? Yes, although it would be counter-productive to prohibit all acquisitions of projects that overlap with existing products or R&D projects. There is a trade-off between acquisitions that extinguish acquired R&D projects and acquisitions that promote incentives for innovation. R&D for buyout is a common business strategy in the pharmaceutical industry, as well as in other high-tech sectors. Some of the acquired projects will be terminated, but many others may not have existed but for the strategic option to sell them to an established firm. To avoid destroying incentives to create R&D projects in the first place, antitrust policy should focus enforcement on acquisitions of targets for which either a buyout is not a business strategy that motivates R&D effort or for which there are other acquirers that do not have significant competitive overlaps.

6 Divestitures and Compulsory Licensing

Antitrust authorities can address innovation concerns by pursuing divestitures or compulsory licensing of intellectual property, either as conditions to allow mergers or as remedies for monopolization. This section briefly reviews one of the most famous examples of antitrust divestiture—the breakup of American Telephone and Telegraph (AT&T)—and describes some notable cases of compulsory licensing to remedy monopolization. Chapter 7 reviews several merger cases in which enforcement agencies addressed innovation concerns by requiring divestitures of R&D assets or compulsory licensing obligations. The chapter reports that divestitures apparently resolved innovation concerns for some mergers, but divestitures were less successful in some other cases. Most of the compulsory licensing obligations had beneficial effects.

The breakup of AT&T

In 1974, the Department of Justice (DOJ) filed an antitrust complaint against AT&T, alleging that AT&T had monopolized markets for a wide range of telecommunications services and products in violation of Section 2 of the Sherman Act. AT&T (a.k.a. the Bell System) was fully integrated into all aspects of telecommunications services. It provided local exchange service through its Bell operating companies and long-distance service between the local exchanges. AT&T manufactured telecommunications equipment in its Western Electric subsidiary and owned Bell Laboratories, a research center with an illustrious history that produced a number of major discoveries, including the transistor, the laser, radio astronomy, information theory, and the Unix computer operating system.

The parties settled the antitrust charges in 1982 with a consent decree with the somewhat oxymoronic title of the Modification of Final Judgment (MFJ), which separated AT&T long distance services, Bell Labs, and Western Electric from the regional Bell operating companies. The MFJ also vacated a 1956 consent decree that restricted AT&T to the provision of regulated common carrier services and businesses incidental to furnishing those services.

The AT&T divestiture was a bold example of antitrust enforcement led by William Baxter, the Assistant Attorney General for Antitrust appointed by President Ronald Reagan. President Reagan worried that divestiture was too aggressive and told Baxter that, "When I was young, it cost 2 cents to mail a letter cross country and $2.00 to make a phone call. By the 1980s, each was 20 cents." Baxter reportedly replied, "Well, Mr. President, when I finish AT&T, I will be happy to take on the Post Office."[48]

The consent decree went into effect in 1984. The breakup had mixed, but overall positive, effects for innovation. Regrettably, the basic scientific research that had flourished at Bell Labs was a casualty of the breakup. The divestiture split Bell Labs into AT&T Bell Labs and Bell Communications Research (known colloquially as "Bellcore"), a smaller operation jointly owned by the operating companies. Bellcore was rebranded as Telcordia Technologies and was acquired by Ericsson in 2011. Most of Bell Labs went to Lucent in 1996, along with the remainder when Lucent and Alcatel merged in 2007. Nokia acquired Alcatel-Lucent in 2016, and what was left of Bell Labs was branded "Nokia Bell Labs." Ericsson and Nokia invest heavily in telecommunications R&D, but their focus is more applied than that of the historical research mission of Bell Laboratories.

Although the AT&T divestiture was a blow to basic scientific research and incurred large administrative costs, competition and applied innovation thrived in the telecommunications industry following the breakup and further liberalization of the US telecommunications industry by the 1996 Telecommunications Act. Prices for telecommunication services fell, as did prices for infrastructure and customer premise equipment. Total R&D expenditures, while more focused on applications, increased dramatically. New entrants provided a diversity of equipment choices and service options that did not exist under the monolithic Bell System. The divestiture and subsequent liberalization of the Bell System demonstrate the positive benefits of competitive markets for investment in applied R&D.

Effects of compulsory licensing on industry innovation and price competition

As discussed in more detail in chapter 7, antitrust agencies have negotiated numerous consent decrees to settle competition concerns for proposed mergers and acquisitions, including concerns about harm to innovation. These consent decrees often included requirements to license intellectual property, along with other conditions. In the more distant past, regulatory authorities, including antitrust agencies, have also used compulsory licensing to address persistent monopolization. Because licensing expands the universe of potential innovators, experience with these obligations provides a window through which to examine the effects of greater competition on innovation incentives.

In 1956, and long before the breakup of AT&T, the DOJ and AT&T settled an antitrust complaint with a consent decree that obligated AT&T to license its existing patents royalty-free and to license any future patents at a reasonable royalty.[49] In the same year, the DOJ settled antitrust charges against International Business Machines (IBM) with a consent decree that included, among other provisions, the requirement that IBM grant nonexclusive licenses royalty-free for any of its patents existing at the time of the decree, plus offer licenses to any patents filed during the subsequent five years at a reasonable royalty.[50] Both decrees required applicants to grant reciprocal cross-licenses to their patents. In 1975, the FTC resolved a complaint that the Xerox Corporation monopolized the market for plain-paper office copiers by requiring Xerox to grant licenses to its relevant patents to any willing licensees at modest royalties.[51]

Compulsory licensing is controversial because it strips the patent holder of rights that are bestowed by the patent system and can have counterproductive consequences by weakening incentives to innovate.

The AT&T and IBM consent decrees were also controversial because they failed to undermine the monopoly power of these companies. AT&T maintained its grip on almost all aspects of telecommunications until it agreed to divestitures under the MFJ. IBM's control of the computer industry continued until technological advances in mini- and micro-computers chipped away at its mainframe monopoly. Only the Xerox consent decree truly opened the market to new competition, but some questioned whether the company engaged in conduct that warranted antitrust condemnation.[52]

Nonetheless, there is evidence that these consent decrees had beneficial effects for innovation and price competition. Martin Watzinger and coauthors rely on detailed information about citations to AT&T patents to conclude that the 1956 AT&T consent decree increased innovation that built on AT&T's patents. Specifically, they report that citations to AT&T's patents increased by 17 percent relative to similar patents in the same technology class that were not covered by the decree. The beneficiaries were mainly small and young companies that operated in fields other than telecommunications, which the authors attribute to the entry barriers that continued to protect AT&T from competition in regulated telecommunication markets. The authors also find that the positive effects for follow-on technologies from the decree more than compensated for a small reduction in patenting by AT&T.[53]

Others reached similar, if more qualitative, conclusions. Gordon Moore, a cofounder of Intel, credited the 1956 AT&T consent decree for much of the growth of the merchant semiconductor industry in the US.[54] AT&T was initially reluctant to license its fundamental patents on transistors, but it relented, in part to stave off antitrust actions.[55] David Mowery concludes that the 1956 AT&T consent decree supported high levels of knowledge diffusion and facilitated the entry of new competition in the semiconductor industry.[56] Peter Grindley and David Teece assert that "[AT&T's licensing policy shaped by antitrust policy] remains one of the most unheralded contributions to economic development—possibly far exceeding the Marshall plan in terms of wealth generation it established abroad and in the United States."[57]

Compared to the AT&T consent decree, available evidence on the benefits of compulsory licensing in the 1956 IBM consent decree is thin, perhaps because the patents at issue were not as fundamental as some of the patents owned by AT&T. However, there is no evidence that the 1956 IBM consent decree discouraged innovation. IBM introduced its enormously successful 360 series of mainframe computers in 1964 based on R&D efforts that occurred at the time of or soon after the decree. Furthermore, some commentators credit the decree and subsequent antitrust litigation with facilitating the entry of plug-compatible peripherals for IBM mainframes and for enabling the development of competing mainframe computers sold by Amdahl and Control Data.[58]

The 1975 Xerox consent decree is noteworthy because, to quote Willard Tom, "Wrong-headed as much of the case appears today, it seems to have done a world of good."[59] The consent decree was "wrong-headed" in the sense that it settled numerous allegations, such as discriminatory pricing arrangements, that draw little antitrust scrutiny today. But the decree accomplished "a world of good" by lowering prices and increasing the diversity of plain-paper copiers for businesses and consumers.[60]

Although IBM and Litton were successful entrants into the market for plain-paper copiers prior to 1975, Xerox's broad patent portfolio helped to protect Xerox from new competition. After the decree was entered, there was innovation and new competition in plain-paper copiers from manufacturers of low-volume, coated-paper copiers and manufacturers of high-volume photographic machines, including Canon, Toshiba, Sharp, Panasonic, Konica, and Minolta. The decree did a "world of good" for consumers, but not for Xerox. Xerox's market share plummeted following entry by new rivals. Xerox executives criticized the FTC compulsory licensing decree for exposing the company to foreign competition, but they also acknowledged that competition forced Xerox to successfully reinvent itself and become a more efficient company.[61]

Other studies confirm increases in the pace of innovation following events that make patented technologies available for use at zero or low royalties. Alberto Galasso and Mark Schankerman examine the effects of litigation outcomes that invalidate patents, thereby making the technologies covered by the patents available for use without compensation, which is similar in some respects to royalty-free compulsory licensing. Citations increased by an average of 50 percent following a finding of invalidity, with most of the effect concentrated in the fields of computers and communications, electronics, biotechnology, and medical instruments.[62] A finding of invalidity only increased citations when the patent was owned by a large firm, with the increase in citations coming mostly from small innovators.

Petra Moser and Alessandra Voena explore the consequences of an episode of compulsory licensing in the US that occurred during and after World War I under the Trading with the Enemy Act.[63] The Act initially permitted US firms to practice enemy-owned patents if they contributed to the war effort. Congress amended the legislation in 1918 to confiscate all enemy-owned patents, and by 1919, German-owned patents were systematically licensed without compensation to US firms. Moser and Voena find that the number of patents granted to US inventors in technological fields with at least one confiscated German patent increased by an average of about 20 percent relative to patents granted to US inventors in similar fields that did not have confiscated patents. Subsequent research shows that the confiscation of intellectual property did not inhibit innovation by the firms whose property was confiscated. The German firms increased their investment in R&D and generated 30 percent more patents after the 1918 confiscation.[64]

Studies of compulsory licensing obligations conducted by Michael Scherer validate the benefits of compulsory licensing for follow-on innovations and do not support a general conclusion that compulsory licensing harms innovation incentives for the firms that were subjected to these requirements.[65] Examples of merger consent decrees that compel the licensing of intellectual property reviewed by Colleen Chien and the examples reviewed in chapter 7 reach similar conclusions.[66]

These studies and observations from the AT&T, IBM, and Xerox consent decrees find that making patented inventions available for use royalty-free or at reasonable royalties has a positive impact on follow-on innovations that build on the patented inventions. While innovators clearly need some protection from imitation, there is little evidence that the largely unanticipated weakening of patent rights of the type encountered in a few compulsory licensing decrees has had offsetting negative effects on invention. The benefits of compulsory licensing stand in stark contrast to arguments that compulsory licensing obligations would strike the death knell for innovation by undermining incentives from intellectual property protection.[67] The evidence is that compulsory licensing, when selectively applied, can promote innovation, in addition to having salutary effects by addressing competition concerns for mergers and limiting industry dominance.

Even if compulsory licensing has a deterrent effect on some innovations, there is good reason to conclude that a slight weakening of patent rights has a positive effect on industry innovation and competition. As discussed in chapter 4, a reduction in royalties charged by frontier innovators or an increase in access to these technologies can increase economic welfare by promoting follow-on innovation, which can be accomplished with a compulsory licensing obligation at a reasonable royalty.

7 Concluding Remarks on Empirical Evidence

Empirical research on the link between competition and innovation has evolved over many decades. Early investigations found that measures of innovation peaked at intermediate levels of industry concentration. However, these studies failed to account for industry factors and technological characteristics that affect innovation opportunities and the ability to appropriate returns from R&D investments. More recent interindustry studies attempt to account for these factors and apply best statistical practices to control for spurious correlations. Several of these studies find a positive relationship between competition and innovation. Other studies find that moderate levels of industry competition are more conducive to innovation, and there is some contrasting support for a negative relationship.

Empirical economic research has yet to reach a consensus about the interaction between market competition and innovation incentives, although the evidence does clearly highlight the significance of technological asymmetries for firms' innovation incentives. Competition appears to have a much greater beneficial effect on R&D investment and innovation by firms that are close to the industry's technological frontier. This is consistent with the theoretical model of stepwise innovation. An increase in competition makes it more profitable for firms that are close to the industry technological frontier to escape competition by innovating. On the other hand, competition can deter innovation for firms that are far from the frontier by making it more difficult for these firms to profit from catching up to their more advanced rivals.

Antitrust enforcers often presume that mergers that substantially lessen competition in a high-tech industry are likely to harm innovation. Unfortunately, there is little empirical research that proves this presumption. Empirical analysis of the effects of mergers on innovation is challenging because it is difficult to find a natural experiment in which a merger affects innovation incentives differently for some set of firms compared to other, otherwise similar, firms. Furthermore, data is rarely available to study the effects of mergers in highly concentrated industries because antitrust authorities typically prevent mergers in highly concentrated industries or condition them on remedies that are intended to eliminate alleged anticompetitive effects. Nonetheless, available evidence does not support a conclusion that mergers generally promote innovation or competition for future products or services.

More aggressive antitrust enforcement can prevent so-called killer acquisitions, in which an established firm acquires and then extinguishes a promising R&D project. Empirical evidence on thousands of acquisitions in the pharmaceutical industry demonstrates that an acquiring firm is more likely to terminate a research project if it is in a concentrated sector and the acquired project is a potential competitor to its products or research projects that are directed to similar therapeutic applications. However, a prohibition on such acquisitions could have negative repercussions by destroying incentives for investment in R&D by entities that rely on acquisitions to monetize their R&D efforts. A better policy would encourage alternative acquisitions by firms that do not have significant product or technology overlaps.

Evidence from compulsory licensing obligations supports the conclusion that opening markets to competition by making intellectual property more generally available has beneficial effects for follow-on innovation and price competition. Widespread compulsory licensing would have negative consequences for incentives to invest in fundamental innovations, but the evidence does not show adverse effects from the few episodes in which antitrust authorities and regulators have used compulsory licensing to open markets to competition. The next chapter explores several examples of divestitures and compulsory licensing that have addressed innovation concerns for mergers.

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