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Innovation Consolidation

Peter Lee[*]

One of the most striking and undertheorized aspects of fields that commercialize patented technologies is their tendency to consolidate. Technological industries are complex ecosystems featuring numerous players of different sizes along the value chain spanning "upstream" research and development and "downstream" commercialization. However, when focusing on downstream industry segments that bring patented technologies to market — "innovation" in an economic sense — a relatively small number of large companies frequently play outsize roles. Technological industries tend to be patent-intensive, and legal and economic theory has long explored the role of patents in shaping industry structure — the number, size, and character of firms in an industry. However, such theory only explains one facet of industry structure. This Article provides a more holistic account of the forces shaping the commercialization of patented technologies by examining three industries: biopharmaceuticals; agricultural biotechnology, seeds, and agrochemicals; and software.

This Article argues that the commercialization of patented technologies is subject to several "concentration drivers" pushing toward consolidation, including direct barriers to entry based on exclusive rights and cost, indirect barriers to entry based on efficiencies of size, and significant merger and acquisition activity. It also argues that several common "fragmentation drivers" push in the opposite direction to increase the number of participants in these industries, including technology-based entry, voluntary divestures, and antitrust enforcement. While such forces are

[*] Copyright © 2020 Peter Lee. Martin Luther King Jr. Professor of Law, UC Davis School of Law. Thanks to Clark Asay, Rebecca Eisenberg, Brett Frischmann, Dmitry Karshtedt, Jessica Litman, Menesh Patel, Nicholson Price, Ted Sichelman, and workshop participants at the University of San Diego School of Law, UC Davis School of Law, DePaul University College of Law, the University of Michigan School of Law, the National and Kapodistrian University of Athens, and Comillas Pontifical University for helpful comments. I am grateful to UC Davis School of Law and the UC Davis Academic Senate for generous financial support for this project. Special thanks to Takuma Nishimura and Ryan Reshke for excellent research assistance. Finally, thanks to the outstanding editors of the *UC Davis Law Review*.

significant, the formidable strength of concentration drivers results in substantial consolidation in the commercialization of drugs, genetically modified seeds, and software. Turning to normative analysis, this Article argues that such consolidation can be salutary to a point but that undue concentration ultimately harms innovation, efficiency, consumer welfare, and democratic representation. It argues that patent law should more fully consider the myriad forces beyond exclusive rights that shape technological commercialization, and it provides prescriptions for enhancing industry entry through private ordering, federal innovation policy, and antitrust enforcement.

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INTRODUCTION

One of the most striking and undertheorized aspects of fields that commercialize patented technologies is their tendency to consolidate. Technological industries are complex ecosystems featuring numerous players of different sizes along the value chain spanning "upstream" research and development and "downstream" commercialization. However, when focusing on downstream industry segments that bring patented technologies to market — "innovation" in an economic sense[1] — a relatively small number of large companies frequently play outsize roles. Examples of consolidation are widespread. In 2019, pharmaceutical giant Bristol-Myers Squib announced it was acquiring rival Celgene for $74 billion, thus "combining two of the world's largest cancer drug businesses in the biggest pharmaceutical deal ever."[2] The acquisition generated predictions of a new era of consolidation similar to one a decade ago featuring major acquisitions by Pfizer, Merck, and Roche.[3] The agricultural biotechnology, seed, and agrochemicals industry, which makes genetically modified seeds and other patented products, is even more consolidated than the biopharmaceutical

[1] *See* Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1037 (1989) (distinguishing between the initial invention of some technology and innovation, which involves commercializing it).

[2] Michael Erman & Ankur Banerjee, *Bristol-Myers to Buy Celgene for $74 Billion in Largest Biopharma Deal*, REUTERS (Jan. 3, 2019, 4:07 AM), https://www.reuters.com/article/us-celgene-m-a-bristol-myers/bristol-myers-to-buy-celgene-for-74-billion-in-largest-biopharma-dealidUSKCN1OX0VM?feedType=RSS&feedName=businessNews&rpc=69 [https://perma.cc/Y84L-AE94].

[3] *See id.*

industry. Dow and DuPont merged in 2017,[4] and Bayer bought rival Monsanto in 2018,[5] thereby creating a Big Four — BASF, Bayer, Corteva (which combined the former agricultural units of Dow and DuPont), and Syngenta — that dominates the industry.[6] Turning to another patent-intensive industry, the top ten global software companies account for almost half of all revenues,[7] and 2018 experienced a five-year-high in software mergers and acquisitions ("M&A").[8]

Such industry concentration is part of a broader trend across many economic sectors that has generated significant concern.[9] The

[4] *DowDuPont Merger Successfully Completed*, DOW (Sept. 1, 2017), https://corporate.dow.com/en-us/news/press-releases/dowdupont-merger-successfully-completed.html [https://perma.cc/7YBQ-2WMJ].

[5] *Bayer Closes Monsanto Acquisition*, BUSINESSWIRE (June 7, 2018, 9:00 AM EDT), https://www.businesswire.com/news/home/20180607005617/en/Bayer-Closes-Monsanto-Acquisition [https://perma.cc/QYN8-FNNE].

[6] *See* M. Garside, *Leading Companies Worldwide Based on Agrochemical Sales 2018*, STATISTA (Oct. 22, 2019), https://www.statista.com/statistics/257489/revenue-of-top-agrochemical-companies-worldwide-2011/ [https://perma.cc/PTQ7-8TJM].

[7] PwC, PWC GLOBAL 100 SOFTWARE LEADERS: DIGITAL INTELLIGENCE CONQUERS THE WORLD BELOW AND THE CLOUD ABOVE 10 (2016), https://www.pwc.com/gx/en/technology/publications/global-software-100-leaders/assets/global-100-software-leaders-2016.pdf [https://perma.cc/8BQF-2952] [hereinafter DIGITAL INTELLIGENCE]. *See generally* Anne Shields, *Why Mergers and Acquisitions Are Shaping the Software Industry*, MKT. REALIST (July 2014), http://marketrealist.com/2014/07/why-mergers-and-acquisitions-are-shaping-the-software-industry/ [https://perma.cc/C7W8-4NVR] (discussing how mergers and acquisitions in the software industry have led to industry maturation).

[8] Angus Loten, *Enterprise Tech Race Spurs M&A Deals*, WALL ST. J. (Mar. 12, 2019, 7:47 PM ET), https://www.wsj.com/articles/enterprise-tech-race-spurs-m-a-deals-11552434454 [https://perma.cc/HYS7-RQ76].

[9] *See, e.g.*, COUNCIL OF ECON. ADVISERS, BENEFITS OF COMPETITION AND INDICATORS OF MARKET POWER 1 (2016) (arguing additional government policies to promote industry competition would benefit consumers and workers); Gustavo Grullon, Yelena Larkin & Roni Michaely, *Are US Industries Becoming More Concentrated?*, 23 REV. FIN. 697 (2019), https://doi.org/10.1093/rof/rfz007 [https://perma.cc/M7Q9-8M3L] (noting no evidence of significant increase in operational efficiency despite significant industry concentration in product markets); Lina M. Khan, *Amazon's Antitrust Paradox*, 126 YALE L.J. 710, 785 (2017) (raising concerns over Amazon's dominance in several commercial fields); Carl Shapiro, *Antitrust in a Time of Populism*, 61 INT'L J. INDUS. ORG. 714, 717-21 (2018) [hereinafter *Antitrust*] (discussing how antitrust enforcement should move forward to address growing concerns of large corporations' power); Matt Phillips, *Apple's $1 Trillion Milestone Reflects Rise of Powerful Megacompanies*, N.Y. TIMES (Aug. 2, 2018), https://www.nytimes.com/2018/08/02/business/apple-trillion.html [https://perma.cc/5BY2-XDT4] (noting rise of powerful megacompanies may be contributing to lackluster wage growth, a shrinking middle class, and rising income inequality); Robert Reich, Opinion, *Break Up Facebook (and While We're at It, Google, Apple and Amazon)*, GUARDIAN (Nov. 20, 2018, 3:00 EST), https://www.theguardian.com/commentisfree/2018/nov/20/facebook-google-antitrust-

enormous economic power of Amazon, Apple, Facebook, Google, and Microsoft has stoked fears over the dominance of these technological megacompanies.[10] While high-profile tech companies have garnered the most attention, rising concentration pervades industries as mundane as airlines,[11] banking,[12] and grocery stores.[13] In 1975, the top 109 U.S. firms accounted for 50% of all earnings; by 2015, that share of earnings was attributable to the top thirty U.S. firms.[14] Over the past two decades, the Herfindahl-Hirschman index ("HHI"), a common measure of concentration, has increased in more than 75% of U.S. industries, and the market share of the four largest companies has "grown significantly" in most industries.[15] Given widespread and rising concentration throughout the economy, the need to understand the forces that shape industry structure — the number, size, and character of competitors in an industry — has assumed greater urgency.

This Article begins this task by focusing on an economically and socially important set of industries: those that produce patented technologies. It focuses on the commercialization of such technologies in three industries: biopharmaceuticals; agricultural biotechnology, seeds, and agrochemicals; and software. Of course, one mechanism that impacts industry structure in these fields is patents themselves. Notably, legal scholars and economists have argued that patents can have opposing effects, promoting both industry entry (and hence

laws-gilded-age [https://perma.cc/PKE5-ZHKG] (noting Facebook, Google, and Amazon's domination in the American economy stifles innovation and concentrates political power); Tim Wu, Opinion, *Be Afraid of Economic 'Bigness.' Be Very Afraid*, N.Y. TIMES (Nov. 10, 2018), https://www.nytimes.com/2018/11/10/opinion/sunday/fascism-economy-monopoly.html [https://perma.cc/EAT6-BXL7] (arguing monopolies and excessive corporate concentration threaten democracy); *Too Much of a Good Thing*, ECONOMIST (Mar. 26, 2016), https://www.economist.com/briefing/2016/03/26/too-much-of-a-good-thing [https://perma.cc/ZSH7-GQ7G] (discussing problems with the increasing concentration of large corporations in America's economy).

[10] *See, e.g.*, Khan, *supra* note 9, at 710 (examining Amazon's dominant position in several fields); Reich, *supra* note 9 (raising concerns regarding Facebook, Google, and Amazon's dominance).

[11] Phillips, *supra* note 9.

[12] *Id.*

[13] USDA ECON. RESEARCH SERV., CONSOLIDATION IN FOOD RETAILING: PROSPECTS FOR CONSUMERS & GROCERY SUPPLIERS 18 (2000), https://www.iatp.org/sites/default/files/Consolidation_in_Food_Retailing_Prospects_for_.pdf [https://perma.cc/2WQ4-58DL]. *See generally* COUNCIL OF ECON. ADVISERS, *supra* note 9, at 4 tbl.1 (indicating a rise in the share of revenue earned by the top fifty firms in ten out of thirteen industries surveyed from 1997-2012).

[14] Kathleen M. Kahle & René M. Stulz, *Is the US Public Corporation in Trouble?*, 31 J. ECON. PERSP. 67, 77 (2017).

[15] Grullon et al., *supra* note 9, at 698.

fragmentation) as well as industry consolidation.[16] Previous work has shed light on this matter by distinguishing between the effects of patents at different points along the value chain. It has shown that patents tend to promote the entry of small entities in "upstream" regions of value chains focused on research and development while tending to promote consolidation when wielded by large incumbents engaged in "downstream" commercialization of technologies.[17]

This Article extends that work to consider a wider set of economic and strategic forces that shape the commercialization of patented technologies. Drawing on economic theory and empirical evidence, it argues that several common "concentration drivers" operate across various technological industries.[18] First, the prevalence of exclusive rights and high fixed costs create direct barriers to entry that deter new competitors. Second, efficiencies of size, which confer significant advantages to large incumbents over potential newcomers, create indirect barriers to entry. Third, firms in these industries have strong incentives to engage in mergers and acquisitions to achieve the benefits of size, obtain exogenous innovation, cut costs, eliminate competition, and respond to consolidation among competitors. These are complex, dynamic environments, however, and this Article also argues that three common "fragmentation drivers" push in the opposite direction to increase the number of participants in these industries. These fragmentation drivers include new entry based on technological advancements (which patents may facilitate), specialization and divestures, and antitrust enforcement. Though these fragmentation drivers are significant, the relative strength of concentration drivers frequently produces an equilibrium marked by substantial consolidation.

It bears emphasizing that this Article addresses innovation, which in an economic sense refers to bringing an existing invention to market.[19] As such, it focuses less on "upstream" industry segments responsible for inventing technologies and more on "downstream" segments that commercialize them. However, it will also address vertical integration

[16] *See infra* Part I.

[17] *See infra* Part I.

[18] Some commentators distinguish between consolidation and concentration. Consolidation arises when the number of firms decline. Concentration occurs when the share of output of a relatively small share of firms increases. James F. Oehmke & Anwar Naseem, *Mergers and Acquisitions (M&As), Market Structure and Inventive Activity in the Agricultural Biotechnology Industry*, 14 J. AGRIC. & FOOD INDUS. ORG. 19, 19 n.1 (2016). Because these two phenomena are highly correlated, this Article will generally use these terms interchangeably, but it will highlight this distinction when relevant.

[19] *See* Eisenberg, *supra* note 1, at 1037.

wherein firms combine upstream research and development and downstream commercialization, which further bolsters consolidation in technological industries.

While many of these structural forces apply to all industries,[20] this Article argues that they are accentuated in fields that commercialize patented technologies. The nonrival nature of technology, the low marginal costs of producing many technological goods, and patent protection all combine to amplify concentration and fragmentation drivers in underappreciated ways. For example, while economies of scale promote concentration in all industries, many patent-intensive industries are particularly susceptible to economies of scale because of the high initial cost of developing (nonrival) technological designs and the low marginal cost of producing additional units of a technological good. Furthermore, patents render such economies of scale profitable for industry leaders; in the absence of exclusive rights, firms would have little incentive to ramp up production due to the threat of free appropriation by competitors. This Article thus illustrates how patents impact industry structure in ways that the existing literature has not yet recognized.

In jointly examining the biopharmaceutical, agricultural biotechnology, and software industries, this Article does not suggest that they feature identical structural dynamics or that patents play similar roles in all of them.[21] While each of these industries warrants extended analysis on its own, the value of this comparison is to illuminate high-level commonalities and divergences among them. Indeed, this Article will highlight the unique histories and trajectories of these industries, which only renders it more noteworthy that they feature similar forces pushing toward consolidation and fragmentation. While this Article makes no strong claims about the generalizability of these forces, the pattern among these particular industries is striking and provides a theoretical model to apply to other technological and non-technological fields.

Turning to normative analysis, this Article considers the implications of significant concentration in the commercialization of patented technologies. In so doing, it sheds new light on a long-running debate over whether industry concentration or fragmentation best promotes innovation. It also considers how industry structure can impact the *kind*

[20] *Cf.* Hal R. Varian, *High-Technology Industries and Market Structure*, 2001 FED. RES. BANK KAN. CITY 65, 67 ("High-technology industries are subject to the same market forces as every other industry.").

[21] It further does not argue that patent-intensive industries are categorically more concentrated than other kinds of industries (though some are).

of innovation that takes place, from incremental to pathbreaking advances. Drawing on theoretical and empirical sources, this Article argues that to a certain degree, concentration in patent-intensive industries can be beneficial by allowing firms to amass the scale and resources necessary to bring technologies to market. Beyond a certain point, however, excessive concentration harms innovation, efficiency, consumer welfare, and democratic representation. Accordingly, this Article concludes with several prescriptions for patent law and industrial policy to enhance entry in technological fields.

In its normative evaluations and prescriptions, it is important to clarify this Article's aims relative to antitrust analysis. This Article draws from and seeks to contribute to the literature on industrial organization. As such, it examines general forces shaping industry structure, and it provides industry-level data illustrating fragmentation and consolidation. Where relevant, it will also examine the application of these forces to *markets*, which are the traditional subjects of antitrust analysis. Markets encompass only goods or services that customers view as close substitutes[22] in a particular geographic region.[23] Industries and markets can diverge quite sharply,[24] and a single industry can encompass a large number of markets.[25] Within the biopharmaceutical

[22] *See* United States v. E.I. du Pont de Nemours & Co., 351 U.S. 377, 404 (1956); U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, HORIZONTAL MERGER GUIDELINES 7 (2010), https://www.justice.gov/atr/file/810276/download [https://perma.cc/M5DV-ZCG8] ("Market definition focuses solely on demand substitution factors, i.e., on customers' ability and willingness to substitute away from one product to another in response to a price increase or a corresponding non-price change such as a reduction in product quality or service.").

[23] *See* Michael E. Porter, *The Five Competitive Forces That Shape Strategy*, HARV. BUS. REV 24, 37 (Jan. 2008), https://www.ibbusinessandmanagement.com/uploads/1/1/7/5/11758934/porters_five_forces_analysis_and_strategy.pdf [https://perma.cc/5NUF-BPEZ] [hereinafter *The Five Competitive Forces*]; *cf.* COUNCIL OF ECON. ADVISERS, *supra* note 9, at 4 ("[A]n increase in revenue concentration at the national level is neither a necessary nor sufficient condition to indicate an increase in market power.").

[24] *See* ORG. FOR ECON. CO-OPERATION AND DEV., MARKET CONCENTRATION – NOTE BY THE UNITED STATES 3 (2018); Grullon et al., *supra* note 9, at 722; Shapiro, *Antitrust*, *supra* note 9, at 723. The typical method for defining a market involves finding the smallest collection of products for which a monopolist "could profitably impose a small but significant and non-transitory increase in price (SSNIP)." Michael L. Katz & Carl Shapiro, *Antitrust in Software Markets*, *in* COMPETITION, INNOVATION AND THE MICROSOFT MONOPOLY: ANTITRUST IN THE DIGITAL MARKETPLACE 29, 39 (Jeffery A. Eisenach & Thomas M. Lenard eds., 1999) [hereinafter *Software*]; *see* U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, *supra* note 22, at 8-9 (describing the "hypothetical monopolist" test for determining product markets).

[25] For this reason, industry-level analyses of concentration, such as Grullon et al., have attracted criticism because they neglect markets. *See* ORG. FOR ECON. CO-

industry, for instance, AIDS treatments and diabetes medicine are not substitutes, and they (along with hundreds of other therapeutic categories) constitute distinct markets. Similarly, one empirical analysis identified 114 different product markets within the software industry.[26] Given the nested relationship of markets and industries, concentration at the industry level often indicates concentration in individual markets.[27] Importantly, however, even if an industry features numerous firms and appears fragmented, individual markets within that industry can be concentrated and raise antitrust concerns. While this Article examines the operation of concentration and fragmentation drivers at the level of industries, the effects of such drivers will be most acute at the level of individual markets.

This Article proceeds in seven Parts. Part I examines prevailing theories of patents and industry structure, exploring how they contend that patents promote both industry concentration and fragmentation.[28] Part II briefly profiles three significant industries that commercialize patented technologies: biopharmaceuticals; agricultural biotechnology, seeds, and agrochemicals; and software. Though featuring very different dynamics, these fields exhibit strong forces pushing toward consolidation in the commercialization of patented technologies.[29] Part III builds on these profiles to argue that three sets of "concentration drivers" produce significant consolidation in innovative industries: direct barriers to entry based on exclusive rights and cost, indirect barriers to entry based on efficiencies of size, and mergers and acquisitions.[30] Part IV considers three "fragmentation drivers" that increase the number of industry participants: entry based on technological advancement, specialization and divestures, and antitrust enforcement.[31]

OPERATION AND DEV., *supra* note 24, at 4. It is also possible for a market to transcend several industries. For example, the market for personal entertainment content can encompass the movie, publishing, music, and video game industries if consumers view their products as close substitutes.

[26] Florencia Marotta-Wurgler & Robert Taylor, *Set in Stone? Change and Innovation in Consumer Standard-Form Contracts*, 88 N.Y.U. L. REV. 240, 252 (2013).

[27] *See* ADIL ABDELA & MARSHALL STEINBAUM, THE UNITED STATES HAS A MARKET CONCENTRATION PROBLEM: REVIEWING CONCENTRATION ESTIMATES IN ANTITRUST MARKETS, 2000-PRESENT 4 (2018), https://rooseveltinstitute.org/wp-content/uploads/2020/07/RI-US-market-concentration-problem-brief-201809.pdf [https://perma.cc/CGD7-B2B9].

[28] *See infra* Part I.

[29] *See infra* Part II.

[30] *See infra* Part III.

[31] *See infra* Part IV.

Part V examines several implications of these findings. It highlights how myriad forces beyond patents shape technological industries, and it also explores the subtle and underappreciated ways in which the commercialization of patented technologies can amplify these forces.[32] Part VI turns to normative assessment. Engaging a longstanding theoretical debate, it argues that industry concentration can promote innovation and efficiency to a point, but that it ultimately harms innovation, efficiency, consumer welfare, and democratic representation.[33] Part VII argues that patent law should be more sensitive to considerations of industry structure, and it provides holistic prescriptions for promoting entry in innovative industries.[34]

I. THEORIES OF PATENTS AND INDUSTRY STRUCTURE

While patents are best understood as mechanisms to encourage invention and innovation,[35] they also have important impacts on industry structure. According to the relevant literature, patents can deeply affect the number, size, and character of participants in an industry. Interestingly, well-established theories push in opposite directions, contending that patents promote both industry fragmentation and concentration. These theories provide valuable context for this Article's broader examination of myriad forces that shape the commercialization of patented technologies.

Turning first to fragmentation, scholars have argued that patents contribute to both vertical disintegration and horizontal fragmentation within technological industries. Vertical disintegration describes an industry structure in which separate firms along a value chain perform different aspects of production and distribution of a good. For instance, within a value chain for a particular consumer technology, an "upstream" firm may conduct research and initially invent the technology, then transfer it to a "downstream" firm for subsequent development, marketing, and distribution. This separation of functions by two independent entities is the opposite of vertical integration, which arises when "two or more successive stages of production and/or distribution of a product are combined under the same control."[36] Of

[32] *See infra* Part V.

[33] *See infra* Part VI.

[34] *See infra* Part VII.

[35] *See* Eisenberg, *supra* note 1, at 1024-38 (discussing several incentives conferred by patents).

[36] Robert H. Cole, *General Discussion of Vertical Integration*, 50 U. ILL. BULL., no. 3, Aug. 1952, at 9. A classic example of vertical integration is General Motors' acquisition

course, a wide range of alternate and intermediary organizational forms can define the relationship between upstream and downstream entities in a value chain, such as relational contracting, iterative collaboration, and networks, but for present purposes the distinction between vertical integration and disintegration is particularly relevant.[37] While vertical disintegration involves more players at various points along a value chain, fragmentation refers to an increase in the number of "horizontal" entities competing against each other in an industry.[38] Scholars have argued that patents contribute to more specialization between separate upstream input suppliers and downstream output producers (vertical disintegration) and greater numbers of competitors within an industry (horizontal fragmentation).

To understand patents' contribution to vertical disintegration, it is instructive to first consider the theory of the firm. In his influential work on the theory of the firm, Ronald Coase explored the question of why firms perform certain production functions in-house when, in principle, all production can be organized through market exchanges.[39] He famously argued that transaction costs determine the existence and size of firms. For many functions, markets and prices represent efficient mechanisms for allocating resources and organizing production.[40] However, at a certain point, the transaction costs of market production exceed the cost of coordinating production within an integrated firm.[41] Among other considerations, determining prices for various goods and services and delineating obligations between contracting parties is expensive, and coordinating production within a firm economizes on these costs.[42] Coase's insights are particularly relevant to the "make or buy" question at the heart of vertical integration.[43] Commentators have

of Fisher Body, previously an independent supplier of auto bodies. *See, e.g.*, Benjamin Klein, *Vertical Integration as Organizational Ownership: The Fisher Body-General Motors Relationship Revisited*, 4 J. L. ECON. & ORG. 199 (1988) (analyzing General Motors' business with Fisher Body as an illustration of the relationship between firm-specific investments, market transaction costs, and vertical integration).

37 *See* Peter Lee, *Innovation and the Firm: A New Synthesis*, 70 STAN. L. REV. 1431, 1443-44 (2018) [hereinafter *Innovation*].

38 A more meaningful measure of horizontal fragmentation accounts for the relative market shares of horizontal competitors. A more fragmented industry is one in which relatively similar market shares are distributed among a greater number of competitors.

39 *See generally* R.H. Coase, *The Nature of the Firm*, 4 ECONOMICA 386 (1937) (articulating the theory of the firm).

40 *See id.* at 387-88.

41 *See id.* at 392.

42 *See id.* at 390-91.

43 *See id.* at 388-89.

built on Coase's work to argue that low transaction costs lead firms to "buy" inputs from independent, upstream suppliers in a value chain while high transaction costs lead them to vertically integrate (by, for example, absorbing suppliers) and "make" those inputs in-house.[44]

Ashish Arora and Robert Merges have influentially drawn on the theory of the firm to argue that patents promote vertical disintegration in technological industries.[45] According to this view, patents lower transaction costs between separate upstream and downstream entities in a value chain, thus promoting contracting between separate, specialized entities. For example, patents enable the existence of small, upstream, research-based biotechnology firms, which license patents to larger, downstream pharmaceutical companies for commercialization.[46] Similarly, scholars have argued that patents promote vertical disintegration in the semiconductor industry, where upstream design firms license designs to downstream foundries for manufacture.[47] The degree to which patents promote vertical integration is contested, however, and in previous work I have shown that several patent-intensive industries exhibit significant vertical integration.[48]

Interestingly, the theory of the firm also predicts some degree of horizontal industry fragmentation among several competitors. As Coase himself mused, given the efficiencies of firm production and economies of scale, "[w]hy is not all production carried out by one big firm?"[49] Here again, transaction costs provide an answer: at a certain point, entrepreneurs cannot effectively manage large, unwieldy enterprises and allocate resources in the most efficient manner.[50] Together with

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[44] *See, e.g.*, Harold Demsetz, *The Theory of the Firm Revisited*, 4 J.L. ECON. & ORG. 141 (1988) [hereinafter *Theory of the Firm*] (arguing a more complete theory of the firm gives greater weight to information costs than is given in Coase's theory); Sanford J. Grossman & Oliver D. Hart, *The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration*, 94 J. POL. ECON. 691 (1986) (presenting a theory of costly contracts that expands on Coase's theory); Oliver E. Williamson, *Transaction-Cost Economics: The Governance of Contractual Relations*, 22 J.L. & ECON. 233 (1979) (building upon Coase's arguments about the importance of transaction costs in intermediate-product market transactions).

[45] *See* Ashish Arora & Robert P. Merges, *Specialized Supply Firms, Property Rights and Firm Boundaries*, 13 INDUS. & CORP. CHANGE 451, 458 (2004).

[46] *See id.*

[47] *See* Jonathan M. Barnett, *Intellectual Property as a Law of Organization*, 84 S. CAL. L. REV. 785, 792-93 (2011) [hereinafter *Organization*]; Bronwyn H. Hall & Rosemarie Ham Ziedonis, *The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995*, 32 RAND J. ECON. 101, 119-20 (2001).

[48] *See* Lee, *Innovation*, *supra* note 37, at 1443.

[49] Coase, *supra* note 39, at 394.

[50] *See id.*

increasing prices for inputs as firms grow large, "diminishing returns to management" suggest a natural limit to firm size.[51] This in turn suggests some degree of industry fragmentation; the inability of "one big firm" to satisfy market demand creates opportunities for simultaneous competition by multiple parties.

Commentators have also argued that patents promote horizontal fragmentation. Drawing on similar insights as Arora and Merges, scholars have argued that patents promote new firm entry and thus help fragment industries.[52] For instance, Ronald Mann has influentially argued that patents promote the entry of mature startups in the software industry.[53] Patents are particularly important to early-stage companies;[54] empirical research reveals that such companies obtain patents for a wide variety of reasons, including to gain competitive advantage, prevent copying, secure financing, and enhance their reputation.[55] In sum, patents can contribute to both vertical disintegration and horizontal fragmentation, thus increasing the number of participants in an industry.

Taking a contrary view, other scholars contend that patents promote industry concentration. Economist Harold Demsetz has influentially argued that patents, by rewarding superior innovation, increase market concentration and may create monopolies.[56] Exclusive rights, by definition, deter entry, and they allow firms to grow large by internalizing the rewards of innovation. Economist Fritz Machlup observed that the "accumulation of patents in the hands of large corporations may secure them an almost unlimited monopoly power."[57] In addition to patents on key technologies, broad "thickets" of patents can significantly raise costs for new entrants.[58] Studies of the pharmaceutical and software industries show that industry incumbents

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[51] *See id.* at 395.

[52] *See* Barnett, *Organization*, *supra* note 47, at 817.

[53] *See* Ronald J. Mann, *Do Patents Facilitate Financing in the Software Industry?*, 83 TEX. L. REV. 961, 967-68 (2005).

[54] Barnett, *Organization*, *supra* note 47, at 788.

[55] Stuart J.H. Graham, Robert P. Merges, Pam Samuelson & Ted Sichelman, *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1297 (2009).

[56] *See* Harold Demsetz, *Industry Structure, Market Rivalry, and Public Policy*, 16 J.L. & ECON. 1, 3 (1973) [hereinafter *Industry Structure*].

[57] FRITZ MACHLUP, THE POLITICAL ECONOMY OF MONOPOLY: BUSINESS, LABOR, AND GOVERNMENT POLICIES 284 (1952).

[58] *See* Iain M. Cockburn & Megan J. MacGarvie, *Entry and Patenting in the Software Industry*, 57 MGMT. SCI. 915, 919 (2011).

utilize exclusive rights to erect barriers to entry and exclude competitors.[59]

Synthesizing both sides of the debate, in previous work I have argued that patents promote both industry fragmentation and concentration, depending on context.[60] Drawing on empirical profiles, this work contends that patents most prominently promote entry of new firms in young industry segments and in upstream areas of technological value chains focused on initial invention.[61] For instance, the availability of patents on plant material enticed the formation and entry of upstream, research-based agricultural biotechnology startups in the agricultural industry.[62] That previous work also argued that patents tend to promote subsequent concentration, particularly in downstream fields focused on commercializing technological products. For instance, as the agricultural biotechnology field matured, downstream incumbents like Monsanto utilized patents to block entry by newcomers, thus contributing to greater concentration.[63]

While theories of patents and industry structure offer helpful insights, they are (conscientiously) limited in their scope. Patents are certainly important to vertical and horizontal industry structure, but they do not tell the entire story. Theories arguing that patents promote industry fragmentation are hard to reconcile with the high degree of vertical and horizontal integration observed in patent-intensive industries. Even theories that associate patents with concentration do not account for many additional forces that also push in that direction. To provide a fuller account, this Article takes a broader view of the economic and strategic forces that shape the commercialization of patented technologies.

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[59] *Id.* at 915; Carlos María Correa, *Ownership of Knowledge: The Role of Patents in Pharmaceutical R&D*, 82 BULL. WORLD HEALTH ORG. 784, 785 (2004); *see* Timothy F. Bresnahan, *Post-Entry Competition in the Plain Paper Copier Market*, 75 AM. ECON. REV. 15, 15 (1985).

[60] Peter Lee, *Reconceptualizing the Role of Intellectual Property Rights in Shaping Industry Structure*, 72 VAND. L. REV. 1197, 1198 (2019) [hereinafter *Reconceptualizing*]. That work considered both patents and copyrights, but this synopsis will focus on patents.

[61] *Id.* at 1197.

[62] *See id.*

[63] *Id.* at 1201-02.

II. INDUSTRY PROFILES: BIOPHARMACEUTICALS, AGRICULTURAL BIOTECHNOLOGY, AND SOFTWARE

This Part briefly profiles the commercialization of patented technologies in three prominent industries: biopharmaceuticals; agricultural biotechnology, seeds, and agrochemicals; and software. Industry definitions differ among various sources, but all of these industries (or a close analog) qualify as patent intensive. Biopharmaceuticals are the "poster child" of the patent system,[64] and the United States Patent and Trademark Office ("USPTO") recognizes the "pharmaceutical and medicines" industry as patent intensive due to its higher-than-average ratio of patents to workers.[65] The agricultural biotechnology, seed, and agrochemical industry produces several patented technologies, including genetically modified traits, germplasm, and tools for plant genetic transformation.[66] It, too, exhibits significant patenting activity, and it features substantial concentration in patent ownership among industry leaders.[67] The software industry is among the leaders in patenting activity, though commentators have questioned the degree to which patents are necessary to drive innovation in this field.[68] While identifying software patents is notoriously difficult, the share of U.S. patents classified as "Electrical Engineering" — which encompasses software, digital communications, computer technology, and communications — rose to 50% of all patents in 2015.[69] Software industry leaders such as IBM and Microsoft

[64] Richard A. Posner, *Why There Are Too Many Patents in America*, ATLANTIC (July 12, 2012), https://www.theatlantic.com/business/archive/2012/07/why-there-are-too-many-patents-in-america/259725/ [https://perma.cc/Z9AC-E5SK].

[65] *See* JUSTIN ANTONIPILLAI & MICHELLE K. LEE, INTELLECTUAL PROPERTY AND THE U.S. ECONOMY: 2016 UPDATE 33 tbl.A-1 (2016).

[66] *See* Gregory D. Graff, Gordon C. Rausser & Arthur A. Small, *Agricultural Biotechnology's Complementary Intellectual Assets*, 85 REV. ECON. & STAT. 349, 349 (2003).

[67] *See* PIET SCHENKELAARS, HUIB DE VRIEND & NICHOLAS KALAITZANDONAKES, DRIVERS OF CONSOLIDATION IN THE SEED INDUSTRY AND ITS CONSEQUENCES FOR INNOVATION 21 (2011), https://www.lisconsult.nl/files/docs/consolidation_seed_industry.pdf [https://perma.cc/P8WY-CRVS].

[68] *See, e.g.*, Maureen K. Ohlhausen, *Patent Rights in a Climate of Intellectual Property Rights Skepticism*, 30 HARV. J.L. & TECH. 103, 140 (2016) (stating that "[p]atents are not always well suited to driving software innovation").

[69] Colleen V. Chien, *Software Patents as a Currency, Not Tax, on Innovation*, 31 BERKELEY TECH. L.J. 1669, 1673-74 (2016) [hereinafter *Software Patents*]. While this technology category includes many non-software inventions, presumably the number of software patents issued by the USPTO every year is quite high.

routinely appear in the list of top ten assignees of U.S. patents,[70] and IBM has been the leading U.S. patentee for twenty-six consecutive years.[71]

While certainly not capturing all patent-intensive industries, this group reflects a broad cross-section of economically and socially significant fields. Of course, each of these industries (and industry segments) is highly unique in its history and dynamics, and the summaries that follow are necessarily brief.[72] Furthermore, it is important to reiterate that this Article focuses on downstream industry segments that *commercialize* patented technologies rather than upstream segments that invent technologies without manufacturing or distributing them. In the biopharmaceutical industry, for example, it will focus on downstream pharmaceutical companies that bring drugs to market as opposed to upstream biotech firms that generate promising compounds. As noted, however, the vertical integration of upstream and downstream entities in technological value chains is part of the narrative of industry consolidation. As we will see, empirical evidence reveals a significant (though not uniform) degree of concentration in technological commercialization across these three industries.

To help understand industry dynamics, this Part will refer to the HHI, which ordinarily reflects the sum of the squares of the shares of all firms (or, commonly, the top fifty firms) competing in a market.[73] The Department of Justice and the Federal Trade Commission ("FTC") consider markets with HHI ranges of 1,500 to 2,500 to be moderately concentrated and markets with HHI measures above 2,500 to be highly concentrated.[74] This Article will also refer to a modified version of the HHI reported by the U.S. census that measures concentration in *industries* rather than markets. As noted, measures of industries and markets can diverge sharply,[75] but the former is helpful for high-level understandings of concentration.

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[70] IFI CLAIMS PATENT SERVS., 2018 TOP 50 U.S. PATENT ASSIGNEES (2018), https://www.ificlaims.com/rankings-top-50-2018.htm [https://perma.cc/44HC-Z3CY].

[71] *IBM Earns Record 9,100 Patents in 2018, Tops U.S. Patent List*, IBM NEWSROOM (Jan. 8, 2019), https://newsroom.ibm.com/2019-01-08-IBM-Earns-Record-9-100-Patents-in-2018-Tops-U-S-Patent-List [https://perma.cc/UXJ6-CU9M].

[72] This Part provides synopses of longer profiles appearing in earlier work. *See* Lee, *Reconceptualizing*, *supra* note 60, at 1214-36.

[73] *Herfindahl-Hirschman Index*, U.S. DEP'T OF JUSTICE, https://www.justice.gov/atr/herfindahl-hirschman-index (last updated July 31, 2018) [https://perma.cc/Z2LT-H2DF].

[74] *Id.*

[75] *See* ORG. FOR ECON. CO-OPERATION AND DEV., *supra* note 24, at 3 ("Concentration is meaningless for competition analysis when measured in an economic sector much

A. Biopharmaceuticals

Although subject to dynamic entry and exit, the biopharmaceutical industry has experienced significant consolidation toward the downstream end of the value chain focused on commercializing drugs.[76] Since the early twentieth century, large, vertically integrated companies that combine research, development, clinical trials, marketing, and distribution have dominated the industry.[77] These companies have traditionally focused on developing small-molecule, chemistry-based drugs. Since the 1970s, the emergence of biotechnology, which uses recombinant DNA and other technologies to produce large-molecule, biologic drugs,[78] has spawned the formation and entry of numerous upstream, research-intensive biotech firms.[79] Biotech firms typically lack the size, resources, and expertise to navigate costly and time-consuming clinical trials, and they often partner with pharmaceutical companies to handle the downstream commercialization of biologic drugs.[80] In some cases, biotech firms license their patents to pharmaceutical companies,[81] thus maintaining a vertically disintegrated value chain. Increasingly, however, many large pharmaceutical companies have vertically integrated by acquiring biotech firms.[82]

In addition to vertical integration, the industry has also experienced significant horizontal concentration among major pharmaceutical

narrower or much broader than a relevant market."); *see supra* notes 22–26 and accompanying text.

[76] For an extended history of the biopharmaceutical industry, see Franco Malerba & Luigi Orsenigo, *The Evolution of the Pharmaceutical Industry*, 57 BUS. HIST. 664, 673-74 (2015).

[77] Iain M. Cockburn, *The Changing Structure of the Pharmaceutical Industry*, 23 HEALTH AFF. 10, 13 (2004); *see* Toby E. Stuart, Salih Zeki Ozdemir & Waverly W. Ding, *Vertical Alliance Networks: The Case of University–Biotechnology–Pharmaceutical Alliance Chains*, 36 RES. POL'Y 477, 477-78 (2007).

[78] Arti K. Rai, *Fostering Cumulative Innovation in the Biopharmaceutical Industry: The Role of Patents and Antitrust*, 16 BERKELEY TECH. L.J. 813, 815 (2001).

[79] Lee, *Innovation*, *supra* note 37, at 1456-57. Biotechnology has thus spawned significant entry in "upstream" regions of the value chain focused on research and development. *See* Malerba & Orsenigo, *supra* note 76, at 667-80.

[80] *See* Stuart et al., *supra* note 77, at 477-78.

[81] *See generally* David T. Robinson & Toby E. Stuart, *Financial Contracting in Biotech Strategic Alliances*, 50 J.L. & ECON. 559 (2007) (analyzing the features of strategic alliance contracts executed between biotech and pharmaceutical firms).

[82] Lee, *Innovation*, *supra* note 37, at 1457-58; *see, e.g.*, Benjamin Gomes-Casseres, *In 2018, Did Business Get Too Big?*, N.Y. TIMES (Dec. 21, 2018), https://www.nytimes.com/2018/12/21/business/dealbook/bigness-mergers-2018.html [https://perma.cc/H2VP-XDRG] (describing Takeda's recent acquisition of biotech firm Shire).

companies, primarily through mergers and acquisitions.[83] Between 1988 and 2000, the industry experienced 165 "transformational" mergers comprising a total of over $500 billion in value.[84] The late 1990s were particularly active for mergers and acquisitions[85] and included mergers of Pfizer and Warner Lambert,[86] Sanofi and Synthelabo,[87] and Rhone-Poulenc and Hoechst.[88] The late 2000s featured further mergers and acquisitions involving Schering-Plough and Organon,[89] Pfizer and Wyeth, Merck and Schering-Plough,[90] and Roche and Genentech.[91] Deals have continued to the present day,[92] and "[d]uring the last 30 plus years we have seen a major consolidation in the industry through mergers and acquisitions."[93] As one commentator observes, "Although M&A have been a staple in the pharmaceutical

[83] Joanna Shepherd, *Consolidation and Innovation in the Pharmaceutical Industry: The Role of Mergers and Acquisitions in the Current Innovation Ecosystem*, 21 J. HEALTH CARE L. & POL'Y 1, 1 (2018); Myoung Cha & Theresa Lorriman, *Why Pharma Megamergers Work*, MCKINSEY & CO. (Feb. 1, 2014), http://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/why-pharma-megamergers-work [https://perma.cc/V2MW-VE9N]; David Davidovic, *The History of Bio-Pharma Industry M&As, Lessons Learned and Trends to Watch*, PM360 (May 23, 2014), https://www.pm360online.com/the-history-of-bio-pharma-industry-mas-lessons-learned-and-trends-to-watch/ [https://perma.cc/9T7V-XBMU] (noting in one cohort that approximately 110 companies had consolidated to about thirty).

[84] Patricia M. Danzon, Andrew Epstein & Sean Nicholson, *Mergers and Acquisitions in the Pharmaceutical and Biotech Industries*, 28 MANAGERIAL & DECISION ECON. 307, 311 (2007) (noting that transformational mergers are defined as those accounting for over $500 million or at least 20% of a firm's pre-merger value).

[85] *See* Rai, *supra* note 78, at 818.

[86] Cha & Lorriman, *supra* note 83.

[87] *Business Digest*, N.Y. TIMES (Dec. 3, 1998), http://www.nytimes.com/1998/12/03/business/business-digest-248800.html [https://perma.cc/N8J9-VV5Q].

[88] David J. Morrow, *International Business; Rhone-Poulenc and Hoechst Agree on Start of a Merger*, N.Y. TIMES (Dec. 2, 1998), https://www.nytimes.com/1998/12/02/business/international-business-rhone-poulenc-and-hoechst-agree-on-start-of-a-merger.html [https://perma.cc/P7HB-HX5T].

[89] Julia Werdigier, *Schering-Plough agrees to Buy Akzo Nobel's Organon Biosciences Unit*, N.Y. TIMES (Mar. 12, 2007), http://www.nytimes.com/2007/03/12/business/worldbusiness/12iht-drug.4885575.html [https://perma.cc/8XDM-S63J] (describing Schering-Plough's 2007 acquisition of Organon Biosciences).

[90] William S. Comanor & F.M. Scherer, *Mergers and Innovation in the Pharmaceutical Industry*, 32 J. HEALTH ECON. 106, 106 (2013).

[91] Cha & Lorriman, *supra* note 83.

[92] *See* Barak Richman, Will Mitchell, Elena Vidal & Kevin Schulman, *Pharmaceutical M&A Activity: Effects on Prices, Innovation, and Competition*, 48 LOY. U. CHI. L.J. 787, 791 (2017); *see, e.g.*, Erman & Banerjee, *supra* note 2 (discussing acquisitions by Pfizer, Merck, and Roche Holding AG).

[93] Davidovic, *supra* note 83.

industry for over a century, recent mergers of industry giants — particularly over the last decade or so — mark an unprecedented level of consolidation."[94] Further evidencing significant consolidation, of the 261 companies that have registered at least one New Molecular Entity ("NME") since 1950, 137 no longer exist because of a merger or acquisition, and nineteen were liquidated.[95]

It should be noted that the degree of consolidation in the pharmaceutical industry can vary depending on the relevant frame of reference. Some commentators contend that the industry as a whole is not particularly concentrated, with no company obtaining more than a 10% share of industry-wide revenues until fairly recently.[96] However, as detailed further below, the pharmaceutical industry encompasses numerous therapeutic markets, many of which are concentrated.[97] Furthermore, although the industry has numerous small and medium-sized players, "[a] remarkably stable and relatively small group of firms has been consistently dominating the industry, almost from its inception."[98]

An important element of the pharmaceutical industry, which at first glance seems to push against the narrative of consolidation, is generic competition.[99] In 1984, Congress enacted the Drug Price Competition and Patent Term Restoration Act, commonly known as the Hatch-Waxman Act.[100] The Act creates a complex statutory framework that promotes incentives to develop pharmaceuticals while facilitating generic competition for drugs whose patent term has expired.[101] Regarding the latter objective, the Act allows generic companies to

94 Richman et al., *supra* note 92, at 788; *see also* Nicole Fisher & Scott Liebman, *Are M&A Replacing R&D in Pharma*?, FORBES (Apr. 22, 2015, 6:14 AM EDT), https://www.forbes.com/sites/nicolefisher/2015/04/22/are-ma-replacing-rd-in-pharma/#2912f380a21d [https://perma.cc/S29P-LQYJ] (noting that a relatively narrow band of major companies commercialize drugs).

95 Bernard Munos, *Lessons from 60 Years of Pharmaceutical Innovation*, 8 NATURE REVIEWS DRUG DISCOVERY 959, 961 (2009).

96 Malerba & Orsenigo, *supra* note 76, at 665.

97 Danzon et al., *supra* note 84, at 312; Malerba & Orsenigo, *supra* note 76, at 670; *see infra* notes 111–114 and accompanying text.

98 Malerba & Orsenigo, *supra* note 76, at 665, 670 (characterizing the industry's structure as comprising "a core of leading firms and a large fringe of smaller ones").

99 *See* Porter, *The Five Competitive Forces*, *supra* note 23, at 31.

100 Drug Price Competition and Patent Term Restoration Act of 1984, Pub. L. No. 98-417, 98 Stat. 1585 (codified as amended in scattered sections of titles 15, 21, 35, and 42 U.S.C. (2018)).

101 Rebecca S. Eisenberg & Daniel A. Crane, *Patent Punting: How FDA and Antitrust Courts Undermine the Hatch-Waxman Act to Avoid Dealing with Patents*, 21 MICH. TELECOMM. & TECH. L. REV. 197, 200 (2015).

piggyback on lengthy and expensive drug approvals already obtained by brand companies when seeking to market a "bioequivalent" drug, thus accelerating generic entry.[102] The Hatch-Waxman Act represents an explicit, legislative "fragmentation driver" and has led to an explosion of generic entry in the biopharmaceutical industry.[103] By 2012, generic drugs accounted for 78% of all prescriptions filled in retail settings and long-term care facilities.[104] While generic entry clearly fragments the pharmaceutical industry, there has been significant consolidation among generic companies, with 2015 and 2016 setting records for mergers and acquisitions.[105] Furthermore, proposed mergers and acquisitions between generic companies are the primary targets of antitrust enforcement in the drug industry.[106] One study found that in 2008, nearly half of ninety generic drug categories had HHIs exceeding 5,000.[107]

More broadly, while the biopharmaceutical industry overall has many players, they are spread among numerous therapeutic markets, many of which are highly concentrated. In 2012 (the latest year for which census data are available), the industry-wide HHI for the top fifty

[102] *Id.* at 204-05.

[103] It is important to note that the Hatch-Waxman Act does not apply to all patented technologies in the biopharmaceutical industry. For example, in 2010, Congress enacted legislation to promote follow-on biologics in a manner analogous to generic drugs. *See* Biologics Price Competition and Innovation Act of 2009, Pub. L. No. 111-148, 124 Stat. 119 (2010) (codified as amended at 42 U.S.C. § 262 (2018)). While in theory the BPCIA also promotes entry and thus fragmentation in the biopharmaceutical industry, difficulties of complying with the law still maintain significant barriers to entry. *See* Arti K. Rai & Jacob S. Sherkow, *The Changing Life Science Patent Landscape*, 34 NATURE BIOTECHNOLOGY 292, 293 (2016).

[104] U.S. GOV'T ACCOUNTABILITY OFFICE, DRUG PRICING: RESEARCH ON SAVINGS FROM GENERIC DRUG USE 2 (2012), http://www.gao.gov/assets/590/588064.pdf [https://perma.cc/LEV8-SEFG].

[105] Marc-André Gagnon & Karena D. Volesky, *Merger Mania: Mergers and Acquisitions in the Generic Drug Sector from 1995 to 2016*, 13 GLOBALIZATION & HEALTH 3 (2017). Furthermore, there is not always a sharp distinction between brand and generic firms, as some companies compete in both kinds of markets. Michael A. Carrier, Mark A. Lemley & Shawn Miller, *Playing Both Sides? Branded Sales, Generic Drugs, and Antitrust Policy*, 71 HASTINGS L.J. 307, 307 (2020).

[106] *See* MARKUS H. MEIER, BRADLEY S. ALBERT & KARA MONAHAN, OVERVIEW OF FTC ACTIONS IN PHARMACEUTICAL PRODUCTS AND DISTRIBUTION 26-61 (2019) (reporting that thirty-two of fifty-three enforcement actions involved generic drugs).

[107] Chintan V. Dave, Aaron S. Kesselheim, Erin R. Fox, Peihua Qiu & Abraham Hartzema, *High Generic Drug Prices and Market Competition*, 167 ANNALS INTERNAL MED. 145, 150 (2017).

pharmaceutical manufacturers was 364.3, which is fairly low.[108] Even so, census data indicate that the top four pharmaceutical firms accounted for 31.2% of the total value of shipments.[109] In contrast to industry-wide measures, many therapeutic categories (which better correspond to markets) are more highly concentrated. Data on HHIs for individual markets are scarce but sometimes appear in antitrust enforcement actions and academic scholarship.[110] In 2000, as part of its assessment of a proposed merger, the Department of Justice reported HHIs of 2,223 in the market for pediculicides (lice treatments), 1,834 in the market for SSRI/SNRI drugs, and 9,801 in the market for Alzheimer's treatments (due to Pfizer's 98% market share).[111] FTC enforcement actions also indicate that several pharmaceutical markets are dominated by small numbers of producers.[112] Drawing on 2005-2008 data,[113] and focusing only on brand markets, Abdela and Steinbaum report HHIs of 2,626 for H2-inhibitors, 1,466 for hydrocortisone treatments, 1,179 for sleep aids, 1,936 for diaper rash treatments, and 4,661 for diarrhea remedies.[114]

B. Agricultural Biotechnology, Seeds, and Agrochemicals

The agricultural biotechnology, seed, and agrochemical industry is even more concentrated than the biopharmaceutical industry. This industry encompasses several related businesses, including: (1) agricultural biotechnology, which applies recombinant DNA technology to create genetically engineered plant traits, such as pest resistance; (2) seeds, into which genetically-modified traits may be

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[108] U.S. CENSUS BUREAU, MANUFACTURING: SUBJECT SERIES: CONCENTRATION RATIOS: SHARE OF VALUE OF SHIPMENTS ACCOUNTED FOR BY THE 4, 8, 20, AND 50 LARGEST COMPANIES FOR INDUSTRIES: 2012 (2012), https://data.census.gov/cedsci/table?q=EC1231SR2&tid=ECNSIZE2012.EC1231SR2&hidePreview=false [https://perma.cc/QD2Y-2E8Q]. This analysis focused on North American Industry Classification System ("NAICS") code 3254, which covers pharmaceutical and medicine manufacturing.

[109] *Id.*

[110] *Cf.* ORG. FOR ECON. CO-OPERATION AND DEV., *supra* note 24, at 5 ("Reliable data on concentration at the market level is available for very little of the U.S. economy.").

[111] *In re* Pfizer, Inc., No. C-3957, 2000 WL 1088335, at *3 (F.T.C. July 27, 2000).

[112] *See, e.g.*, *In re* King Pharm. Inc., No. C-4246, 2009 WL 285502, at *2 (F.T.C. Feb. 2, 2009) (indicating that King and Alpharma were "the only two significant branded morphine sulfate products [long acting opioid analgesics] in the market").

[113] *See* Steven Tenn & John M. Yun, *The Success of Divestitures in Merger Enforcement: Evidence from the J&J–Pfizer Transaction*, 29 INT'L J. INDUS. ORG. 273, 275 (2011).

[114] ABDELA & STEINBAUM, *supra* note 27, at 11.

inserted,[115] and (3) agrochemicals, such as herbicides, which firms design to work with specific engineered traits.[116] Agricultural biotechnology arose from university spinouts in the 1980s and received a significant boost from expansions of patentability for plant-related inventions.[117] As detailed in other work, the industry has experienced significant vertical integration as large chemical companies like Monsanto acquired upstream agricultural biotech firms and seed companies.[118]

In addition to vertical integration, the industry has also experienced substantial horizontal concentration. The roots of the agricultural biotechnology industry lay in the chemicals industry, which by 2001 had consolidated into a Big Six: BASF, Bayer, Dow, DuPont, Monsanto, and Syngenta.[119] As the industry matured, it consolidated into fewer vertically integrated actors.[120] Throughout the 1990s, concentration

[115] Scientists utilize various technologies for plant "transformation" to insert exogenous DNA into seeds; many of these technologies are patented. Graff et al., *supra* note 66, at 352.

[116] The archetypal example is Monsanto's Roundup Ready soybeans, which are genetically engineered to survive spraying with Monsanto's Roundup herbicide. *See* William Neuman & Andrew Pollack, *Farmers Cope with Roundup-Resistant Weeds*, N.Y. TIMES (May 3, 2010), https://www.nytimes.com/2010/05/04/business/energy-environment/04weed.html [https://perma.cc/Y7BU-9P7J].

[117] Lee, *Reconceptualizing*, *supra* note 60, at 1223.

[118] Graff et al., *supra* note 66, at 349 ("As newly minted 'agronomic systems' companies, these firms acquired all of the large, national seed firms in North America . . . ."); Lee, *Innovation*, *supra* note 37, at 1467-69; Keith Fuglie, Paul Heisey, John King & David Schimmelpfennig, *Rising Concentration in Agricultural Input Industries Influences New Farm Technologies*, USDA: AMBER WAVES MAG. (Dec. 3, 2012), https://www.ers.usda.gov/amber-waves/2012/december/rising-concentration-in-agricultural-input-industries-influences-new-technologies/ [https://perma.cc/K7SD-RA7H] ("Of 27 crop biotechnology SMEs that were acquired between 1985 and 2009, 20 were acquired either directly by one of the Big 6 or by a company that itself was eventually acquired by a Big 6 company."). Because genetically engineered traits are an input to producing genetically modified seeds, the combination of these functions represents vertical integration. Technically, agrochemicals like pesticides are a complement to genetically modified seeds, so chemical companies' acquisitions of such capabilities represent concentric acquisition. As a shorthand, however this Article will follow prevailing conventions to refer to combining genetically engineered traits, seeds, and agrochemicals as vertical integration.

[119] Philip H. Howard, *Intellectual Property and Consolidation in the Seed Industry*, 55 CROP SCI. 2489, 2491 (2015). The Big Six refers to the major industry players before DuPont's merger with Dow, which was completed in 2017.

[120] *See* Brett D. Begemann, *Competitive Strategies of Biotechnology Firms: Implications for U.S. Agriculture*, 29 J. AGRIC. & APPLIED ECON. 117, 118 (1997).

grew in corn, cotton, and soybean seed markets,[121] and the share of the agrochemicals market controlled by the top four firms grew from 28.5% to 53%.[122] By 2009, the top three seed companies (all of which were owned by multinationals) controlled 34% of the market.[123] As of 2011, the Big Six controlled 60% of the global proprietary seed market and 76% of the global agrochemical market.[124] Turning to individual product markets, a 2011 analysis concluded that the U.S. cotton seed market significantly increased in concentration since the early 1990s, and the soybean and maize seed markets had been highly concentrated for almost two decades.[125]

In 2012, the top four firms in the "pesticide and other agricultural chemical manufacturing" industry accounted for 57.0% of the total value of shipments.[126] In 2017, ChemChina acquired Syngenta[127] and Dow and DuPont merged.[128] In 2018, Bayer acquired Monsanto, thus further concentrating the industry into a Big Four.[129] The Dow-DuPont merger increased the HHI in the corn and soybean seed markets to over 3,000 and 2,700, respectively,[130] both of which exceed the 2,500 threshold to be considered highly concentrated.[131] Additionally, the

[121] David E. Schimmelpfennig, Carl E. Pray & Margaret F. Brennan, *The Impact of Seed Industry Concentration on Innovation: A Study of US Biotech Market Leaders*, 30 AGRIC. ECON. 157, 159 (2004).

[122] Fuglie et al., *supra* note 118.

[123] SCHENKELAARS ET AL., *supra* note 67, at 4.

[124] ETC GROUP, PUTTING THE CARTEL BEFORE THE HORSE …AND FARM, SEEDS, SOIL, PEASANTS, ETC.: WHO WILL CONTROL THE AGRICULTURAL INPUTS, 2013?, at 3 (2013), https://www.etcgroup.org/putting_the_cartel_before_the_horse_2013 [https://perma.cc/Y8UY-PJ78].

[125] SCHENKELAARS ET AL., *supra* note 67, at 61.

[126] U.S. CENSUS BUREAU, *supra* note 108. This covers NAICS 325320.

[127] Michael Shields, *ChemChina Clinches Landmark $43 Billion Takeover of Syngenta*, REUTERS (May 4, 2017, 10:19 PM), https://www.reuters.com/article/us-syngenta-ag-m-a-chemchina/chemchina-clinches-landmark-43-billion-takeover-of-syngenta-idUSKBN1810CU [https://perma.cc/8D5A-4SXX].

[128] *DowDuPont Merger Successfully Completed*, *supra* note 4.

[129] Naomi Kresge, *Bayer Closes Monsanto Deal to Cap $63 Billion Transformation*, BLOOMBERG (June 7, 2018, 6:09 AM PDT), https://www.bloomberg.com/news/articles/2018-06-07/bayer-closes-monsanto-deal-to-cap-63-billion-transformation [https://perma.cc/TQ85-CUGU].

[130] *Consolidation and Competition in the U.S. Seed and Agrochemical Industry: Hearing Before the S. Comm. on the Judiciary*, 114th Cong. 6 (2016) [hereinafter *Hearing*] (statement of Diana L. Moss, President, American Antitrust Institute).

[131] *Herfindahl-Hirschman Index*, *supra* note 73. Congressional testimony indicates that the Dow-DuPont merger would increase concentration in the corn and soybean seed markets by 400 and 350 HHI points, respectively. *Hearing*, *supra* note 130, at 6. According to the DOJ and FTC, "[m]ergers resulting in highly concentrated markets

Bayer-Monsanto merger increased the HHI in the genetically modified cotton and canola seed markets to 4,100 and 5,600, respectively.[132] In sum, the agricultural biotechnology industry has experienced significant consolidation.

C. Software

While the software industry has experienced several cycles of concentration and fragmentation, a few firms typically dominate the downstream commercialization of software in various product markets.[133] Although software pervades almost all modern industries, this Article focuses on companies that develop software as their core business. In the 1950s, an oligopoly of mainframe computer companies dominated the provision of software services.[134] As prices fell and mainframe computers became more widespread in the 1960s, an enterprise software industry emerged to serve corporate clients.[135] IBM's momentous 1968 decision to unbundle software from hardware significantly boosted the independent software industry,[136] which expanded again with the introduction of personal computers in the mid-1970s.[137] The spread of the Internet in the 1990s further transformed the industry, creating entirely new software markets.[138] Throughout

that involve an increase in the HHI of more than 200 points will be presumed to be likely to enhance market power." U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, *supra* note 22, at 15.

132 United States v. Bayer AG and Monsanto Company, 83 FED. REG. 27652, 27654 (June 13, 2018).

133 *See* SANDRA A. SLAUGHTER, A PROFILE OF THE SOFTWARE INDUSTRY: EMERGENCE, ASCENDANCE, RISKS, AND REWARDS 53 (2014).

134 Martin Campbell-Kelly, *Development and Structure of the International Software Industry, 1950-1990*, 24 BUS. & ECON. HIST. 73, 80 (1995).

135 Martin Campbell-Kelly & Daniel D. Garcia-Swartz, *From Products to Services: The Software Industry in the Internet Era*, 81 BUS. HIST. REV. 735, 736 (2007); *see* Mann, *supra* note 53, at 968 (noting the software industry arose in the mid-1960s). The challenges of developing more complex software also drove the emergence of an independent software industry.

136 SLAUGHTER, *supra* note 133, at 62; Mann, *supra* note 53, at 968.

137 *See* John R. Allison, Abe Dunn & Ronald J. Mann, *Software Patents, Incumbents, and Entry*, 85 TEX. L. REV. 1579, 1586 (2007) (noting that the introduction of IBM's personal computer in 1981 "transformed the software industry"); Campbell-Kelly & Garcia-Swartz, *supra* note 135, at 736; Mann, *supra* note 53, at 968 (discussing the rise of companies that developed software for personal computers).

138 *See* Campbell-Kelly & Garcia-Swartz, *supra* note 135, at 735 (identifying the advent of the commercial Internet in 1994); *see also* SLAUGHTER, *supra* note 133, at 54 (noting significant expansion and double-digit growth rates throughout the 1980s and 1990s); Campbell-Kelly & Garcia-Swartz, *supra*, at 737.

this period, the industry featured many participants,[139] but only a few very large firms had annual sales exceeding $1 billion, and thousands had annual revenues of less than $10 million.[140] While the Internet created a tremendous influx of capital (and new entry),[141] after the dot.com bubble burst, the software industry weeded out weaker companies and reconsolidated.[142]

The Internet has continued to drive both initial entry and subsequent consolidation in many segments of the software industry. For instance, the Internet spawned the market for security software, which then consolidated throughout the early 2000s, when Symantec controlled about one-third of the market.[143] The Internet has also enabled a cloud-based model for software consumption known as software-as-a-service ("SaaS") or Web services.[144] SaaS has enabled the rise of new entrants such as Salesforce.com, but the industry has experienced consolidation (including, in some instances, vertical integration) as many incumbents are buying cloud computing firms. This is evident, for example, in Oracle's recent purchase of Responsys and SAP's recent acquisition of Concur Technologies.[145] In broader strokes, the software industry continues to undergo a continual process of "creative destruction" in which firms abandon old technologies for new ones, often by acquiring innovative startups.[146]

Commentators have argued that the wide availability of venture capital and significant demand for software have prevented industry concentration.[147] Compared to developing a new biologic drug or genetically modified seed, creating software requires relatively little capital,[148] and patents can promote market entry for new startups.[149] Especially in light of relatively low development costs, first-mover advantage can motivate significant entry, thus pushing toward fragmentation. However, the industry experiences significant merger

139 Campbell-Kelly & Garcia-Swartz, *supra* note 135, at 755.

140 *Id.* at 756.

141 *See* SLAUGHTER, *supra* note 133, at 53.

142 *See id.*; Mann, *supra* note 53, at 969.

143 Campbell-Kelly & Garcia-Swartz, *supra* note 135, at 750.

144 *Id.* at 751; *see* SLAUGHTER, *supra* note 133, at 66-67 (noting the rise of subscription software services).

145 PwC, DIGITAL INTELLIGENCE, *supra* note 7, at 14.

146 Campbell-Kelly & Garcia-Swartz, *supra* note 135, at 755.

147 Allison et al., *supra* note 137, at 1579-80; *see* Mann, *supra* note 53, at 970.

148 *See* SLAUGHTER, *supra* note 133, at 72 (noting that creating a software application is relatively inexpensive).

149 *See* Mann, *supra* note 53, at 967-68.

and acquisition activity,[150] and according to the 2012 census, the top four software publishers accounted for 41.4% of total revenues.[151] Microsoft alone accounts for more than 17% of worldwide software revenues.[152] Downstream marketing and distribution of software require significant infrastructure and resources, and "[s]oftware firms producing mature products . . . usually form an oligopoly market where there are a few well-established software firms such as Microsoft, SAP, and Oracle that dominate the market."[153] Not surprisingly, concentration in the software industry is more pronounced at the level of product markets. For instance, TurboTax controls 67% of the tax preparation software market.[154] HHIs for individual software markets are rarely reported, but in two enforcement actions, the FTC calculated HHIs of 4,291 in the market for do-it-yourself tax preparation software[155] and 3,650 and 4,900 in two markets for software to calculate losses for insurance claims.[156] A 2013 analysis of the Internet software market revealed an HHI of 2,500.[157] Another study calculated an average HHI of 3,700 across 114 distinct software product markets, observing that "software markets tend to be concentrated."[158]

Though varied in their unique histories and dynamics, the three patent-intensive industries profiled here all exhibit strong consolidating tendencies, which are evident at the industry-wide level and particularly at the level of individual product markets. The following two Parts delve deeper into the forces shaping such industry structure.

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150 SLAUGHTER, *supra* note 133, at 53.

151 U.S. CENSUS BUREAU, EC1251SSSZ6, INFORMATION: SUBJECT SERIES - ESTAB AND FIRM SIZE: CONCENTRATION BY LARGEST FIRMS FOR THE U.S.: 2012 (2012), https://data.census.gov/cedsci/table?text=concentration%20ratio&n=511210&tid=ECNSIZE2012.EC1251SSSZ6&hidePreview=false [https://perma.cc/PY7M-C3MP]. This covers NAICS industry 511210, "software publishers."

152 SLAUGHTER, *supra* note 133, at 72.

153 *Id.*; *see id.* at 57 tbl.3.1 (ranking the top thirty software suppliers of 2012).

154 Paul Kiel & Justin Elliott, *TurboTax's Bid to Buy Free Tax Prep Competitor Might Violate Antitrust Law, Experts Say*, PROPUBLICA (Feb. 28, 2020, 11:30 AM EST), https://www.propublica.org/article/turbotax-bid-to-buy-free-tax-prep-competitor-might-violate-antitrust-law-experts-say [https://perma.cc/R5BW-467C].

155 United States v. H & R Block, Inc., 833 F. Supp. 2d 36, 72 (D.D.C. 2011).

156 FTC v. CCC Holdings, Inc., 605 F. Supp. 2d 26, 46 (D.C.C. 2009) (finding a pre-merger HHI of 3,650 in the market for Estimatics and a pre-merger HHI that exceeded 4,900 in the market for total loss software systems).

157 Diana L. Moss, *Merger Policy and Rising Concentration: An Active Agenda for Antitrust Enforcement*, 33 ANTITRUST 68, 68 (2018).

158 Marotta-Wurgler & Taylor, *supra* note 26, at 252.

III. CONCENTRATION DRIVERS IN TECHNOLOGICAL COMMERCIALIZATION

While patents certainly impact the structure of industry segments that commercialize technologies, they are only one of several forces shaping such fields. This Part delves deeper to explore three related sets of "concentration drivers" operating in such contexts. First, these fields feature direct barriers to entry based on exclusive rights and cost, which explicitly deter new entrants.[159] Second, these industry segments exhibit indirect barriers to entry in the form of efficiencies of size, which indirectly hamper entry by conferring significant advantages to large incumbents.[160] Third, firms have strong incentives to engage in mergers and acquisitions for a variety of overlapping reasons, including to realize the benefits of size, obtain exogenous innovation, realize synergies, eliminate competition, and respond to other acquisitions.[161] Of course, not all of these forces are present to the same degree in each of these industries, though several of them transcend all three fields. These forces — and the subtle ways that the nonrival nature of technology and patents amplify them — are critical to understanding the consolidated nature of industry segments that commercialize patented technologies.

A. Direct Barriers to Entry Based on Exclusivity and Cost

1. Patents

The most obvious concentration driver in the commercialization of patented technologies is patents themselves.[162] Exclusive rights on foundational technologies or broad patent thickets directly raise costs for potential entrants.[163] Even if new firms manage to enter, incumbents wielding patents can weaken them by suing for infringement. In some

159 *See infra* Part III.A.

160 *See infra* Part III.B.

161 *See infra* Part III.C.

162 *See generally* Lee, *Reconceptualizing*, *supra* note 60 (noting that empirical evidence reveals a relatively high degree of concentration in industries that commercialize intellectual property). Porter characterizes exclusive rights as a barrier to entry independent of a firm's size. *See* Michael E. Porter, *How Competitive Forces Shape Strategy*, 57 HARV. BUS. REV. 137, 139 (1979) [hereinafter *How Competitive Forces*]; Porter, *The Five Competitive Forces*, *supra* note 23, at 33.

163 *See* Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, 1 INNOVATION POL'Y & ECON 119, 119 (2001) [hereinafter *Patent Thicket*]; *cf.* MACHLUP, *supra* note 57 at 284 ("[A]ccumulation of patents in the hands of large corporations may secure them an almost unlimited monopoly power.").

innovative industries, incumbents are more likely to bring infringement suits against new entrants rather than established players, with which they maintain a strategic détente.[164] Additionally, rather than suing new entrants out of existence, incumbents can leverage large patent portfolios to acquire them, which also drives industry consolidation.[165]

In biopharmaceuticals, "brand" companies wield patents to exclude potential competitors, including both rival brand companies and generic firms. Patents are critical to blocking entry and sustaining a viable business model; the day that Merck's patent on Zocor expired, three competitors entered the market,[166] and generic competition typically results in initial price decreases of 50%.[167] To shore up barriers to entry, biopharmaceutical companies engage in "evergreening" to extend the effective period of exclusivity over a drug by patenting relatively minor variations of it.[168] Furthermore, exploiting the Hatch-Waxman regime,[169] brand companies have paid generic manufacturers to settle patent challenges, thereby avoiding patent invalidation and delaying generic entry.[170] Thus in addition to suing brand competitors for patent infringement, pharmaceutical companies "expend tremendous energy blocking generic entry by any means possible, with some companies using ever more clever and complicated strategies."[171] Beyond patents themselves, pharmaceutical companies enjoy various "regulatory exclusivities" from the Food and Drug Administration, including market exclusivity for new chemical entities and for changes to previously approved products that require new clinical trials for

164 William Lesser, *Intellectual Property Rights and Concentration in Agricultural Biotechnology*, 1 AGBIOFORUM 56, 58 (1998).

165 *See* Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. PA. L. REV. 1, 33-34 (2005).

166 Porter, *The Five Competitive Forces*, *supra* note 23, at 34.

167 IMS INST. FOR HEALTHCARE INFORMATICS, PRICE DECLINES AFTER BRANDED MEDICINES LOSE EXCLUSIVITY IN THE U.S. 2-3 (2016), https://www.iqvia.com/-/media/iqvia/pdfs/institute-reports/price-declines-after-branded-medicines-lose-exclusivity-in-the-us.pdf [https://perma.cc/PMG8BM4A].

168 Rebecca S. Eisenberg, *The Role of the FDA in Innovation Policy*, 13 MICH. TELECOMM. & TECH. L. REV. 345, 354 (2007).

169 *See supra* notes 99–103 and accompanying text.

170 *See, e.g.*, FTC v. Actavis Inc., 570 U.S. 136, 147 (2013) (holding that such agreements are subject to antitrust challenges under the rule of reason); Robin Feldman & Evan Frondorf, *Drug Wars: A New Generation of Generic Pharmaceutical Delay*, 53 HARV. J. LEGIS. 499, 503 (2016) (noting Hatch-Waxman has created opportunities for pharmaceutical companies to hold off generic competition).

171 Feldman & Frondorf, *supra* note 170, at 503.

approval.[172] By design, patents and regulatory exclusivities create barriers to entry, which help promote industry concentration.

Patents also create barriers to entry in the agricultural biotechnology, seed, and agrochemical industry.[173] The vast majority of patents are held by industry leaders; by 2007, the top ten companies accounted for 75% of U.S. patent applications for genetically engineered traits, biotech products, and transformation techniques.[174] A broad patent thicket covers most of the world's desirable germplasm, which hinders entry by new competitors[175] and confers a competitive advantage on incumbent patent holders.[176] Further raising barriers to entry, established incumbents tend to cross-license patents with each other[177] while suing new entrants.[178] Within the agricultural biotechnology industry, intellectual property rights restrict market entry and "result in concentrated, protected markets."[179]

Patents also raise barriers to entry in the software industry. This is notable because commentators have argued that patents promote startup formation, market entry, and fragmentation in that industry.[180] While this may apply to some contexts, empirical research reveals that from 1990-2004, a 10% increase in the number of patents reduced the rate of entry by 3-8% in the software industry.[181] Strengthening intellectual property ("IP") rights in software particularly deters the entry of young, specialized firms compared to more established

[172] *See* Rebecca S. Eisenberg, *Patents, Product Exclusivity, and Information Dissemination: How Law Directs Biopharmaceutical Research and Development*, 72 FORDHAM L. REV. 477, 482-83 (2003) [hereinafter *Product Exclusivity*].

[173] *See* DEBBIE BARKER, BILL FREESE, GEORGE KIMBRELL, SAM COHEN, HUDSON KINGSTON, SHARON PERRONE, ABIGAIL SEILER, CRISTINA STELLA & PAIGE TOMASELLI, SEED GIANTS VS. U.S. FARMERS 2 (2013).

[174] SCHENKELAARS ET AL., *supra* note 67, at 21.

[175] *See* BARKER ET AL., *supra* note 173, at 8.

[176] Howard, *supra* note 119, at 2492.

[177] SCHENKELAARS ET AL., *supra* note 67, at 79; Howard, *supra* note 119, at 2492.

[178] John H. Barton, *The Impact of Contemporary Patent Law on Plant Biotechnology Research*, *in* INTELLECTUAL PROPERTY RIGHTS III, GLOBAL GENETIC RESOURCES: ACCESS AND PROPERTY RIGHTS 85, 96 (1998).

[179] JOHN L. KING, CONCENTRATION AND TECHNOLOGY IN AGRICULTURAL INPUT INDUSTRIES, AGRIC. INFO. BULL. NO. 763, at 4 (2001), https://ers.usda.gov/webdocs/publications/42325/31960_aib763_002.pdf?v=4701.6 [https://perma.cc/6ZCBH4G9].

[180] Mann, *supra* note 53, at 967-68.

[181] Cockburn & MacGarvie, *supra* note 58, at 915. Notably, the entry-dampening effect of patents decreases significantly when entrants have their own patents. *Id.*

companies.[182] Empirical research also shows that startups take longer to obtain venture financing in markets with more patents.[183]

The entry-deterring effects of patents in the software industry are heightened by several related dynamics. First, unlike the biopharmaceutical industry, which generally features a relatively low number of patents per product,[184] developing a complex product in the software industry can require clearing thousands of patents on complementary technologies.[185] The need to navigate dense patent thickets deters entry by new competitors.[186] Second, in order to maintain freedom to operate, large incumbents amass large "defensive" patent portfolios,[187] thus exacerbating patent thickets and raising barriers to entry.[188] Similar to the agricultural biotechnology industry, incumbents with large patent portfolios maintain a "cross-licensing equilibrium" with each other,[189] which helps industry leaders while hampering new entrants. Finally, an important contributor to patent thickets are non-practicing entities (known colloquially as "patent trolls"): entities that amass large patent portfolios, do not manufacture products, and rely on licensing fees or settlements for revenues.[190] On the one hand, patent trolls function as market-makers and channel

[182] *Id.* at 930.

[183] Iain M. Cockburn & Megan J. MacGarvie, *Patents, Thickets, and the Financing of Early-Stage Firms: Evidence from the Software Industry*, 18 J. ECON. MGMT. STRATEGY 729, 729 (2009).

[184] *See* Lisa Larrimore Ouellette, *How Many Patents Does It Take to Make a Drug - Follow-On Pharmaceutical Patents and University Licensing*, 17 MICH. TELECOMM. TECH. L. REV. 299, 300 (2010) (finding that in 2005, the average small-molecule drug was covered by 3.5 patents).

[185] Cockburn & MacGarvie, *supra* note 58, at 919.

[186] *See* Shapiro, *Patent Thicket*, *supra* note 163, at 120.

[187] Colleen V. Chien, *Opening the Patent System: Diffusionary Levers in Patent Law*, 89 S. CAL. L. REV. 793, 821 (2016); *see Oracle Corporation – Patent Policy*, ORACLE, https://groups.csail.mit.edu/mac/projects/lpf/Patents/testimony/statements/oracle.statement.html (last visited Sept. 11, 2020) [https://perma.cc/6MTV-G2T4] ("Unfortunately, as a defensive strategy, Oracle has been forced to protect itself by selectively applying for patents which will present the best opportunities for cross-licensing between Oracle and other companies who may allege patent infringement.").

[188] *See* Colleen V. Chien, *From Arms Race to Marketplace: The Complex Patent Ecosystem and Its Implications for the Patent System*, 62 HASTINGS L.J. 297, 307-10 (2010); Shapiro, *Patent Thicket*, *supra* note 163, at 126-27 (noting that patent thickets particularly hinder new firms).

[189] Allison et al., *supra* note 137, at 1594; *see* Mann, *supra* note 53, at 996 (discussing cross-licensing in the software industry).

[190] Brian J. Love, *An Empirical Study of Patent Litigation Timing: Could a Patent Term Reduction Decimate Trolls Without Harming Innovators?*, 161 U. PA. L. REV. 1309, 1314 (2013).

resources to small inventors, which may enhance fragmentation. On the other hand, they amass and assert huge portfolios of patents, thus likely raising entry costs for new competitors. In a variety of ways, a proliferation of patents raises barriers to entry and promotes concentration in the software industry.

2. High Fixed Costs

While patents are a highly visible concentration driver, fields that commercialize patented technologies also share other structural features that promote concentration. Across these fields, high fixed costs also raise barriers to entry.[191] Notably, because this Article focuses on *commercialization*, fixed costs include not only research and development expenses (where applicable), but the formidable costs of testing, marketing, and distributing technological goods.

For decades, economists have recognized that the enormous research and development ("R&D") and marketing costs necessary to commercialize drugs create barriers to entry.[192] One influential study estimates that it currently costs $2.6 billion to bring a new drug to market.[193] From 1995-2007, biopharmaceutical firms spent 18.7% of their net sales on research and development.[194] Furthermore, the expense of drug development is rising as firms shift from small-molecule drugs to more expensive, large-molecule biologics.[195] Additionally, obtaining regulatory approval is highly costly, which also limits entry, and costs for clinical trials are rising.[196] While R&D expenses attract significant attention, large pharmaceutical firms spend

191 *See* Grullon et al., *supra* note 9, at 708.

192 *See* William S. Comanor, *Research and Competitive Product Differentiation in the Pharmaceutical Industry in the United States*, 31 ECONOMICA 372, 380 (1964).

193 Joseph A. DiMasi, Henry G. Grabowski & Ronald W. Hansen, *Innovation in the Pharmaceutical Industry: New Estimates of R&D Costs*, 47 J. HEALTH ECON. 20, 21 (2016). *But see* Aaron E. Carroll, *$2.6 Billion to Develop a Drug? New Estimate Makes Questionable Assumptions*, N.Y. TIMES: THE UPSHOT (Nov. 18, 2014), https://www.nytimes.com/2014/11/19/upshot/calculating-the-real-costs-of-developing-a-new-drug.html [https://perma.cc/A765-78UA] (critiquing the DiMasi et al. analysis).

194 Shanling Li, Jennifer Shang & Sandra A. Slaughter, *Why Do Software Firms Fail? Capabilities, Competitive Actions, and Firm Survival in the Software Industry from 1995 to 2007*, 21 INFO. SYS. RES. 631, 634 n.2 (2010).

195 *See* Ajay Gautam & Xiaogang Pan, *The Changing Model of Big Pharma: Impact of Key Trends*, 21 DRUG DISCOVERY TODAY 379, 382 (2016).

196 Eisenberg, *Product Exclusivity*, *supra* note 172, at 481-82; *see* Shepherd, *supra* note 83, at 8-9.

far more on sales and marketing.[197] For example, in 2013, Johnson & Johnson spent $17.5 billion on sales and marketing and $8.2 billion on R&D.[198] In particular, maintaining an extensive sales force to visit healthcare providers and personally market drugs represents a substantial fixed cost.[199] Aside from any patent exclusivity, the extraordinary expense of drug development, clinical trials, marketing, and distribution creates a formidable barrier to entry.[200]

In similar fashion, developing, testing, obtaining regulatory approval for, and marketing genetically modified seeds is very expensive,[201] which "creates a strong barrier to entry for smaller firms" in agricultural biotechnology.[202] In 2009, Monsanto had a research and development budget of nearly $1 billion and estimated that it cost $100 million to bring a new genetically modified seed to market.[203] More generally, an industry survey found that from 2008-2012, the average cost to bring a new genetically engineered crop trait to market was $136 million.[204] As noted above,[205] patents on research inputs contribute to high research and development costs.[206] Here, the Big Four (BASF, Bayer, Corteva, and Syngenta) enjoy a double advantage relative to new entrants; they not only maintain vast portfolios that enhance freedom to operate, but

197 *See* Ana Swanson, *Big Pharmaceutical Companies Are Spending Far More on Marketing than Research*, WASH. POST (Feb. 11, 2015, 8:01 AM PST), https://www.washingtonpost.com/news/wonk/wp/2015/02/11/big-pharmaceutical-companies-are-spending-far-more-on-marketing-than-research/?utm_term=.d9f0636738d3 [https://perma.cc/HLG2-MCHU].

198 *Id.*

199 Richard E. Caves, Michael D. Whinston & Mark A. Hurwitz, *Patent Expiration, Entry, and Competition in the U.S. Pharmaceutical Industry*, *in* BROOKINGS PAPERS: MICROECONOMICS 1, 11 (1991); Richman et al., *supra* note 92, at 814-15. Maintaining utilization of this resource also motivates firms to acquire other firms when key patents expire, which further drives consolidation. Richman et al., *supra*, at 791-92.

200 While costs for biopharmaceutical companies are high, revenues have decreased due to increased generic competition and greater leverage by downstream distributors. *See* Shepherd, *supra* note 83, at 4-8.

201 *Cf.* PHILLIPS MCDOUGALL, THE COST AND TIME INVOLVED IN THE DISCOVERY, DEVELOPMENT AND AUTHORISATION OF A NEW PLANT BIOTECHNOLOGY DERIVED TRAIT 3 (2011) ("The discovery, development and authorisation of a new plant trait using modern genetic engineering techniques is a complex and time consuming procedure.").

202 Howard, *supra* note 119, at 2492.

203 *The Parable of The Sower*, ECONOMIST (Nov. 19, 2009), https://www.economist.com/briefing/2009/11/19/the-parable-of-the-sower [https://perma.cc/FD3N-YZSN].

204 MCDOUGALL, *supra* note 201, at 7. *But see* SCHENKELAARS ET AL., *supra* note 67, at 5 (indicating a wider range of estimated costs from $15–30 million to $100–180 million).

205 *See supra* notes 173–179 and accompanying text.

206 *See* SCHENKELAARS ET AL., *supra* note 67, at 7.

they also cross-license patents among themselves but not to new competitors.[207] In addition to R&D costs, bringing a new trait to market requires regulatory approval, which is the longest single phase of plant-trait product development and accounts for 25.8% of total cost.[208] High regulatory compliance costs discourage small- and medium-sized firms, as well as public institutions, from commercializing genetically modified crops.[209] Ultimately, barriers to entry are additive: "firm entry in the U.S. seed industry may be limited by large entry costs due to high research and development investments and regulatory compliance costs as well as by the complexity of intellectual property rights."[210]

Somewhat surprisingly, high costs also hinder entry in the commercialization of software. While writing code is perceived as relatively inexpensive, development costs vary widely depending on the nature and complexity of programs. Furthermore, software companies invest significantly in research and development. From 1995-2007, software companies spent 28.7% of their net sales on R&D,[211] which is a higher percentage than the biopharmaceutical and hardware industries.[212] Additionally, software firms face significant marketing and advertising expenses,[213] and many leading firms maintain expensive sales and customer service forces.[214] Software companies on average spend 15-25% of revenues on sales and marketing.[215] Beyond any patent exclusivity, the surprisingly high cost of software development coupled with formidable expenditures for sales and marketing creates a significant barrier to entry in the commercialization of software.

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[207] *See* Howard, *supra* note 119, at 2492.

[208] MCDOUGALL, *supra* note 201, at 14.

[209] *See* SCHENKELAARS ET AL., *supra* note 67, at 5.

[210] Nicholas Kalaitzandonakes, Alexandre Magnier & Douglas Miller, *A Worrisome Crop?*, 33 REG. 20, 20 (2010).

[211] Li et al., *supra* note 194, at 634 n.2.

[212] *See id.*

[213] SLAUGHTER, *supra* note 133, at 66.

[214] *See id.* at 72-73.

[215] Anne Shields, *Overview: Understanding the Software Industry Cost Structure*, MARKET REALIST, http://marketrealist.com/2014/07/overview-understanding-software-industry-cost-structure/ (last visited Sept. 12, 2020) [https://perma.cc/7RHC-S4V9] [hereinafter *Cost Structure*].

B. Indirect Barriers to Entry Based on Efficiencies of Size

1. Economies of Scale and Scope

While patents and high costs directly inhibit potential entrants, other barriers to entry operate indirectly by conferring significant competitive advantages to large incumbents.[216] For instance, economies of scale and scope also drive concentration in technological industries.[217] Economies of scale and scope arise when costs are spread over an increasing volume[218] and variety[219] of output, respectively. Firms exploit economies of scale by expanding production of an output and economies of scope by leveraging an asset into multiple developmental pathways to produce numerous products. Economies of scale and scope confer advantages to large incumbents, thus inhibiting the entry of new competitors.

Notably, while economies of scale apply to all industries, they are particularly pronounced in the commercialization of patented technologies. In many technological fields, virtually the entire value of a product derives from a (nonrival) technical design, and the marginal cost of producing additional units of output is very low. Unlike rivalrous resources like coal or steel, the information inherent in a patented invention is nonrival, meaning that additional consumption does not diminish its supply. "Consumption" of the chemical formula for Nexium, the design of a genetically modified trait, or the latest version of Microsoft Office does not diminish its availability for additional uses. Furthermore, many technological industries — including the ones examined here — feature very low marginal costs of production. Once a drug, genetically modified seed, or piece of software has been developed, it is a trivial expense to produce many copies.[220] Such technologies "scale" easily, and in markets where economies of

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[216] *See* Malerba & Orsenigo, *supra* note 76, at 667 ("Increasing returns can arise from mechanisms involving scale economies in R&D, learning curves, marketing efforts or so-called network externalities.").

[217] *See* COUNCIL OF ECON. ADVISERS, *supra* note 9, at 6; Grullon et al., *supra* note 9, at 735; David Levy, *Specifying the Dynamics of Industry Concentration*, 34 J. INDUS. ECON. 55, 56 (1985); Porter, *How Competitive Forces*, *supra* note 162, at 138.

[218] Porter, *The Five Competitive Forces*, *supra* note 23, at 26; *see* Demsetz, *Industry Structure*, *supra* note 56, at 1.

[219] *See generally* Joel D. Goldhar & Mariann Jelinek, *Plan for Economies of Scope*, HARV. BUS. REV. (1983), https://hbr.org/1983/11/plan-for-economies-of-scope [https://perma.cc/PTW9-UF3Q] (describing economies of scope).

[220] This is not the case for all patent- and technology-intensive industries. For instance, airplane production requires thousands of patented components, but marginal production costs are very high.

scale are substantial, "the process of competition often leads quite naturally to high levels of significant concentration."[221] More generally, "[b]ecause economies of scale and scope mean that larger and [more] diversified firms have lower average costs, there is clearly an incentive for firms to get large."[222]

Economies of scale and scope contribute to concentration in the commercialization of biopharmaceuticals. Pharmaceutical companies exploit economies of scale by spreading the formidable costs of drug development and commercialization over larger volumes of output.[223] Downstream activities such as manufacturing and distribution tend to be even more scale-intensive than upstream activities such as early-stage research.[224] Notably, patents help companies realize economies of scale. While the design of a drug is nonrival by nature, companies would have little incentive to ramp up production in the absence of exclusive rights. By excluding competitors, patents help protect large sales volumes for particular drugs, thus enabling the patent holder to increase production and exploit scale economies. Biopharmaceutical companies also enjoy economies of scope in utilizing production and distribution infrastructure for multiple purposes. Incumbents maintain expensive sales forces[225] and spread the cost of this resource across a large variety of products. As Barak Richman and his colleagues argue, "[t]reating sales forces as fixed costs that would go unutilized without actively marketed products is one leading explanation for the steady frequency of acquisitions and the surge of megamergers."[226] Economies of scale both deter entry by small players and promote their acquisition by large incumbents. For instance, the inability of biotechnology firms to develop the large-scale infrastructure necessary to commercialize drugs

[221] Herbert Hovenkamp & Carl Shapiro, *Horizontal Mergers, Market Structure, and Burdens of Proof*, 127 YALE L.J. 1996, 2005 (2018).

[222] Murray Fulton & Konstantinos Giannakas, *Agricultural Biotechnology and Industry Structure*, 4 AGBIOFORUM 137, 142 (2001); *see* Katz & Shapiro, *Software*, *supra* note 24, at 34-35.

[223] *See* Richman et al., *supra* note 92, at 805.

[224] Joel A.C. Baum & Brian S. Silverman, *Picking Winners or Building Them? Alliance, Intellectual, and Human Capital as Selection Criteria in Venture Financing and Performance of Biotechnology Startups*, 19 J. BUS. VENTURING 411, 426 (2004).

[225] *See* Gary P. Pisano, Weijian Shan & David J. Teece, *Joint Ventures and Collaboration in the Biotechnology Industry*, *in* INTERNATIONAL COLLABORATIVE VENTURES IN U.S. MANUFACTURING 183, 208 (David C. Mowery ed., 1988).

[226] Richman et al., *supra* note 92, at 815.

helps motivate them to accept acquisition bids from large pharmaceutical companies.[227]

In the agricultural biotechnology, seed, and agrochemical industry, economies of scale motivate companies to spread the cost of developing a genetically modified trait over large production volumes.[228] Interestingly, many multinational companies that had acquired seed companies in the early 1990s perceived economies of scale to be low due to the need to adapt seeds to local geographies.[229] However, a few multinationals — primarily major agrochemical companies — sought to realize economies of scale by acquiring numerous biotech and seed firms, thereby vertically integrating the production, development, and distribution of genetically modified seeds.[230] In this fashion, one form of consolidation — vertical integration — helped companies realize economies of scale, thus increasing barriers to entry and horizontal concentration.[231] Beyond economies of scale, once a firm has developed a genetically modified trait (such as for drought resistance), it can exploit economies of scope by inserting this trait into several different crops.[232] This in turn creates an incentive to acquire multiple seed companies,[233] which further drives consolidation.

Economies of scale and scope are particularly intense in the software industry. Code is nonrival, and once a company has developed a valuable program, it is a trivial expense to produce many copies. Many information-based industries such as software feature large fixed costs and small or even zero marginal costs, thus approaching the economic archetype of a natural monopoly.[234] The drive to exploit low marginal costs and expand scale economies also fuels mergers and acquisitions

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[227] *See* Lee, *Innovation*, *supra* note 37, at 1456 (discussing the complementary capabilities of biotechnology and pharmaceutical firms).

[228] *See* SCHENKELAARS ET AL., *supra* note 67, at 28.

[229] *Id.* at 17.

[230] *Id.* at 25.

[231] It should be noted that vertical integration can constitute its own barrier to entry, thus exacerbating horizontal concentration. *See, e.g.*, *Hearing*, *supra* note 130, at 11 (discussing the likely effects of "[v]ertically integrated Dow-DuPont and Monsanto-Bayer traits-seeds-chemicals platforms").

[232] *See id.* at 3.

[233] *See* Lee, *Innovation*, *supra* note 37, at 1471.

[234] Varian, *supra* note 20, at 77; *see also* Alfred D. Chandler, *Organizational Capabilities and the Economic History of the Industrial Enterprise*, 6 J. ECON. PERSP. 79, 94 (1992) (noting that science-based industries scale easily).

to increase a company's user base.[235] In sum, economies of scale "are certainly present and are very powerful in the software industry," and they "can lead to market concentration as it is most efficient for one or a few large firms to dominate the industry."[236]

2. Network Effects, Standards, and Lock-In

Another barrier to entry operating in some — but not all — industries commercializing patented technologies is network effects. Also called demand-side economies of scale[237] or network externalities, network effects arise when the value of a good or service increases as more people use it, such as when the value of a telephone network rises as additional users join it.[238] Network markets tend to move toward standardization[239] and are frequently "winner-take-most" or "winner-take-all" contests characterized by tipping; standards initially compete, but eventually consumers will tip toward one standard that dominates the market.[240] Ultimately, network effects contribute to lock-in.[241] Network effects and standards can exacerbate concentration, as a prevailing platform will push competing platforms out of the market. The potential to accelerate concentration increases, however, if standards are protected by exclusive rights. As Julie Cohen and Mark Lemley observe, "The nexus among intellectual property rights, compatibility, and network effects is quite strong. To the extent that intellectual property rights confer ownership interests in a strong network standard, they may create durable market power in network markets."[242]

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235 Markus Schief, Peter Buxmann & Dirk Schiereck, *Mergers and Acquisitions in the Software Industry: Research Results in the Area of Success Determinants*, 6 BUS. & INFO. SYS. ENGINEERING 421, 422 (2013).

236 SLAUGHTER, *supra* note 133, at 68-69; *see also* Shapiro, *Antitrust*, *supra* note 9, at 744.

237 Varian, *supra* note 20, at 81; *see* Porter, *The Five Competitive Forces*, *supra* note 23, at 27.

238 *See* COUNCIL OF ECON. ADVISERS, *supra* note 9, at 3; Michael L. Katz & Carl Shapiro, *Systems Competition and Network Effects*, 8 J. ECON. PERSP. 93, 94 (1994) [hereinafter *Systems*].

239 Katz & Shapiro, *Systems*, *supra* note 238, at 105.

240 Michael A. Carrier, *Unraveling the Patent-Antitrust Paradox*, 150 U. PA. L. REV. 761, 822 (2002); Katz & Shapiro, *Systems*, *supra* note 238, at 111; Robert Pitofsky, *Challenges of the New Economy: Issues at the Intersection of Antitrust and Intellectual Property*, 68 ANTITRUST L.J. 913, 916 (2001); Varian, *supra* note 20, at 76.

241 Varian, *supra* note 20, at 85.

242 Julie E. Cohen & Mark A. Lemley, *Patent Scope and Innovation in the Software Industry*, 89 CALIF. L. REV. 3, 22 (2001); *see also* Joseph Farrell, *Arguments for Weaker*

In a somewhat surprising example, standardization has contributed to concentration in agricultural biotechnology. From the late 1990s to the 2000s, Monsanto acquired almost forty agricultural biotechnology and seed companies.[243] Prior to its acquisition by Bayer, Monsanto controlled nearly 27% of global commercial seed sales.[244] Firms in the industry sometimes combine different genetically engineered traits into "stacks" that are inserted as packages into germplasm. Monsanto has a dominant position in inter-firm stacks: 100% of soybean and cotton inter-firm stacks and 36% of corn inter-firm stacks include a genetically engineered trait developed by Monsanto.[245] According to Diana Moss, "the 'ubiquity' of a dominant firm's traits in inter-firm stacks creates incentives for both seed companies and rival biotechnology developers to 'standardize' on that platform."[246] Monsanto's inter-firm stacks achieved the level of an industry standard around which others tailored their products, further entrenching Monsanto's dominance.

Network effects are most pertinent as a concentration driver in the software industry.[247] The value of interoperability and standardization, as well as lock-in from existing consumers accustomed to a particular technological paradigm, can create significant network effects that establish one dominant platform while crowding out competitors. In operating systems, for example, these factors have helped tip the market to Microsoft Windows, which enjoys a 90% market share.[248] For users accustomed to Windows, switching to another operating system like Linux can be very expensive,[249] thus producing lock-in and reducing

Intellectual Property Protection in Network Industries, 3 STANDARDVIEW 46, 47 (1995); Varian, *supra* note 20, at 95.

[243] *See* Diana L. Moss & C. Robert Taylor, *Short Ends of the Stick: The Plight of Growers and Consumers in Concentrated Agricultural Supply Chains*, 2014 WIS. L. REV. 337, 362.

[244] *See* BARKER ET AL., *supra* note 173, at 6.

[245] Diana L. Moss, *Competition, Intellectual Property Rights, and Transgenic Seed*, 58 S.D. L. REV. 543, 555 (2013).

[246] *Id.*

[247] *See* SLAUGHTER, *supra* note 133, at 70; Katz & Shapiro, *Software*, *supra* note 24, at 30; Robert P. Merges, Patents, Entry and Growth in the Software Industry 5 (Aug. 24, 2006) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=926204 [https://perma.cc/9VY4-WTPM] (observing that proprietary "backbones" in the software industry give rise to network effects); Anne Shields, *Overview: The Software Industry Landscape*, MARKET REALIST, http://marketrealist.com/2014/07/overview-software-industry-landscape/ (last visited Oct. 19, 2020) [https://perma.cc/5MWA-F2P4] [hereinafter *Landscape*]; *see also* Varian, *supra* note 20, at 85 (describing network effects in word processing software and operating systems).

[248] Shields, *Landscape*, *supra* note 247.

[249] Varian, *supra* note 20, at 75.

the threat of substitutes.[250] The value of interoperability may also lead large firms to pressure suppliers to adopt the same enterprise resource planning ("ERP") software.[251] Commentators note that "network effects can represent a decisive competitive advantage for a provider."[252] As suggested above, the coupling of interoperability standards with patent protection further raises barriers to entry in network industries.[253] Some have even argued that New Economy businesses based on software and the Internet operate as "sequential monopolies in which dominant firms leapfrog each other's market position."[254] Ultimately, concentration drivers are cumulative: "patents, high switching costs, and the concentration of the software market create significant barriers" to entry.[255]

3. Risk-Spreading and Portfolios

The benefit of spreading risk across broad patent portfolios also represents an "efficiency of size" that contributes to industry concentration. Given the high cost of production and the uncertainty of success, technology firms frequently develop numerous prospects in parallel and allow a few successes to subsidize many failures. The risk advantages of broad portfolios create an incentive for firms to become larger, sometimes through acquiring other companies, both of which drive consolidation. Furthermore, they create a barrier to entry for new competitors who do not have the resources to amass broad portfolios.[256]

Uncertainty is endemic to the commercialization of technology. In biopharmaceuticals, the widely cited estimate of $2.6 billion to bring a

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[250] *See* SLAUGHTER, *supra* note 133, at 74.

[251] *See* PETER BUXMANN, HEINER DIEFENBACH & THOMAS HESS, THE SOFTWARE INDUSTRY: ECONOMIC PRINCIPLES, STRATEGIES, PERSPECTIVES 21 (2013).

[252] *Id.* at 27.

[253] *See* Cohen & Lemley, *supra* note 242.

[254] David McGowan, *Innovation, Uncertainty, and Stability in Antitrust Law*, 16 BERKELEY TECH. L.J. 729, 791 (2001); *cf.* Khan, *supra* note 9, at 785 (observing that "technology platform markets will yield to dominance by a small number of firms").

[255] Shields, *Cost Structure*, *supra* note 215. Michael Katz and Carl Shapiro's observations from two decades ago ring true in contemporary times: "Today's software markets involve large, valuable, and entrenched installed-bases of users, extensive data that may be difficult to transfer to work with a new brand of software, and integration among various types of software." Katz & Shapiro, *Software*, *supra* note 24, at 44.

[256] This is particularly true in the traditional case where new entrants are small, undercapitalized entities. In some instances, however, large incumbents from one market are new entrants in another, such as when Microsoft entered the browser market with Internet Explorer. In such instances, the capacity of a new entrant to mitigate risk (and enjoy the other benefits of size) is greater.

drug to market includes expenditures for many failed prospects.[257] One study estimates an 11.8% probability that a drug that enters clinical trials (which is already a relatively late stage of development) will ultimately receive regulatory approval.[258] Additionally, the failure rate of drug prospects is increasing.[259] The enormous cost and risk of developing a profitable drug motivates pharmaceutical companies to spread efforts across large numbers of prospects. This in turn drives both endogenous growth and acquisitions. In addition to increasing the sheer number of drugs in a pipeline, incumbents also hedge risk by acquiring companies in new therapeutic categories to diversify their product offerings.[260]

The development of new plant traits also involves significant risk. A survey of the former Big Six (BASF, Bayer, Dow, DuPont, Monsanto, and Syngenta) revealed that from 2008-2012, each company screened an average of 6,204 candidate genes, constructs, or genetic events in "early discovery" and 4,005 candidates in "late discovery" to yield one candidate that ultimately obtained regulatory approval and registration.[261] Over that period, the average time from discovery of a trait to first commercial sale for all crops was 13.1 years.[262] Large firms can better manage risk than new entrants by screening thousands of compounds in parallel over many years.

The cost and risk of product development differs in the software industry relative to biopharmaceuticals and agricultural biotechnology due to lower development costs, shorter development times, and the absence of regulatory approval requirements. However, incumbent software companies utilize size to manage a different kind of risk: the risk of patent infringement suits by others. Aside from the "lottery theory" that justifies spreading risk across large numbers of products, technology companies — including software companies — also manage risk by amassing large patent portfolios to maintain freedom to operate. Patent portfolios expand the total scope of protection, thus operating as

257 *See* DiMasi et al., *supra* note 193, at 21.

258 *Id.* at 23.

259 Fabio Pammolli, Laura Magazzini & Massimo Riccaboni, *The Productivity Crisis in Pharmaceutical R&D*, 10 NATURE REVIEWS DRUG DISCOVERY 428, 429-30 (2011).

260 *See, e.g.*, Andrew Pollack, *Roche Agrees to Buy Genentech for $46.8 Billion*, N.Y. TIMES (Mar. 12, 2009), https://www.nytimes.com/2009/03/13/business/worldbusiness/13drugs.html [https://perma.cc/M9DR-V7Z8] (noting that Pfizer's acquisition of Wyeth and Merck's acquisition of Schering-Plough would diversify their respective product offerings).

261 MCDOUGALL, *supra* note 201, at 6, 8.

262 *Id.* at 10.

a "super-patent"[263] that can hedge against future uncertainties.[264] Notably, large patent portfolios preserve a firm's freedom to operate not only by reducing the likelihood that it will infringe another party's patents, but also by conferring valuable leverage if the firm actually does infringe another party's patents, particularly those of a competitor. In such cases, the offending firm can likely assert infringement of patents from its own portfolio, thus forcing the competitor to the bargaining table and encouraging cross-licensing.[265] To this end, software companies have amassed enormous patent portfolios, which raise entry costs for new entrants. The capital requirements and benefits of patent portfolios create a self-perpetuating cycle wherein the big get bigger,[266] and commentators predict that the patent system will increasingly favor large, highly capitalized incumbents.[267]

C. Incentives for Mergers and Acquisitions

In addition to direct and indirect barriers to entry, mergers and acquisitions drive significant consolidation in technological industries. Firms engage in mergers and acquisitions for a wide variety of reasons, including to achieve the benefits of size, obtain innovation and complementary assets, cut costs, eliminate competition, and respond to other acquisitions. While some motivations are industry-specific,[268] this subpart will focus on general motivations that apply to multiple industries. Vertical integration via acquisition of small, upstream firms

263 Parchomovsky & Wagner, *supra* note 165, at 7, 31-32.

264 *Id.* at 8, 32.

265 *See, e.g.*, *Oracle Corporation – Patent Policy*, *supra* note 187 ("Oracle consequently believes that it must have a patent portfolio with which to respond to potential aggressors, so as to settle with them by cross-licensing to avoid litigation."); *see also* Chien, *Software Patents*, *supra* note 69, at 1703 (noting how patents can be used defensively).

266 *See* Parchomovsky & Wagner, *supra* note 165, at 10.

267 *Id.* at 65.

268 *See, e.g.*, Gautam & Pan, *supra* note 195, at 380 (describing tax inversions in pharmaceutical mergers and acquisitions); Bloomberg, *Bristol-Myers Is Buying Celgene for $74 Billion in One of the Largest Big Pharma Mergers Ever*, FORTUNE (Jan. 3, 2019, 5:08 AM PST), http://fortune.com/2019/01/03/bristol-myers-celgene-merger/ [https://perma.cc/4ZKR-H9KN] (noting that investor skepticism over Celgene's future prospects helped fuel its acquisition by Bristol-Myers Squibb); Natasha Singer, *Merck to Buy Schering-Plough for $41.1 Billion*, N.Y. TIMES (Mar. 9, 2009), http://www.nytimes.com/2009/03/10/business/10drug.html [https://perma.cc/65KK-A8JY] (noting that increasing cash reserves and declining stock prices for pharmaceutical companies in the 2000s created pressure for acquisitions).

and horizontal mergers and acquisitions of major competitors drive significant consolidation in these fields.

1. Achieving the Benefits of Size

Not surprisingly, the drive to realize the benefits of size frequently motivates mergers and acquisitions. As discussed above, size confers several competitive benefits, from enhancing economies of scale[269] to increasing leverage over suppliers, customers, and rivals. While companies commercializing patented technologies can achieve size through endogenous growth, frequently they accelerate growth through mergers and acquisitions.

In the biopharmaceutical industry, "mergers are often rationalized by claims of economies of scale and scope in R&D and marketing."[270] Notably, the so-called "patent cliff" of recent and upcoming patent expirations and the need to maintain economies of scale have contributed to several mergers and acquisitions.[271] From 2013-2018, global pharmaceutical companies were at risk of losing $200 billion in sales because of patent expirations and generic competition.[272] Considering individual companies, between 2010 and 2012, drugs that accounted for 42% of Pfizer's revenues (including blockbuster Lipitor) went off patent,[273] and the expiration of Bristol-Myers Squibb's patents on Plavix and Avapro caused similar declines.[274] One response to patent expirations is vertical integration wherein pharmaceutical firms have acquired biotechnology firms to shore up their pipelines.[275] Patent

[269] *See* Graeme K. Deans, Fritz Kroeger & Stefan Zeisel, *The Consolidation Curve*, HARV. BUS. REV., Dec. 2002, at 20, 20-21.

[270] Danzon et al., *supra* note 84, at 308; *see also* Gagnon & Volesky, *supra* note 105, at 1.

[271] *See* Comanor & Scherer, *supra* note 90, at 106; Gagnon & Volesky, *supra* note 105, at 5-6; Ashish Kumar Kakkar, Editorial, *Patent Cliff Mitigation Strategies: Giving New Life to Blockbusters*, 25 EXPERT OPINION THERAPEUTIC ON PATENTS. 1353, 1353 (2015); Carmine Ornaghi, *Mergers and Innovation in Big Pharma*, 27 INT'L J. INDUS. ORG. 70, 73 (2009); Jordan Paradise, *A Profile of Bio-Pharma Consolidation Activity*, 25 ANNALS HEALTH L. 34, 38 (2016).

[272] ANNA SON, M&A FOCUS: BIOTECHNOLOGY 2 (2013); *see also* PWC, FROM VISION TO DECISION: PHARMA 2020, at 6 (2020), https://www.pwc.com/gx/en/pharma-life-sciences/pharma2020/assets/pwc-pharma-success-strategies.pdf [https://perma.cc/HJF7-5WWB] [hereinafter PHARMA 2020] (estimating that generics will eliminate $148 billion in pharmaceutical profits from 2012 to 2018).

[273] SON, *supra* note 272, at 2.

[274] *Id.*

[275] *Id.* at 1-2; *see* Matthew J. Higgins & Daniel Rodriguez, *The Outsourcing of R&D Through Acquisitions in the Pharmaceutical Industry*, 80 J. FIN. ECON. 351, 355 (2006); Dan Primack, *No New Drugs? Blame Wall Street*, FORTUNE (Nov. 28, 2011, 7:00 AM

expirations have also driven horizontal acquisitions of large competitors. Impending patent expirations on Lipitor and other key drugs contributed to Pfizer's 2009 acquisition of rival Wyeth.[276] Similarly, expirations on key Merck drugs Fosamax and Singulair contributed to Merck's 2009 acquisition of Schering-Plough.[277] Analysts observe that "[a] major driver of mounting M&A activity is the Patent Cliff that Big Pharma companies have been tiptoeing around since 2011."[278]

Commentators further suggest that one objective of consolidation is to maintain robust sales volumes to support the enormous fixed cost of sales forces and other infrastructure.[279] An empirical study found evidence supporting the hypothesis that for large firms, "mergers are frequently the response to expected excess capacity that is triggered by patent expirations and gaps in the product pipeline which render marketing resources unproductive."[280] Economies of scale can thus be both a benefit and a trap, compelling companies to expand to cover immense fixed costs.

The desire to realize the benefits of size also drives consolidation in other fields of technological commercialization. As noted, agrochemical companies sought to exploit economies of scale by vertically integrating with biotech and seed firms.[281] Turning to horizontal acquisitions between leading competitors, analysts and company representatives have cited economies of scale in connection with Dow's merger with DuPont and Bayer's acquisition of Monsanto.[282] In the software

PST), https://fortune.com/2011/11/28/no-new-drugs-blame-wall-street/ [https://perma.cc/H4L7-2XTB].

276 Andrew Ross Sorkin & Duff Wilson, *Pfizer Agrees to Pay $68 Billion for Rival Drug Maker Wyeth*, N.Y. TIMES (Jan. 25, 2009), http://www.nytimes.com/2009/01/26/business/26drug.html [https://perma.cc/P52N-9X4G]. At the time, Lipitor accounted for 14% of Pfizer's revenue. SON, *supra* note 272, at 2.

277 Singer, *supra* note 268.

278 SON, *supra* note 272, at 2; *see also* Malerba & Orsenigo, *supra* note 76, at 677.

279 *See e.g.*, Danzon et al., *supra* note 84, at 309 (noting that when a patent expires, sales drop and it becomes advantageous to merge with a company with pipeline drugs); Richman et al., *supra* note 92, at 815 ("Treating sales forces as fixed costs . . . is one leading explanation for the steady frequency of acquisitions and the surge of megamergers.").

280 Danzon et al., *supra* note 84, at 325.

281 *See supra* notes 228–233 and accompanying text.

282 *See* Emma Cowan, *DowDuPont Kicks Off the Race to Consolidation with Lackluster Response*, AGFUNDERNEWS (Dec. 15, 2015), https://agfundernews.com/dowdupont-kicks-off-the-race-to-consolidation-with-lacklustre-investor-response5163.html [https://perma.cc/578M-SMK2]; Julie Deering, *Bayer: Farmers to Benefit from Economies*

industry, acquisitions frequently seek to exploit economies of scale.[283] Such scale economies helped justify Oracle's acquisition of PeopleSoft and Symantec's acquisition of Veritas.[284] On a related note, a leading motivation for mergers and acquisitions in the software industry is to increase a company's user base.[285] Google's acquisition of analytics firm Looker was motivated in part by a desire to sell Google's services to Looker's customers.[286] Similarly, Salesforce's acquisition of integration software firm MuleSoft provided greater access to MuleSoft's clients.[287] Microsoft acquired LinkedIn in significant part because of the latter's extensive subscriber community and valuable brand.[288] Mergers and acquisitions confer multiple benefits of size, including economies of scale and an expanded consumer base.

2. Obtaining Innovation and Aggregating Complementary Capabilities

An important motivation for mergers and acquisitions — particularly in technological industries — is to obtain outside innovations and aggregate complementary capabilities. While technology companies conduct internal research and development, in many cases it is more efficient to source innovation externally. Furthermore, beyond acquiring outside innovations, companies often acquire other firms to enhance their innovative *capacity*, namely their ability to generate technologies going forward. Notable in this regard, numerous companies in high-technology fields acquire other companies simply to obtain talented employees — so-called "acqui-hires"[289] — or to obtain a combination of those companies' employees and promising

of Scale, SEED WORLD (Mar. 1, 2018), https://seedworld.com/bayer-farmers-benefit-economies-scale/ [https://perma.cc/54HT-9X6N].

283 BUXMANN ET AL., *supra* note 251, at 65.

284 *Id.*

285 Schief et al., *supra* note 235, at 422.

286 Ron Miller, *Google to Acquire Analytics Startup Looker for $2.6 Billion*, TECHCRUNCH (June 6, 2019, 6:35 AM PDT), https://techcrunch.com/2019/06/06/google-to-acquire-analytics-startup-looker-for-2-6-billion/ [https://perma.cc/HRX7-EC53] [hereinafter *Looker*].

287 Ron Miller, *Salesforce is Buying MuleSoft at Enterprise Value of $6.5 Billion*, TECHCRUNCH (Mar. 20, 2018, 2:10 PM PDT), https://techcrunch.com/2018/03/20/salesforce-is-buying-mulesoft-at-enterprise-value-of-6-5-billion/ [https://perma.cc/V87W-PKYK] [hereinafter *MuleSoft*].

288 *See* James B. Stewart, *Microsoft-LinkedIn Deal Ignites Twitter Speculation*, N.Y. TIMES (June 16, 2016), https://www.nytimes.com/2016/06/17/business/microsoft-linkedin-deal-ignites-twitter-speculation.html [https://perma.cc/7PUJ-G8ZH].

289 John F. Coyle & Gregg D. Polsky, *Acqui-hiring*, 63 DUKE L.J. 281, 283-84 (2013).

technologies.[290] Acquisitions of external innovations and innovative capacity may be particularly valuable when they allow the acquirer to bundle together complementary capabilities. Such acquisitions can take the form of vertical integration through acquiring other entities in the value chain, concentric acquisition of firms in complementary fields, or horizontal acquisition of direct competitors.

In the biopharmaceutical industry, declining scientific productivity and the need to bolster drug pipelines with outside innovations have motivated numerous mergers and acquisitions. For several decades, the pharmaceutical industry's output and efficiency has decreased.[291] Given the paucity of new innovations, companies have turned to mergers and acquisitions to replenish faltering pipelines. Biotech firms are particularly promising sources of new drugs,[292] and large pharmaceutical companies have vertically integrated by bringing such firms in-house.[293] Such vertical integration combines two sets of complementary capabilities: biotech firms' expertise in research and development and pharmaceutical firms' strengths in bringing drugs to market. Additionally, large pharmaceutical companies have acquired innovation via horizontal acquisitions of competitors. For example, in the 1990s and early 2000s, Pfizer acquired Warner-Lambert and Pharmacia largely to obtain Lipitor and Celebrex, respectively.[294] Similarly, Merck's 2009 acquisition of rival drug maker Schering-Plough was motivated to obtain the latter's lucrative Nasonex allergy spray and pipeline of promising biologics.[295] Bristol-Myers Squibb's 2019 acquisition of Celgene was motivated to obtain Celgene's

[290] Lee, *Innovation*, *supra* note 37, at 1449.

[291] Jack W. Scannell, Alex Blanckley, Helen Boldon & Brian Warrington, Opinion, *Diagnosing the Decline in Pharmaceutical R&D Efficiency*, 11 NATURE REVIEWS DRUG DISCOVERY 191, 191 (2012); *see also* PWC, PHARMA 2020, *supra* note 272, at 5; Comanor & Scherer, *supra* note 90, at 106; Pammolli et al., *supra* note 259, at 428 (reporting empirical evidence of "a long-term decline in the productivity of research and development (R&D)"). *But see* Cockburn, *supra* note 77, at 10-11 (observing that the quality of NMEs may be increasing over time, thus suggesting a higher degree of innovation than low numbers suggest).

[292] *See* Shepherd, *supra* note 83, at 16 (noting that about two thirds of all NMEs originate from biotech firms and small pharmaceutical companies).

[293] Lee, *Innovation*, *supra* note 37, at 1457-59.

[294] Richman et al., *supra* note 92, at 812-13; *see* Robert Frank & Scott Hensley, *Pfizer to Buy Pharmacia for $60 Billion in Stock*, WALL ST. J., https://www.wsj.com/articles/SB1026684057282753560 (last updated July 15, 2002, 11:59 PM EST) [https://perma.cc/P4HG-2TWJ].

[295] *See* Singer, *supra* note 268.

complementary product portfolio and robust drug pipeline.[296] Beyond acquiring actual products in development, companies also acquire firms for their patent portfolios, which accelerates innovation.[297]

A similar drive to acquire innovation and complementary assets also motivates mergers and acquisitions in agricultural biotechnology. As noted, large agrochemical companies like Monsanto have combined complementary capabilities by vertically integrating with numerous agricultural biotech firms[298] and seed companies.[299] Empirical analysis of a wave of consolidation in the 1990s found evidence that such restructuring was "causally driven by the attempt of firms to achieve coordination between complementary intellectual assets in the face of the difficulties or transaction costs of accessing these assets externally."[300] Additionally, industry incumbents have obtained innovation by acquiring large competitors. The latest blockbuster deal is Bayer's acquisition of Monsanto, which created the current Big Four. In addition to expanding economies of scale, Bayer sought to combine its strengths in crop chemicals with Monsanto's industry-leading portfolio of patented genetically modified seeds.[301] In this fashion, the drive to obtain outside innovations has fueled both vertical and horizontal integration.[302]

Software companies routinely acquire other firms to obtain innovations and expand innovative capacity. In some cases, incumbents are primarily interested in acquiring firms for their employees; acqui-hires are particularly prevalent for obtaining talented software engineers.[303] In many cases, however, incumbents are meaningfully

[296] *See Bristol-Myers Squibb to Acquire Celgene to Create a Premier Innovative Biopharma Company*, BRISTOL MYERS SQUIBB (Jan. 3, 2019, 6:58 AM EST), https://news.bms.com/press-release/corporatefinancial-news/bristol-myers-squibb-acquire-celgene-create-premier-innovative [https://perma.cc/QT63-SPSH].

[297] *See* Parchomovsky & Wagner, *supra* note 165, at 33, 38-39.

[298] Lee, *Innovation*, *supra* note 37, at 1467-69; *see* Oehmke & Naseem, *supra* note 18, at 21.

[299] *See* BARKER ET AL., *supra* note 173, at 5.

[300] Graff et al., *supra* note 66, at 362.

[301] *See* Joseph Marks, *Monsanto's IP Assets Make Attractive Target for Bayer*, 92 PAT. TRADEMARK & COPYRIGHT J. 249, 249 (2016); Greg Roumeliotis & Ludwig Burger, *Bayer to Buy Monsanto, Creating a Massive Seeds and Pesticides Company*, SCI. AM. (Sept. 14, 2016), https://www.scientificamerican.com/section/reuters/bayer-to-buy-monsanto-creating-a-massive-seeds-and-pesticides-company/ [https://perma.cc/9ZCG-9QZK].

[302] *See generally* Graff et al., *supra* note 66, at 362 (discussing how the coordination of R&D with M&A strategies leads to an "assembly of the large and diverse arrays of IP needed to pursue biotechnology-based approaches to complex agricultural product development").

[303] Coyle & Polsky, *supra* note 289, at 283.

interested in outside firms' technologies (perhaps in addition to their human capital).[304] Incumbents struggle to sustain market leadership over innovative startups, and "corporate takeovers can be considered a source of innovation."[305] In 2018, the volume of mergers and acquisitions in the global enterprise software segment hit a five-year high with 1,241 deals.[306] While this total includes numerous types of transactions and participants,[307] large incumbents such as Microsoft, Oracle, Salesforce.com, Adobe, and SAP were particularly active.[308] Many of these deals involved incumbents acquiring outside innovations,[309] punctuated by IBM's blockbuster $34 billion acquisition of Red Hat to ramp up its cloud computing business — the largest software acquisition ever.[310] Similarly, Salesforce (which has engaged in numerous acquisitions) recently acquired data visualization firm Tableau[311] and integration software company MuleSoft to expand its capabilities.[312] More generally, many information technology ("IT") and business services companies seeking to develop capabilities in big data analytics, cloud computing, and the Internet of things, "are taking a 'buy' rather than 'build' approach, purchasing companies and their expertise."[313]

A consistent theme among software transactions is incumbents aggregating complementary technologies to expand product offerings and increase revenues from customers.[314] For example, Google justified acquiring analytics startup Looker by noting that "[t]he combination provides an end-to-end analytics platform to connect, collect, analyze

304 Lee, *Innovation*, supra note 37, at 1473.

305 Schief et al., *supra* note 235, at 422.

306 Loten, *supra* note 8.

307 For instance, private equity firms and non-software firms were active acquirers of software companies.

308 Loten, *supra* note 8.

309 In 2018, about 15% of all strategic deals over $1 billion involved acquisitions to acquire new capabilities. BAIN & CO., M&A IN DISRUPTION: 2018 IN REVIEW 12 (2019).

310 Eric J. Savitz, *IBM Completes Red Hat Deal — The Largest Software Acquisition Ever*, BARRON'S (July 9, 2019, 3:28 PM ET), https://www.barrons.com/articles/ibm-completes-red-hat-deal-the-largest-software-acquisition-ever-51562700501 [https://perma.cc/DP7U-WEPX].

311 Ron Miller, *Salesforce closes $15.7B Tableau deal*, TECHCRUNCH (Aug. 1, 2019, 6:44 AM PDT), https://techcrunch.com/2019/08/01/salesforce-closes-15-7b-tableau-deal/ [https://perma.cc/5BBN-Q4RK].

312 Miller, *MuleSoft*, *supra* note 287.

313 HAMPLETON, IT & BUSINESS SERVICES M&A OVERVIEW 1H 2019, at 1 (2019).

314 *See id.* at 1, 9. *See generally* BUXMANN ET AL., *supra* note 251, at 66 (noting that there are three strategic motivations for M&A: market motivations, performance motivations, and risk motivations).

and visualize data across" numerous platforms.[315] Similarly, Broadcom announced that its acquisition of CA Technologies would help round out its portfolio of services,[316] and a similar justification drove Oracle's acquisition of Siebel.[317] While it is not clear if such acquisitions are strictly vertical in nature, they combine complementary assets under one corporate roof. One commentator notes that most leading standalone applications "will eventually be sucked into integrated suites of software, which are easier to manage and prevent the build-up of data silos within big organisations."[318] In sum, synergies through combining complementary product offerings have contributed to software industry consolidation.

While incumbents seek the innovations of smaller companies, such companies, especially startups, often welcome acquisition by a larger entity. Many startup founders and venture capital investors seek the monetary rewards of an "exit" through acquisition by an established industry player.[319] Startups also value the ability to exploit the resources of a large incumbent to bring their innovations to scale. As illustrated in SAP's acquisition of Qualtrics, "[b]ig software companies with huge sales organisations can greatly accelerate the growth of promising new services."[320] The CEO of analytics startup Looker expressed similar sentiments upon Google's acquisition of the company, noting that Looker would have much greater reach through integration into Google Cloud.[321]

315 Miller, *Looker*, *supra* note 286.

316 Press Release, Broadcom, Broadcom Inc. Completes Acquisition of CA Techs. (Nov. 5, 2018), https://www.broadcom.com/company/news/financial-releases/2375294 [https://perma.cc/2PRL-E6GT]; *see also* Frederic Lardinois, *Broadcom Acquires CA Technologies for $18.9B in Cash*, TECHCRUNCH (July 11, 2018, 3:49 PM PDT), https://techcrunch.com/2018/07/11/broadcom-acquires-ca-technologies-for-18-9b-in-cash/ [https://perma.cc/FW5X-2HYZ] ("Broadcom is clearly trying to diversify its offerings.").

317 *See* BUXMANN ET AL., *supra* note 251, at 69.

318 Richard Waters, *Consolidation Ahead for Business Software Start-ups*, FIN. TIMES (Nov. 29, 2018), https://www.ft.com/content/e7c0c4e8-f3e9-11e8-ae55-df4bf40f9d0d [https://perma.cc/2WGP-YQWP].

319 Brian Broughman & Jesse M. Fried, *Carrots and Sticks: How VCs Induce Entrepreneurial Teams to Sell Startups*, 98 CORNELL L. REV. 1319, 1322 (2013) (observing that acquisition is a more frequent "exit" event than an initial public offering for venture capital-based startups); *see id.* at 1325 (implying that venture capitalists often try to coordinate sales of portfolio companies to larger players).

320 Waters, *supra* note 318.

321 Miller, *Looker*, *supra* note 286.

3. Cutting Costs

Firms commercializing patented technologies also engage in mergers and acquisitions to cut costs and increase efficiency. This has been particularly pertinent to the biopharmaceutical and agricultural biotechnology industries. In biopharmaceuticals, "cost synergies" based on eliminating overlapping research, development, marketing, and sales infrastructure have driven mergers and acquisitions.[322] Consolidation deals were prevalent in the mid- to late-1990s, when, for example, Pfizer's acquisition of Warner-Lambert and merger with Wyeth significantly reduced costs.[323]

More recently, Bristol-Myers Squibb cited $2.5 billion in cost synergies to justify its acquisition of Celgene.[324] Additionally, GlaxoSmithKline and Pfizer have recently created a joint venture combining their consumer health divisions with the aim of eliminating $650 million in costs.[325] In generic drug segments, many mergers and acquisitions — which have increased significantly — are motivated by cost-cutting efficiencies.[326] In agricultural biotechnology, anticipated cost savings of $3.6 billion helped justify Dow and DuPont's merger.[327] Additionally, Bayer originally forecast $1.5 billion in cost savings upon acquiring Monsanto.[328] Reducing redundancy and streamlining operations are powerful motivations for mergers and acquisitions.

4. Eliminating Competition

In several patent-intensive industries, companies engage in mergers and acquisitions in substantial part to eliminate competition.[329] In the

322 *See* Danzon et al., *supra* note 84, at 309; Shepherd, *supra* note 83, at 4.

323 Cha & Lorriman, *supra* note 83.

324 *See* Bristol-Myers Squibb, *supra* note 296.

325 Allison Gatlin, *Glaxo Stock Pops on Pfizer Deal to Merge Consumer Health Units*, INV'RS BUS. DAILY (Dec. 19, 2018, 4:22 PM ET), https://www.investors.com/news/technology/glaxo-pfizer-consumer-health/ [https://perma.cc/N9LB-WHUJ].

326 Gagnon & Volesky, *supra* note 105, at 2.

327 *See* Al Root, *DowDuPont Delivers, With Earnings and Reassurance*, BARRON'S (Nov. 1, 2018, 2:40 PM ET), https://www.barrons.com/articles/dowdupont-delivers-with-earnings-and-reassurance-1541097644 [https://perma.cc/L942-KCKP].

328 Dede Williams, *Bayer Cuts Forecast for Monsanto Cost Savings*, CHEMANAGER (May 28, 2018) https://www.chemanager-online.com/en/news-opinions/headlines/bayer-cuts-forecast-monsanto-cost-savings [https://perma.cc/JZM6-PC5J].

329 *See* Porter, *The Five Competitive Forces*, *supra* note 23, at 35 (describing acquisitions to eliminate competition but cautioning that they can backfire); *cf.* Spencer Weber Waller & Matthew Sag, *Promoting Innovation*, 100 IOWA L. REV. 2223, 2224 (2015) ("Modern businesses are well aware of the threat of disruptive outsiders and,

biopharmaceutical industry, scholars estimate that 5.3-7.4% of acquisitions are "killer acquisitions" wherein established companies obtain innovative competitors and then discontinue their projects.[330] For example, Questcor, which enjoyed a monopoly in adrenocorticotropic hormone drugs, purchased the U.S. development rights for the competing drug Synacthen Depot from Novartis, then terminated its development.[331] In agricultural biotechnology, the transformation of agrochemical companies into huge seed companies "was not a result of outcompeting more established seed firms, but by acquiring them."[332] The notion of buying one's adversaries also applies to legal disputes, as illustrated in litigation between Agracetus and Monsanto over Agracetus's soybean patent.[333] In accusing Monsanto of infringement, Agracetus advanced a broad construction of a key claim that would have conferred exclusive rights over all transgenic soybeans, regardless of the genes inserted in the germplasm.[334] Monsanto initially challenged Agracetus's patent but then resolved the dispute by simply acquiring Agracetus for $150 million.[335] Departing from its prior legal arguments, Monsanto then vigorously asserted its newly acquired patent against other industry players.[336]

Turning to the software industry, the FTC recently ordered Microsoft, along with Alphabet (including Google), Amazon.com, Apple, and Facebook, to provide information about acquisitions falling below the threshold for automatic reporting to antitrust authorities.[337] In reviewing this information for possible anticompetitive effects, the FTC expressed concern that large technological companies, including

left unchecked, will do their utmost to prevent future waves of creative destruction from threatening the status quo.").

330 Colleen Cunningham, Florian Ederer & Song Ma, Killer Acquisitions 6 (Sept. 12, 2018, last revised Apr. 22, 2020) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3241707 [https://perma.cc/4U8K-P9AE]; *see also* ORG. FOR ECON. CO-OPERATION AND DEV., START-UPS, KILLER ACQUISITIONS AND MERGER CONTROL – NOTE BY BEUC 9 (June 4, 2020), http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DAF/COMP/WD(2020)30&docLanguage=En [https://perma.cc/92MW-YJDX].

331 Cunningham, *supra* note 330, at 1.

332 Howard, *supra* note 119, at 2490.

333 *Id.*

334 *Id.*

335 *Id.*

336 *See id.*

337 Press Release, Fed. Trade Comm'n, FTC to Examine Past Acquisitions by Large Technology Companies (Feb. 11, 2020, 1:00 PM ET), https://www.ftc.gov/news-events/press-releases/2020/02/ftc-examine-past-acquisitions-large-technology-companies [https://perma.cc/6G8U-LR6E].

Microsoft, were engaged in killer acquisitions by buying nascent competitors.[338] Furthermore, the structure of venture capital financing, which impacts several innovative fields but especially software, also promotes killer acquisitions. When venture capitalists fund startups, they often seek an "exit" involving the sale of those startups to an industry incumbent, which frequently terminates the startups' projects.[339] Venture capital financing may thus sow the seeds for greater industry consolidation.

5. Responding to Other Acquisitions

Consolidation begets consolidation. A historical analysis of mergers and acquisitions "reveals that they often occur in waves and concentrate on specific sectors within these waves."[340] "Merger mania" has appeared in the biopharmaceutical industry, where Pfizer's takeover of Wyeth in 2009 began the "consolidation race" that prompted Merck to acquire Schering-Plough and Roche to acquire Genentech.[341] In agricultural biotechnology, Monsanto has justified numerous mergers and acquisitions as responses to similar activity by its competitors.[342] In reciprocal fashion, large seed companies have reacted to industry consolidation by engaging in defensive acquisitions to increase their size and ensure independence.[343] Mergers and acquisitions tend to occur in batches. From 2016-2017, the industry experienced a spate of proposed and completed mega mergers between ChemChina and Syngenta, Dow and DuPont, and Bayer and Monsanto.[344]

Waves of acquisitions also occur in the software industry, which in recent history has experienced more mergers and acquisitions than any

[338] Cecilia Kang & David McCabe, *F.T.C. Broadens Review of Tech Giants, Homing in on Their Deals*, N.Y. TIMES (Feb. 11, 2020), https://www.nytimes.com/2020/02/11/technology/ftc-tech-giants-acquisitions.html [https://perma.cc/9RFQ-3H5J].

[339] Mark A. Lemley & Andrew McCreary, Exit Strategy 5, 7 (Jan. 30, 2020) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3506919 [https://perma.cc/T7QL-A9AT].

[340] Schief et al., *supra* note 235, at 421.

[341] Singer, *supra* note 268; *see also* Erman & Banerjee, *supra* note 2.

[342] Begemann, *supra* note 120, at 122.

[343] Howard, *supra* note 119, at 2493 (describing how French conglomerate Groupe Limagrain and its seed subsidiary, Vilmorin, have acquired other seed companies in response to outside threats).

[344] Bartholomew D. Sullivan, *Mega-Mergers in Agribusiness Raise Concerns About Food Costs, Biodiversity*, USA TODAY (Aug. 29, 2017, 11:28 AM ET), https://www.usatoday.com/story/news/politics/2017/08/29/mega-mergers-agribusiness-raise-concerns-food-costs-biodiversity/558980001/ [https://perma.cc/66V7-BEGG].

other industry in the United States and Europe.[345] Firms have strong incentives to be on the leading edge of an acquisition frenzy, as they can "enlarge their customer base and establish market power through network effects."[346] This incentive increases the probability of acquisitions sparking other acquisitions, and it enhances the intensity of transactional cascades.[347] Empirical studies indicate that large players are driving waves of consolidation in the software industry.[348]

IV. FRAGMENTATION DRIVERS IN TECHNOLOGICAL COMMERCIALIZATION

Given the strength of concentration drivers, one might wonder why industry segments that commercialize patented technologies are not even more consolidated than they are. However, several factors push in the opposite direction. To provide a more holistic account of structural forces, this Part explores several "fragmentation drivers" operating in these and other fields. It reveals that entry based on technological advances, specialization and focus, and antitrust enforcement all push to increase the number of industry participants, thus countering concentration.

A. Entry Based on Technological Advancement

New entry represents the primary mechanism for increasing the number of firms participating in technological commercialization. This subpart explores an important catalyst for new entry: technological advancement.[349] Product or process innovations can negate the efficiencies of size and experience that favor incumbents and create new opportunities for entry.[350] Of course, it bears emphasizing that new entrants often immediately try to raise barriers to entry against others, thus closing the door to potential competitors. Nevertheless, technological advances are an important driver of industry entry and fragmentation.

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345 Schief et al., *supra* note 235, at 421.

346 *Id.* at 429.

347 *Cf.* BUXMANN ET AL., *supra* note 251, at 69 (discussing how M&A activity can force other companies to make their own acquisitions).

348 *Id.*

349 *See* Porter, *The Five Competitive Forces*, *supra* note 23, at 34-35; Scott Shane, *Technology Regimes and New Firm Formation*, 47 MGMT. SCI. 1173, 1174 (2001).

350 Porter, *How Competitive Forces*, *supra* note 162, at 139.

Technological advances have been critical to forming — and creating ongoing entry opportunities in — all of the industries profiled here.[351] The development of recombinant DNA technology in the 1970s spawned the biotechnology industry and enabled the formation and entry of companies like Genentech to exploit it.[352] Biotechnology has given rise to a sprawling list of technologies — from monoclonal antibodies to recombinant proteins to vaccines — that have created new markets.[353] More recently, advances such as CAR T-cell therapy, which is a form of immunotherapy involving a patient's own blood, and CRISPR/Cas9, a gene editing technology,[354] have created new entry opportunities. Turning to agriculture, the advent of recombinant DNA technology also gave rise to agricultural biotechnology and the entry of both startups and large incumbents from the chemicals industry to exploit it. Earlier scientific advances such as hybridization also facilitated market entry, and over its history, "[e]ach scientific breakthrough drove a wave of private investments in the seed and biotech industry."[355] More recent developments, such as CRISPR/Cas9 and the development of methods to enhance the efficiency of photosynthesis,[356] promise new opportunities for entry.

The role of technology in spurring entry and fragmentation is perhaps best illustrated by the software industry. IBM's technical decision in 1968 to unbundle software from hardware significantly boosted the independent software industry.[357] The introduction of personal computers in the mid-1970s[358] was another technical advance that

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[351] *See generally* Robin Gustafsson, Mikko Jääskeläinen, Markku Maula & Juha Uotila, *Emergence of Industries: A Review and Future Directions*, 18 INT'L J. MGMT. REVIEWS 28, 30 (2015) (describing how technological development has supported the emergence of new companies in a variety of industries).

[352] *See* Sally Smith Hughes, *Making Dollars Out of DNA: The First Major Patent in Biotechnology and the Commercialization of Molecular Biology, 1974-1980*, 92 ISIS 541, 541-42 (2001).

[353] *See* Lisa Sapp & Ning Tang, *Overcoming Challenges in Biopharma: Transformational Innovation is Key*, TECH. NETWORKS (Jan. 7, 2019), https://www.technologynetworks.com/biopharma/articles/overcoming-challenges-in-biopharma-transformational-innovation-is-key-313526 [https://perma.cc/UU5S-3NW7].

[354] *Id.*

[355] Schenkelaars et al., *supra* note 67, at 5.

[356] Paul F. South, Amanda P. Cavanagh, Helen W. Liu & Donald R. Ort, *Synthetic Glycolate Metabolism Pathways Stimulate Crop Growth and Productivity in the Field*, 363 SCIENCE 45 (2019); Benjamin Ryan, *To Feed a Hot Planet, They're Making More Efficient Plants*, N.Y. TIMES (Sept. 21, 2019), https://www.nytimes.com/2019/09/21/climate/australia-climate-crops.html [https://perma.cc/J7D4-W3QL].

[357] SLAUGHTER, *supra* note 133, at 62; Mann, *supra* note 53, at 968.

[358] Mann, *supra* note 53, at 968.

expanded the industry.[359] Several thousand new software companies entered the field between 1975-1981, after which the industry reconsolidated.[360] The emergence of the Internet in the 1990s again transformed the industry[361] and created new entry opportunities. More recent advances have produced new segments such as security and software-as-a-service, which have enabled entry by companies like Symantec,[362] Salesforce.com,[363] and a large number of startups.

In this regard, patents, which encourage technological advance, can serve as an important fragmentation driver.[364] As mentioned, patents are particularly important to startups, and some have argued that patents promote fragmentation in the software industry.[365] It is important to note, however, that technological advances do not need to be patented (or subject to the full exclusivity of patents) to foster industry formation and entry. In some contexts, moreover, patents can hinder the ability of new technological advances to foster industry expansion. In biotechnology, foundational recombinant DNA technology was patented by Stanford University, but the university widely licensed the patents to research institutions and charged a relatively low price for commercial licenses.[366] Historical analysis shows that patents were not critical to the initial diffusion and commercial exploitation of biotechnology.[367] In this case, while a patented technology facilitated industry formation and entry (much of it upstream), patents were not necessary to encourage the original invention, and the *absence* of full patent assertion promoted its dissemination. In agriculture, publicly sponsored research on hybridization that was not immediately subject to exclusive rights helped spur private investment and industry expansion.[368] In the software industry, open source software, which stands at odds to the traditional exclusivity inherent in patents, has enabled robust market

359 Allison et al., *supra* note 137, at 1587; Campbell-Kelly & Garcia-Swartz, *supra* note 135, at 736; *see* Mann, *supra* note 53, at 968 (discussing the rise of companies that developed software for personal computers).

360 Campbell-Kelly, *supra* note 134, at 94.

361 *See* Campbell-Kelly & Garcia-Swartz, *supra* note 135, at 735 (identifying the advent of the commercial Internet in 1994).

362 *Id.* at 750.

363 *Id.* at 753.

364 *See* Shane, *supra* note 349, at 1185 (noting that firm formation is more likely in lines of businesses where patents are more effective).

365 *See supra* notes 52–55 and accompanying text.

366 Hughes, *supra* note 352, at 569-70.

367 *Id.* at 571.

368 Schenkelaars et al., *supra* note 67, at 5.

entry.[369] Furthermore, a case study of the encryption software industry indicates that the industry arose twenty years after patents were granted on its core technologies, which suggests that patents were not necessary to industry formation.[370] While technology helps drive industry expansion and entry, the precise role of patents in this process varies by context.

Additionally, it is important to note that much technology-based new entry occurs in the upstream regions of value chains focused on R&D instead of downstream regions focused on product commercialization. In biopharmaceuticals, biotechnology has led to significant entry by upstream, research-intensive biotech firms. While some of these firms have integrated downward to commercialize drugs, many of them either license outputs to larger firms for commercialization or have been acquired by those larger firms. Similarly, the emergence of biotechnology spawned the entry of numerous upstream, research-intensive agricultural biotechnology firms — many of them university spinoffs. However, large conglomerates have vertically integrated to acquire a substantial number of these firms. In the software industry, technological advances often fuel entry by innovative startups, which are then acquired by large incumbents. It is likely that more recent technological advances will disproportionately spur entry in upstream fields, where small firms will either license technologies to large firms or be acquired by them. While technological advances remain an important vehicle for new industry entry, their fragmenting effects in downstream segments focusing on commercialization are somewhat attenuated.

B. Specialization and Divestures

In addition to new entry, the other primary mechanism for enhancing the number of participants in an industry is to split existing players. Such fragmentation may arise to realize the benefits of specialization and more rationally allocate capital.[371] As predicted by the theory of the firm, management costs of large bureaucracies can grow very high,[372] and firms may expand into areas in which they lack expertise. To

[369] *See* Mike Volpi, *How Open-Source Software Took over the World*, TECHCRUNCH (Jan. 12, 2019, 9:00 AM PST), https://techcrunch.com/2019/01/12/how-open-source-software-took-over-the-world/ [https://perma.cc/ADF2-Y3QB].

[370] *See* Marco S. Giarratana, *The Birth of a New Industry: Entry by Start-ups and the Drivers of Firm Growth: The Case of Encryption Software*, 33 RES. POL'Y 787, 791 (2004).

[371] *See* Gomes-Casseres, *supra* note 82 ("It seems clear that focus is in, and diversification is out.").

[372] *See supra* notes 49–51 and accompanying text.

remedy such lack of focus, firms sometimes strategically divest particular units. It is important to add a caveat that while such splits increase the number of companies, they do not necessarily enhance fragmentation in particular markets. Typically, large conglomerates split off companies in different markets to enhance specialization rather than create two entities that compete directly against each other. That caveat notwithstanding, it is important to consider the impact of such splits — and the more general value of specialization — on industry structure.

Strategic divestures have increased the number of players in the biopharmaceutical industry. Reflecting diminishing returns to scale, companies with revenues of $35 billion or more significantly underperform companies with annual revenues of $5-35 billion in total shareholder returns.[373] Sleeker, more focused companies that lead their respective product categories often dominate conglomerates with diversified portfolios containing few category leaders and numerous "follower" products.[374] While large, diversified companies predominated throughout the 1990s and 2000s, companies have since embraced a "leaner and focused" model by divesting non-core assets and concentrating on strengths.[375] This drive to improve focus has led to "divestures, spin-offs, and swaps," such as Novartis' sale of its influenza-vaccine business to biotech company CSL, Bristol-Myers Squibb's sale of its diabetes division to AstraZeneca, and Biogen's spinoff of its hemophilia business.[376] Of course, merely selling a unit to an existing competitor does not increase the number of industry players, but divestures and spin-offs can enhance fragmentation. For example, in 2013, Abbott Laboratories split into separate medical products and pharmaceutical companies.[377] Similarly, in 2015, diversified healthcare

[373] Jeff Haxer, Andy Pasternak, Dave Fleisch & Todd Sangster, *Focus Matters: How Biopharma Can Reward Shareholders*, BAIN & CO. 1 (2016), https://www.bain.com/contentassets/eef4610eb8c24a3cac3f7ccfd218f2ab/bain_brief_focus_matters_how_biopharma_can_reward_shareholders.pdf [https://perma.cc/S7BP-Y4AE]; *see id.* at 3 ("As biopharma companies reach a certain size, countervailing forces begin to undercut the advantages of scale.").

[374] *Id.* at 1.

[375] Gautam & Pan, *supra* note 195, at 379-80; *see* Davidovic, *supra* note 83.

[376] Haxer et al., *supra* note 373, at 4.

[377] Noelle Knox, *Abbott CFO: How and Why to Spin Off*, WALL ST. J. (May 29, 2014, 10:50 PM PT) (on file with the UC Davis Law Review).

company Baxter spun off its global biopharmaceutical business as Baxalta.[378]

Corporate reorganization has also produced splits in the agricultural biotechnology, seed, and agrochemical industry. Here as well, however, splits to achieve specialization typically do not create new competitors in the same market. As noted, former industry leaders Dow and DuPont merged in 2017.[379] Rather than operate as a single merged entity, the combination will split into three separate companies: Corteva Agriscience (the agriculture division), Dow (the materials science division), and DuPont (the specialty products division).[380] In an odd sort of math, the Dow-Dupont merger will combine two companies to create three companies, but the number of companies competing in the agricultural industry will decrease by one.

Specialization and restructuring have also caused fragmentation between the medical and agricultural biotechnology industries. In the late 1990s, a drive to spread the risks and rewards of biotechnology contributed to large-scale consolidation of medical biotechnology, pharmaceuticals, agricultural biotechnology, and seeds in diversified "life sciences" companies.[381] However, these combinations were short-lived. Large agrochemical companies like BASF, Dow, DuPont, and Monsanto exited the biopharma business,[382] and large life sciences companies engaged in a spate of divestures and separated their medical and agricultural divisions.[383] Rather than proceed as integrated life science companies, these entities decided to pursue specialization as separate companies. While these splits did not create direct market competitors, they do reflect a kind of industrial fragmentation.

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[378] *Baxalta Spins Off from Baxter*, GENETIC ENG'G & BIOTECHNOLOGY NEWS (July 1, 2015), https://www.genengnews.com/news/baxalta-spins-off-from-baxter/ [https://perma.cc/R47P-W5PV].

[379] *See supra* note 4.

[380] Press Release, DowDuPont, DowDuPont Announces Brand Names for the Three Independent Companies It Intends to Create, Reflecting Ongoing Progress Towards Separations (Feb. 26, 2018), https://www.investors.dupont.com/news-and-media/press-release-details/2018/DowDuPont-Announces-Brand-Names-for-the-Three-Independent-Companies-It-Intends-to-Create-Reflecting-Ongoing-Progress-towards-Separations/default.aspx [https://perma.cc/87J6-KQXN].

[381] KING, *supra* note 179, at 1.

[382] Davidovic, *supra* note 83.

[383] KING, *supra* note 179, at 1; Fulton & Giannakas, *supra* note 222, at 141; Jorge Fernandez-Cornejo & David Schimmelpfennig, *Have Seed Industry Changes Affected Research Effort?*, AMBER WAVES (Feb. 1, 2004), https://www.ers.usda.gov/amber-waves/2004/february/have-seed-industry-changes-affected-research-effort/ [https://perma.cc/2V2A-MRF4].

C. Antitrust Enforcement

Antitrust enforcement represents a significant fragmentation driver in fields commercializing patented technologies. In general, economists have speculated that lax enforcement of antitrust laws has contributed to higher barriers to entry and greater industry concentration.[384] It bears emphasizing that while this Article has primarily explored forces shaping *industries*, antitrust analysis focuses on *markets*, which are defined by substitutable goods and are generally much narrower than industries. Particularly relevant for present purposes is Section 7 of the Clayton Act, which prohibits acquisitions of assets or securities if "the effect of such acquisition may be substantially to lessen competition, or to tend to create a monopoly."[385] Enforcement actions under the Clayton Act can bar or impose conditions on proposed mergers and acquisitions, such as requiring the merging parties to divest some line of business to an existing competitor.[386] Notably, while such divestures do not increase the number of players in an industry, they increase or preserve the number of participants in a market. Although a comprehensive treatment of antitrust enforcement lies beyond the scope of this Article, such enforcement has prevented greater consolidation in biopharmaceuticals, agricultural biotechnology, and software.

In biopharmaceuticals, antitrust enforcement has pushed against industry consolidation.[387] Focusing first on merger enforcement, several high-profile mergers and acquisitions have attracted antitrust scrutiny, such as Pfizer's acquisition of Wyeth,[388] Merck's acquisition of Schering-Plough,[389] and Ciba-Geigy's merger with Sandoz to create Novartis.[390] The FTC lists fifty-four enforcement actions involving horizontal mergers between direct competitors in the pharmaceutical

384 Grullon et al., *supra* note 9, at 734.

385 15 U.S.C. § 18 (2018).

386 *See id.* § 26 (2018); California v. Am. Stores Co., 495 U.S. 271, 275-76, 296 (1990) (holding that divesture is a "form of injunctive relief" under the enforcement provisions of the Clayton Act).

387 *See, e.g.*, Paradise, *supra* note 271, at 44-57 (profiling several antitrust actions).

388 *In re* Pfizer, Inc., No. C-4267, at 1 (Fed. Trade Comm'n Jan. 25, 2010), https://www.ftc.gov/sites/default/files/documents/cases/2010/01/100129pwyethdo.pdf [https://perma.cc/C88T-V679].

389 Comanor & Scherer, *supra* note 90, at 107.

390 Rai, *supra* note 78, at 851.

industry between 1994-2018.[391] Interestingly, the FTC brought most of these enforcement actions against generic companies.[392] However, in several cases the FTC targeted mergers involving brand companies. For example, in 2010, the FTC considered Novartis's $28.1 billion acquisition of Alcon. Both companies competed in the market for a drug used in cataract surgery, and the FTC required Novartis to divest its rights in that drug to Bausch & Lomb, an eye-health company that did not compete in that U.S. drug market.[393] In similar fashion, in 2007, the FTC conditioned Johnson & Johnson's acquisition of Pfizer's Consumer Healthcare business on divesting four drug assets to other industry players.[394] This remedy of forcing merging parties to divest assets is common in enforcement actions,[395] and it preserves the number of competitors in a market. Other kinds of antitrust enforcement also promote industry entry and fragmentation. Most notably, the Supreme Court noted skepticism at "reverse payment" settlements in which brand companies pay generic firms to delay entering a market, thus opening up such conduct to rule-of-reason scrutiny.[396] Greater antitrust challenges to reverse payment settlements may lead to more cases being litigated to judgment, more patent invalidations, and more generic entry.[397]

Antitrust enforcement has also preserved fragmentation in the agricultural biotechnology, seed, and agrochemical industry. There, antitrust authorities have also conditioned mergers and acquisitions on divestures. For example, Monsanto's 1997 acquisition of Holden's Foundation Seeds was conditioned on Monsanto making corn germplasm available to competitors for several years.[398] In 1998, the

[391] MEIER ET AL., *supra* note 106, at 26-61; *see also* David A. Balto & James F. Mongoven, *Antitrust Enforcement in Pharmaceutical Industry Mergers*, 54 FOOD & DRUG L.J. 255, 261-64 (1999) (profiling several of these early mergers).

[392] Thirty-three of fifty-four enforcement actions involved generic drugs. MEIER ET AL., *supra* note 106, at 26-60.

[393] Novartis AG, 150 F.T.C. 281, 318 (2010); MEIER ET AL., *supra* note 106, at 43.

[394] Johnson & Johnson, No. C-4180, at 22-28 (Fed. Trade Comm'n Jan. 16, 2007), https://www.ftc.gov/sites/default/files/documents/cases/2007/01/0610220c4180decisionorder_publicversion.pdf [https://perma.cc/G8K7-FHR5]; MEIER ET AL., *supra* note 106, at 48-49.

[395] *See* Paradise, *supra* note 271, at 50-51.

[396] FTC v. Actavis, Inc., 570 U.S. 136, 152-59 (2013); Waller & Sag, *supra* note 329, at 2236.

[397] Interestingly, early empirical evidence shows that the number of generic challenges to brand firms' patents increased immediately following *Actavis*. Lauren Krickl & Matthew Avery, *Roberts Was Wrong: Increased Antitrust Scrutiny After* FTC v. Actavis *Has Accelerated Generic Competition*, 19 VA. J.L. & TECH. 509, 543 (2015).

[398] Schimmelpfennig et al., *supra* note 121, at 159.

Department of Justice ("DOJ") Antitrust Division conditioned Monsanto's acquisition of DeKalb Genetics on Monsanto spinning off its transformation technology to UC Berkeley and licensing Holden's germplasm widely.[399] In 2007, DOJ conditioned Monsanto's $1.5 billion merger with Delta & Pine Land Company on Monsanto divesting a seed company, multiple seed lines, and other assets.[400] The FTC approved ChemChina's acquisition of Syngenta only after ChemChina committed to divesting generic versions of an herbicide and fungicide similar to branded versions produced by Syngenta.[401] More recently, the DOJ Antitrust Division challenged Bayer's $66 billion acquisition of Monsanto, arguing that it would substantially lessen competition in seventeen agricultural product markets.[402] The court ultimately entered a judgment compelling Bayer to divest assets valued at approximately $9 billion to BASF.[403] Again, while such actions did not block a merger or acquisition, they preserved the number of competitors in particular markets.

Antitrust enforcement in the software industry has a long history, including high-profile enforcement actions against IBM and Microsoft.[404] Merger enforcement has helped maintain or increase the number of competitors in particular markets.[405] Early cases involved approving mergers contingent on licensing key technology to a competitor. For instance, the Department of Justice approved Borland's 1991 acquisition of Ashton-Tate, which would combine the two leading database management companies at the time, on Borland licensing the

399 SCHENKELAARS ET AL., *supra* note 67, at 108; Press Release, U.S. Dep't of Justice, Justice Dep't Approves Monsanto's Acquisition of DeKalb Genetics Corp. (Nov. 30, 1998), https://www.justice.gov/archive/atr/public/press_releases/1998/2103.htm [ttps://perma.cc/ETU5-PAMZ].

400 Press Release, U.S. Dep't of Justice, Justice Dep't Requires Divestitures in $1.5. Billion Merger of Monsanto and Delta & Pine Land (May 31, 2007), https://www.justice.gov/archive/atr/public/press_releases/2007/223676.htm [https://perma.cc/F3UT-5KYT]; *see also* Oehmke & Naseem, *supra* note 18, at 19.

401 Sullivan, *supra* note 344.

402 Complaint at 5, United States v. Bayer AG, No. 1:18-cv-01241 (D.D.C. Feb. 8, 2019).

403 *See* United States v. Bayer AG, No. 1:18-cv-01241, 2019 WL 1431903, at *1, *8 (D.D.C. Feb. 8, 2019); Marcy Gordon, *Bayer Selling $9B in Ag Business Ahead of Monsanto Merger*, WASH. POST. (May 29, 2018, 3:33 PM PDT), https://www.washingtonpost.com/business/bayer-selling-9b-in-ag-business-ahead-of-monsanto-merger/2018/05/29/0b902ebe-6361-11e8-81ca-bb14593acaa6_story.html [https://perma.cc/9NLY-7H62].

404 *See* Katz & Shapiro, *Software*, *supra* note 24, at 29.

405 *See generally id.* at 48-54 (profiling numerous enforcement actions from the 1990s).

source code for Ashton-Tate's product to rival FoxPro.[406] More recently, the FTC lists fourteen merger enforcement actions in "Information and Technology – Software/Databases" between FY 1996-2019.[407] Aside from merger enforcement, actual or potential enforcement actions against unilateral conduct have also lowered barriers to entry and enhanced industry fragmentation. For instance, antitrust pressure has prevented IBM from fully asserting its patents in the software industry, thus helping to mitigate a potential anticommons or thicket problem.[408]

V. A BROADER UNDERSTANDING OF INDUSTRY STRUCTURE AND THE COMMERCIALIZATION OF PATENTED TECHNOLOGIES

While theories exploring the impact of patents on industry structure offer valuable insights, a more holistic perspective reveals myriad concentration and fragmentation drivers shaping the commercialization of patented technologies. Direct barriers to entry based on exclusive rights and cost, indirect barriers to entry based on efficiencies of size, and mergers and acquisitions push toward concentration, while technology-based entry, specialization, and antitrust enforcement push toward fragmentation. In many contexts, the resulting equilibrium is marked by significant consolidation.[409]

On one level, this Article reveals how the commercialization of patented technologies is subject to the same general structural forces that apply to all fields. Patents are a unique presence in these industries, and a wide literature has examined the impact of patents on industry structure.[410] While patents are certainly important, their effects must be considered within a wider context of structural forces that transcend many industries, such as high fixed costs, economies of scale, and significant merger and acquisition activity. In some ways, these findings push against a narrative of patent exceptionalism by revealing that

406 *Id.* at 49.

407 Fed. Trade Comm'n, *Merger Enforcement Actions FY96-FY19*, DATA.GOV (Feb. 6, 2019), https://catalog.data.gov/dataset/ftc-merger-enforcement-actions [https://perma.cc/WH2E-63RB].

408 Mann, *supra* note 53, at 1005; *cf.* Tim Wu, Tech Dominance and the Policeman at the Elbow 2-3 (Feb. 26, 2019, last revised July 5, 2019) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3342598 [https://perma.cc/HW9T-TBYQ] (arguing that antitrust enforcement against IBM, though regarded as unsuccessful, ultimately shaped the company's behavior).

409 Additionally, it should be noted that industries simply tend to consolidate over time as they mature. Deans et al., *supra* note 269, at 20; *see* Porter, *How Competitive Forces*, *supra* note 162, at 144; Porter, *The Five Competitive Forces*, *supra* note 23, at 35.

410 *See supra* Part I.

technological industries are subject to the same structural forces as all other industries.

At a deeper level, however, this Article reveals that patents and the nature of technological commercialization enhance structural forces — especially concentration drivers — in powerful and underappreciated ways. In downstream regions of the value chain focused on commercialization, patents wielded by industry incumbents create direct barriers to entry.[411] In addition, this Article has shown that patents shore up other barriers to entry as well. For instance, patents allow incumbents to surmount the high cost and risk of commercializing technologies that deter would-be entrants. Furthermore, while economies of scale and scope benefit large incumbents in all industries, they are particularly pronounced in technological fields given the nonrival nature of technology and low marginal costs of producing many of these goods.[412] Importantly, patents are critical for firms to realize economies of scale. Without exclusive rights, the underlying technological asset (such as the design of a drug, genetically modified seed, or piece of software) would still be nonrival and scale easily. However, companies would have little incentive to expand production and exploit efficiencies of size if competitors could freeride on their investments and simply copy their technologies.

Patents amplify other concentration and fragmentation drivers as well. Network effects in the software industry push toward standardization, but standards are more likely to promote concentration when patented.[413] While mergers and acquisitions pervade all industries, patents play an important role in supporting such transactions in technological industries. As described above, incumbents in such fields often utilize M&A to obtain outside innovations. However, firms would have less incentive to acquire other innovative companies if those companies' technologies were not protected by patents.[414] Patent protection of key innovations thus represents an important background condition that undergirds mergers

[411] *See supra* Part III.A.1.

[412] *See supra* Part III.B.1.

[413] *Cf.* Mark A. Lemley, *Intellectual Property Rights and Standard-Setting Organizations*, 90 CALIF. L. REV. 1889, 1952-53 (2002) (discussing the difficulties of patents on interoperability standards in markets characterized by network effects).

[414] Incentives to acquire would be lower but would not be nonexistent. As I have explored elsewhere, the tacit nature of technical knowledge lends some degree of natural excludability to cutting-edge technologies. Lee, *Innovation*, *supra* note 37, at 1461-62.

and acquisitions. While strong patents can promote concentration, in some cases, the *limitations* of patents can also drive concentration. For example, in the biopharmaceutical industry, the patent cliff of expirations has fueled significant M&A activity.[415] Turning to fragmentation drivers, it is important to acknowledge that patents can induce the generation of new technologies, which drives industry entry. However, this effect is most pronounced in upstream regions of the value chain focused on research and development. In sum, patents subtly shore up numerous concentration and fragmentation drivers and thus impact industry structure in previously underappreciated ways.

While this Article has highlighted common structural forces in these three innovative industries, it is important to emphasize their significant differences as well.[416] Not all of these industries exhibit comparable levels of concentration; agricultural biotechnology, seeds, and agrochemicals is the most concentrated, followed by biopharmaceuticals and software. It also bears emphasizing that even where an industry has many players and appears fragmented overall, individual markets within industries (for example, for diabetes medications, cotton seed, or security software) may be highly concentrated. Additionally, each industry features idiosyncratic forces that shape its structure. For example, the biopharmaceutical industry is subject to a unique regulatory environment — including increased focus on cost and price from the Patient Protection and Affordable Care Act — which has contributed to industry consolidation.[417] More generally, high fixed costs in biopharmaceuticals and agricultural biotechnology are compounded by expensive, lengthy processes of regulatory approval that are absent from the software industry.[418] On the other hand, network effects are particularly pronounced in the software industry and help explain its tendency toward concentration.[419] The significant diversity of these industries renders it even more noteworthy that they share several common structural forces producing a relatively high degree of consolidation.

It is also important to recognize the significant diversity *within* these industries. Because this Article focuses on the downstream commercialization of patented technologies, it has highlighted the large incumbents that tend to dominate that function. However, all of these

[415] *See supra* notes 270–278.

[416] *See supra* Part II.

[417] Patient Protection and Affordable Care Act, Pub. L. No. 111-148, 124 Stat. 119 (2010); Paradise, *supra* note 271, at 36.

[418] *See supra* Part III.A.2.

[419] Katz & Shapiro, *Software*, *supra* note 24, at 30.

industries possess numerous small- and medium-sized enterprises, particularly in more upstream regions of value chains focused on the initial invention of technologies. The characterization of the software industry as comprised of "boulders, pebbles, and sand"[420] is an apt description for all innovative industries. Small medical and agricultural biotech firms, software startups, and medium-sized enterprises all play important roles in these innovation ecosystems.

At an even more granular level, it is also important to acknowledge the significant diversity *within* the large incumbents that dominate commercialization in each of these industries. These companies feature significant internal heterogeneity with multiple divisions and units that may operate independently of each other.[421] For instance, when pharmaceutical companies acquire biotech firms, oftentimes scientists from those biotech firms will form a discrete research unit within the new company.[422] When agricultural biotechnology conglomerates acquire a new seed firm, that entity retains its brand identity in its new corporate home.[423] Following IBM's blockbuster acquisition of Red Hat to shore up its cloud computing capabilities, Red Hat retained its own branding and organizational autonomy.[424] While the theory of the firm cautions against the inefficiencies of large bureaucracies, decentralized corporate structures can approximate some of the advantages of small firms within large organizations.[425] Multidivisional ("M-Form") structures[426] illustrate Coase's observation that "[a]ll changes which improve managerial technique will tend to increase the size of the firm."[427] While formally concentrated, it is important to consider the internal diversity within industries and companies that commercialize patented technologies.

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[420] Campbell-Kelly & Garcia-Swartz, *supra* note 135, at 755-56.

[421] *Cf.* Lee, *Innovation*, *supra* note 37, at 1436 (describing semi-integration in which acquired firms maintain a semi-autonomous existence within a broader corporate home).

[422] *Id.* at 1464.

[423] *See, e.g.*, *Our Brands*, MONSANTO, https://perma.cc/3GCX-JCMY (archived Mar. 7, 2018, 1:37 AM) (listing twenty-nine U.S. brands within Monsanto).

[424] *Red Hat | IBM: Innovation at Scale*, RED HAT (July 8, 2019), https://www.redhat.com/en/about/videos/red-hat-ibm-innovation-scale?mhsrc=ibmsearch_a&mhq=red%20hat [https://perma.cc/A8UE-WHVF].

[425] *Cf.* Lee, *Innovation*, *supra* note 37, at 1486-87 (describing the phenomenon of semi-integration in vertical integration).

[426] Paul L. Robertson & Richard N. Langlois, *Innovation, Networks, and Vertical Integration*, 24 RES. POL'Y 543, 551 (1995) (describing M-form corporate organization).

[427] Coase, *supra* note 39, at 397.

VI. NORMATIVE ASSESSMENTS OF CONSOLIDATION IN TECHNOLOGICAL COMMERCIALIZATION

Having explored numerous concentration and fragmentation drivers, this Article now turns to a normative assessment of the relatively concentrated nature of technological commercialization. While a comprehensive evaluation of all three industries lies beyond the scope of this Article, a high-level comparison reveals several general insights. Due to patent law's particular concern with innovation, this Part will focus on the relationship between industry concentration and innovation before turning to other implications. This Part argues that while concentration can enhance innovation and efficiency to a point, significant concentration ultimately undermines innovation, efficiency, consumer welfare, and democratic representation.

A. Innovation

The impact of industry concentration on innovation is the subject of a long-running scholarly debate.[428] On the one hand, Joseph Schumpeter influentially argued that large firms in concentrated industries best promote innovation and enhance standards of living.[429]

[428] Rai, *supra* note 78, at 823-25. This debate is particularly evident in the antitrust literature. *See, e.g.*, Richard J. Gilbert & Steven C. Sunshine, *Incorporating Dynamic Efficiency Concerns in Merger Analysis: The Use of Innovation Markets*, 63 ANTITRUST L.J. 569, 576-77 (1995) (advocating the delineation of innovation markets to help assess the effects of mergers and acquisitions on research and development incentives); Herbert Hovenkamp, *Antitrust and Innovation: Where We Are and Where We Should Be Going*, 77 ANTITRUST L.J. 749 (2011) (arguing that intellectual property laws have increased the costs of innovation); Joseph Kattan, *Antitrust Considerations in Innovation-Driven Markets*, 21 CAN.-U.S. L.J. 115 (1995) (discussing the impact of intellectual property and antitrust enforcement guidelines on innovation and competition); McGowan, *supra* note 254 (addressing the debate over what kind of market structure best promotes innovation). For a comprehensive examination of the impact of mergers on innovation, see Michael L. Katz & Howard A. Shelanski, *Mergers and Innovation*, 74 ANTITRUST L.J. 1, 2 (2007).

[429] JOSEPH A. SCHUMPETER, CAPITALISM, SOCIALISM, AND DEMOCRACY 82 (3d ed. 2008); *see* Jonathan B. Baker, *Beyond Schumpeter vs. Arrow: How Antitrust Fosters Innovation*, 74 ANTITRUST L.J. 575, 578 (2007); McGowan, *supra* note 254, at 732; Oehmke & Naseem, *supra* note 18, at 20 ("Schumpeter hypothesized that higher levels of innovative activity are more likely to occur in industries that are concentrated . . . ."); Waller & Sag, *supra* note 329, at 2226; *see also* William J. Baumol, *Entrepreneurial Enterprises, Large Established Firms and Other Components of the Free-Market Growth Machine*, 23 SMALL BUS. ECON. 9, 10 (2004) (noting that competition among oligopolists produces high levels of innovation); Katz & Shelanski, *supra* note 428, at 17-18 (describing Schumpeter's theory). *See generally* Rai, *supra* note 78, at 823-25 (describing theories correlating monopolies with greater innovation).

Within Schumpeter's model of "creative destruction," restrictive practices by large firms "steady the ship" against constant gales of competition and create breathing space for innovation.[430] On the contrary, Schumpeter argued that perfect competition and free entry deter innovation.[431] Commentators have also noted that industry consolidation can accelerate innovation by allowing entities to aggregate complementary assets necessary to innovate.[432] One particular form of consolidation — mergers and acquisitions — can reduce duplicative research efforts and create knowledge synergies, thus enhancing research productivity.[433] Beyond general arguments, scholars have advanced more context-specific arguments by which industry concentration promotes innovation. In network markets, such as in the software industry, concentration and standardization can enhance market performance and promote application-level innovation.[434] Additionally, large firm size, which is characteristic of concentrated industries, produces greater incentives for *internal*, process innovations, such as automated manufacturing processes.[435]

On the other hand, economist Kenneth Arrow influentially argued that competitive markets promote greater innovation than those subject to monopoly power.[436] Relatedly, Robert Merges and Richard Nelson have drawn from historical examples to argue that "multiple and competitive sources of invention are socially preferable to a structure where there is only one or a few sources."[437] Consolidation hinders the entry of new innovative firms[438] and reduces incentives for incumbents

[430] SCHUMPETER, *supra* note 429, at 87.

[431] *Id.* at 105.

[432] Katz & Shelanski, *supra* note 428, at 50-51.

[433] Ornaghi, *supra* note 271, at 72.

[434] McGowan, *supra* note 254, at 810. While such standardization may promote innovation within an accepted platform, it may not encourage innovation among potential rival platforms.

[435] Gilbert & Sunshine, *supra* note 428, at 587.

[436] KENNETH J. ARROW, *Economic Welfare and the Allocation of Resources for Invention, in* ESSAYS IN THE THEORY OF RISK-BEARING 144, 156-60 (Julius Margolis ed., Markham Publ'g Co. 1971); *see* Richard J. Gilbert & Hillary Greene, *Merging Innovation Into Antitrust Agency Enforcement of the Clayton Act*, 83 GEO. WASH. L. REV. 1919, 1923-24 (2015); McGowan, *supra* note 254, at 732. *See generally* Katz & Shelanski, *supra* note 428, at 14-15 (citing studies indicating that perfect competition produces more cost-reducing innovation than monopolies); Rai, *supra* note 78, at 825 (describing theories associating competition with greater innovation).

[437] Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 908 (1990); *see also* Comanor & Scherer, *supra* note 90, at 110.

[438] *See* Tim Wu, *Taking Innovation Seriously: Antitrust Enforcement if Innovation Mattered Most*, 78 ANTITRUST L.J. 313, 315, 317 (2012) ("[I]t is clear that high barriers

to invest in innovation.[439] Incumbents may even quash new innovations that can cannibalize existing products.[440] Furthermore, large players in consolidated industries feature sprawling bureaucracies that may dampen innovation.[441] In general, empirical studies reveal a negative correlation between industry concentration and R&D expenditures.[442] Mergers and acquisitions can particularly harm innovation by focusing attention on cost savings rather than novel advancements, increasing profits from existing products (thereby lessening incentives to innovate), and combining two firms that would otherwise compete against each other.[443] Consolidation affects not only the amount but also the *kind* of innovation that companies produce. Monopolists often favor incremental innovation rather than more revolutionary advances that threaten existing products.[444] A wide literature shows that small entities, which may be more prevalent in fragmented industries, are disproportionately innovative compared to larger entities.[445]

Empirical studies have added an intermediate perspective positing that innovation is greatest not in competitive or monopolistic markets but in oligopolies.[446] While some argue that no general relationship can be discerned between industry structure and innovation,[447] "many

to entry in a given industry, whether maintained by a monopoly or an oligopoly, can discourage product innovation by new firms.").

[439] *Id.* at 318; *see* Baker, *supra* note 429, at 578-79; Kattan, *supra* note 428, at 116.

[440] Cockburn, *supra* note 77, at 17; *see* Bresnahan, *supra* note 59, at 15.

[441] Rai, *supra* note 78, at 825.

[442] F.M. SCHERER, INNOVATION AND GROWTH: SCHUMPETERIAN PERSPECTIVES 246-47 (1984); *see* Zoltan J. Acs & David B. Audretscsh, *Innovation in Large and Small Firms: An Empirical Analysis*, 78 AM. ECON. REV. 678, 679 (1988). However, the effect appears to be industry-specific. Richard C. Levin, Wesley M. Cohen & David C. Mowery, *R&D Appropriability, Opportunity, and Market Structure: New Evidence on Some Schumpeterian Hypotheses*, 75 AM. ECON. REV. 20, 20 (1985).

[443] Chris Lo, *Pharma Mergers: Big Business, Bad Science?*, PHARM. TECH. (Jan. 6, 2015), https://www.pharmaceutical-technology.com/features/featurepharma-mergers-big-business-bad-science-4467897/ [https://perma.cc/9Q45-ZHRR]; *see* Gilbert & Sunshine, *supra* note 428, at 587.

[444] *See* Baumol, *supra* note 429, at 10-11; Bresnahan, *supra* note 59, at 18; F.M. Scherer, *Antitrust, Efficiency, and Progress*, 62 N.Y.U. L. REV. 998, 1011 (1987).

[445] *See, e.g.*, Arora & Merges, *supra* note 45, at 451-52 (discussing how "smaller, more dynamic firms are in some cases especially innovative").

[446] Baker, *supra* note 429, at 583. These studies, however, have been critiqued for not isolating the effect of competition on innovation. *Id.* at 584.

[447] *See, e.g.*, Gilbert & Sunshine, *supra* note 428, at 576-78 ("[E]ven if all firms have the same incentive to engage in research and development, it is highly unlikely that all firms are equal in the effectiveness of their innovative efforts."); McGowan, *supra* note 254, at 769 (holding that "economic theory provides no strong reason to believe that fragmented markets are inherently more innovative than concentrated ones").

believe that a moderately concentrated structure — with the top four firms holding perhaps a fifty percent aggregate market share — is likely to be the most fertile ground for innovation."[448] Within this view, "oligopoly — competition among a few firms — is the market structure most conducive to development of new products and processes."[449] Additionally, it bears emphasizing that even in concentrated markets, the *threat* of external competition can spur incumbents to innovate.[450] However, this threat depends on barriers to entry being low,[451] which is not the case in many industries, such as the ones examined in this Article.[452] As this Article underscores, analyses of industry consolidation can benefit from more granular distinctions between upstream and downstream participants in an industry's value chain. For instance, the biopharmaceutical industry appears rather fragmented when considering the presence of numerous upstream biotech firms, but it appears more concentrated when examining downstream segments focused on commercializing drugs.

Turning to specific fields, empirical studies of the biopharmaceutical industry reveal that mergers and acquisitions of large players typically lead to a decrease in aggregate research and development.[453] Acquirers frequently terminate non-core research,[454] decrease combined R&D budgets, and eliminate research sites.[455] Integrating R&D units of merging companies is difficult,[456] and an impending merger and

[448] Kattan, *supra* note 428, at 117; *see, e.g.*, Philippe Aghion, Nick Bloom, Richard Blundell, Rachel Griffith & Peter Howitt, *Competition and Innovation: An Inverted-U Relationship*, 120 Q.J. ECON. 701 (2005) (finding "strong evidence of an inverted-U relationship").

[449] Katz & Shelanski, *supra* note 428, at 18.

[450] SCHUMPETER, *supra* note 429, at 85; Bresnahan, *supra* note 59, at 15; *see* KING, *supra* note 179, at 2; Kalaitzandonakes et al., *supra* note 210, at 20.

[451] *See* Cockburn & MacGarvie, *supra* note 58, at 915; Fulton & Giannakas, *supra* note 222, at 138; Kattan, *supra* note 428, at 122.

[452] *See* COUNCIL OF ECON. ADVISORS, *supra* note 9, at 3 ("[T]here is little empirical evidence of potential entry having a substantial impact on monopolists' behavior, except in certain specific cases . . . .").

[453] Comanor & Scherer, *supra* note 90, at 106; *see* Ornaghi, *supra* note 271, at 78 (casting doubt on the notion that mergers promote innovation or research productivity for biopharmaceutical companies).

[454] Lo, *supra* note 443.

[455] John L. LaMattina, Comment, *The Impact of Mergers on Pharmaceutical R&D*, 10 NATURE REVIEWS DRUG DISCOVERY 559, 559 (2011).

[456] Richman et al., *supra* note 92, at 807; *see* LaMattina, *supra* note 455, at 560.

attendant job insecurity can depress researcher productivity.[457] Focusing on one company, combined R&D expenditures decreased by $5.5 billion upon Pfizer's acquisition of Wyeth,[458] and the combined company experienced a decrease in productivity.[459] Industry-wide consolidation reduces parallel research and development, which is particularly important in areas of technical uncertainty.[460] The harms of consolidation are especially significant given that the rate of NME production increases *more* than proportionally with an increase in the number of companies.[461] Some commentators suggest that the impact of mergers and acquisitions on pharmaceutical R&D has been "devastating."[462]

It is important to acknowledge critiques contending that the link between consolidation and reduced R&D is overstated or misleading. According to one view, decreased R&D spending by large pharmaceutical companies may not necessarily indicate lower overall innovation.[463] It may be the case that biopharmaceutical companies are becoming more efficient and thus generating the same or more innovation with lower expenditures. This hypothesis is unlikely, however, given evidence of increasing costs[464] of biopharmaceutical development and decreasing scientific productivity.[465] Empirical evidence considering actual innovation outputs rather than just R&D expenditures suggests that "merged companies are consistently found to have worse innovation performances than the group of non-merging firms."[466] Some commentators invoke the distinction between upstream

457 *See* LaMattina, *supra* note 455, at 560; Ornaghi, *supra* note 271, at 72. Furthermore, workforce reductions can reduce accumulated know-how after a merger or acquisition. *Id.*

458 Lo, *supra* note 443.

459 *See* LaMattina, *supra* note 455, at 560.

460 Comanor & Scherer, *supra* note 90, at 110-11; *see* Pammolli et al., *supra* note 259, at 437; *cf.* Demsetz, *Theory of the Firm*, *supra* note 44, at 148 ("Merged firms may be unable to duplicate the sum of what independently standing firms can accomplish for a variety of reasons . . . .").

461 Munos, *supra* note 95, at 961.

462 LaMattina, *supra* note 455, at 559; *see also* Munos, *supra* note 95, at 961.

463 *Cf.* Shepherd, *supra* note 83, at 3 (arguing that mergers and acquisitions, and resulting decreases in R&D spending by pharmaceutical companies, involve outsourcing innovation to smaller firms).

464 *See* DiMasi et al., *supra* note 193, at 26; Gautam & Pan, *supra* note 195, at 382; Shepherd, *supra* note 83, at 8.

465 *See* PWC, PHARMA 2020, *supra* note 272, at 5; Pammolli et al., *supra* note 259, at 428 (reporting empirical evidence of "a long-term decline in the productivity of research and development (R&D)").

466 Ornaghi, *supra* note 271, at 71.

and downstream functions in the value chain to argue that consolidation and decreased R&D by pharmaceutical companies is not problematic because innovation is increasingly shifting upstream to research-intensive biotech firms.[467] However, even defenders of consolidation concede that it could harm innovation if it involves the primary innovators in a therapeutic area.[468] Furthermore, mergers and acquisitions among large, downstream commercializers leave less outlets for either buying the outputs of upstream biotechs or acquiring those biotechs outright, which can depress upstream R&D.

Empirical studies of the agricultural biotechnology, seed, and agrochemical industry similarly indicate that consolidation ultimately harms innovation. Interestingly, empirical research of the corn-seed market shows that firms with a larger market share are more innovative to a point, but that eventually, increases to market share and innovation are not proportional.[469] In general, industry consolidation — which encompasses both vertical integration and horizontal concentration — has decreased sources of innovation and overall R&D spending. The number of firms conducting field trials of new genetically modified varieties to be registered with the USDA increased rapidly in the mid-1990s and started to decline slowly thereafter,[470] coinciding with a period of significant consolidation. By 1998, the four most active firms accounted for 80% of all field trials, with Monsanto conducting a third of all trials.[471] Researchers have found that as the number of firms decreases, inventive activity also decreases,[472] and "as the seed industry became more concentrated during the late 1990s, private research intensity dropped or slowed."[473] According to the USDA, "Those companies that survived seed industry consolidation appear to be sponsoring less research relative to the size of their individual markets than when more companies were involved."[474] Along with direct R&D

[467] *See* Richman et al., *supra* note 92, at 802; Shepherd, *supra* note 83, at 2, 16-17.

[468] *See* Shepherd, *supra* note 83, at 2.

[469] Dana Varinsky, *The $66 Billion Bayer-Monsanto Merger Just Got a Major Green Light — But Farmers Are Terrified*, BUS. INSIDER (May 29, 2018, 10:27 AM), https://www.businessinsider.com/bayer-monsanto-merger-has-farmers-worried-2018-4 [https://perma.cc/CKR3-KNH6].

[470] Schimmelpfennig et al., *supra* note 121, at 159.

[471] *Id.*

[472] Oehmke & Naseem, *supra* note 18, at 30. The authors found that industry consolidation decreased inventive activity, but that industry concentration did not. *Id.*

[473] Fernandez-Cornejo & Schimmelpfennig, *supra* note 383, at 19. *But see* SCHENKELAARS ET AL., *supra* note 67, at 61 (indicating that the U.S. cotton, soybean, and maize seed markets have featured robust innovation while remaining concentrated).

[474] Fernandez-Cornejo & Schimmelpfennig, *supra* note 383, at 19.

cuts, consolidation reduces the parallel research that is critical to innovation in areas of uncertainty.[475] Due to numerous interfirm partnerships and alliances, concentration in innovation markets may be even greater than that of product markets featuring high HHIs.[476] Turning to recent events, while Bayer justified its acquisition of Monsanto with the promise of enhancing agricultural research and innovation,[477] the deal has raised concern, even among U.S. Senators, about stifling innovation.[478]

Rapid technological advances in the software industry suggest that industry concentration has not dampened innovation, but the potential for harm is present. Analysts note that consolidation can spur innovation, faster product development, and greater integration among rival software offerings.[479] Certainly, the acquisition of innovative startups by well-resourced incumbents can help accelerate bringing those innovations to market.[480] Furthermore, the potential for acquisition by a large incumbent helps motivate startups to start up in the first place.[481] However, industry concentration raises concerns. First, vertical integration via acquisition of a promising startup could prevent that startup from developing into a legitimate competitor to the acquiring firm.[482] Additionally, the benefits of scaling up that startup's technology must be weighed against the costs of foreclosing access to that technology by other firms. Second, horizontal integration via acquisition of an established competitor offers comparatively little

[475] *See supra* note 460.

[476] *See* James F. Oehmke & Christopher A. Wolf, *Measuring Concentration in the Biotechnology R&D Industry: Adjusting for Interfirm Transfer of Genetic Material*, 6 AGBIOFORUM 134, 137 (2003).

[477] *See* Varinsky, *supra* note 469.

[478] Press Release, Senators Mike Lee & Amy Klobuchar, Lee, Klobuchar React to Proposed Bayer-Monsanto Merger (Sept. 14, 2016), https://www.lee.senate.gov/public/index.cfm/2016/9/lee-klobuchar-react-to-proposed-monsanto-bayer-merger [https://perma.cc/7GPY-U89S]; *see* Drew Harwell, *Bayer Agrees to Buy Monsanto in $66 Billion Deal that Could Reshape Agriculture*, WASH. POST. (Sept. 14, 2016), https://www.washingtonpost.com/business/economy/bayer-agrees-to-buy-monsanto-in-66-billion-deal-that-could-reshape-agriculture/2016/09/14/4599de48-7aa6-11e6-ac8e-cf8e0dd91dc7_story.html [https://perma.cc/V77F-SSTB]; Varinsky, *supra* note 469 (quoting agriculture analyst Mark Connelly).

[479] Jamie Yap, *Software Market Consolidation is Customers' Gain*, ZDNET (Mar. 6, 2012, 4:01 GMT), https://www.zdnet.com/article/software-market-consolidation-is-customers-gain/ [https://perma.cc/G2MX-GCS6].

[480] *See* Waller & Sag, *supra* note 329, at 2243; *see also* Schief et al., *supra* note 235, at 422.

[481] *See* Waller & Sag, *supra* note 329, at 2243.

[482] Shapiro, *Antitrust*, *supra* note 9, at 741.

benefit in the form of scaling up a novel technology. While mergers of large competitors may allow the merged entity to offer a larger suite of integrated products, this is a different kind of innovation than developing new products with novel functionalities. Additionally, industry concentration coupled with network effects can cause innovation-dampening lock-in that entrenches technologically inferior paradigms.[483]

B. Efficiency

Turning to efficiency considerations, concentration in technology commercialization can promote efficiency by allowing a few large players to amass the size and resources necessary to bring innovative goods to market.[484] Relatedly, large companies can exploit significant economies of scale and scope, which are particularly acute in technological industries.[485] For instance, economies of scale and network effects suggest that some horizontal mergers in the software industry enhance efficiency.[486] Mergers and acquisitions can also enhance efficiency by eliminating redundant functions[487] and allowing an entity to aggregate complementary resources.[488] Focusing on one form of consolidation — vertical integration — Chicago school scholars have argued that such integration eliminates the "double monopoly markup" between separate upstream suppliers and downstream producers.[489] More generally, combining complementary assets can promote both innovation and efficiency.[490]

While concentration promotes efficiency to a point, theory and empirical evidence reveal that significant concentration undermines efficiency. The theory of the firm predicts that firm expansion experiences diminishing marginal returns; at some point, the costs of

[483] *See* Katz & Shapiro, *Software*, *supra* note 24, at 38.

[484] *See* Shepherd, *supra* note 83, at 12-13 (discussing this advantage in the biopharmaceutical industry).

[485] *See* Demsetz, *Industry Structure*, *supra* note 56, at 2; *see supra* Part III.B.

[486] Katz & Shapiro, *Software*, *supra* note 24, at 47.

[487] *See* U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, *supra* note 22, at 29.

[488] Katz & Shelanski, *supra* note 428, at 11.

[489] James L. Hamilton & Ibrahim Mqasqas, *Double Marginalization and Vertical Integration: New Lessons from Extensions of the Classic Case*, 62 S. ECON. J. 567, 567 (1996); Michael H. Riordan & Steven C. Salop, *Evaluating Vertical Mergers: A Post-Chicago Approach*, 63 ANTITRUST L.J. 513, 518 (1995); Varian, *supra* note 20, at 92.

[490] *See* U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, *supra* note 22, at 23-24.

managing a large bureaucracy outweigh its benefits.[491] Management costs are particularly high for sprawling, global enterprises and for firms extending into areas beyond their expertise.[492] Integrating acquired companies and reconciling divergent cultures is very difficult.[493] The inefficiencies of managing large bureaucracies are evident in the spate of divestures in the 1990s and 2000s wherein large life sciences companies separated their medical and agricultural divisions.[494] Empirical evidence from the pharmaceutical industry shows that smaller, focused companies with category-leading products outperform large companies with broad product portfolios.[495] In the software industry, when incumbents acquire smaller companies, the incumbent often does not sustain previous levels of support for the acquired company's technologies,[496] which suggests some inefficiencies from managing a growing enterprise. Focusing on vertical integration, at some point the gains from reduced transaction costs are outweighed by the efficiency losses of forgone specialization.[497] More broadly, shareholders value highly specialized firms more than larger and more diversified companies.[498] Notably, researchers have found that the

491 *See generally* Coase, *supra* note 39 (articulating the theory of the firm); Cockburn, *supra* note 77, at 17 (noting the inefficiencies of large, bureaucratic enterprises).

492 *See* David C. Mowery, *Alfred Chandler and Knowledge Management Within the Firm*, 19 INDUS. & CORP. CHANGE 483, 484 (2010).

493 *See, e.g.*, Lars Schweizer, *Organizational Integration of Acquired Biotechnology Companies into Pharmaceutical Companies: The Need for a Hybrid Approach*, 48 ACAD. MGMT. J. 1051, 1063-66 (2005) (discussing industry examples of difficulty with cultural integration); *cf.* Valerie Bannert & Hugo Tschirky, *Integration Planning for Technology Intensive Acquisitions*, 34 R&D MGMT. 481, 481-82 (2004) ("[A]cquisitions in general and in particular technology driven acquisitions are associated with high risks and are vulnerable to failure." (citation omitted)).

494 *See* KING, *supra* note 179, at 1; Fernandez-Cornejo & Schimmelpfennig, *supra* note 383, at 19; Fulton & Giannakas, *supra* note 222, at 141.

495 Haxer et al., *supra* note 373, at 2 ("Category leaders with focused portfolios — the focused leaders — outperform, because they avoid the distraction and complexity of managing multiple noncore businesses that contribute little to overall performance.").

496 *See* Mary Hayes Weier, *Does Software Consolidation Stifle Innovation?*, INFORMATIONWEEK (Jan. 26, 2007, 2:15 PM), https://www.informationweek.com/does-software-consolidation-stifle-innovation/d/d-id/1051193? [https://perma.cc/3LEP-3L5V].

497 *Cf.* Barnett, *Organization*, *supra* note 47, at 791 (noting that a high degree of vertical integration can lead an innovator to "forfeit[] specialization gains that could have been accrued by allocating one or more supply chain functions to lower-cost providers").

498 *How Would Bayer-Monsanto Affect Workers, Farmers, Investors?*, CHI. TRIB. (May 23, 2016, 11:51 AM), https://www.chicagotribune.com/business/ct-bayer-monsanto-offer-20160523-story.html [https://perma.cc/4929-L6LA] [hereinafter *Bayer-Monsanto Affect*] (quoting Professor Michael H. Grote).

heightened profitability of large firms in concentrated industries is due to increased profit margins, not increased efficiency.[499]

C. Consumer Welfare

Industry concentration tends to negatively impact consumer welfare, though effects vary by context. In theory, large firms in concentrated industries that enjoy economies of scale and scope can pass cost savings on to consumers.[500] However, evidence across multiple industries reveals that increased concentration correlates with increases in prices or price-cost margins.[501] As demonstrated below, in some industries concentration can contribute to dramatic increases in prices and decreases in choice, thus harming consumer welfare.

Consolidation among biopharmaceutical companies has raised concern over decreased competition and increased price.[502] At least one study has found that M&A activity "appears to play only a limited role" in recent drug price increases.[503] Other developments seem to play a more important role, such as the shift to more expensive specialty drugs.[504] Commentators also note that concentration in other parts of the biopharmaceutical value chain — most notably among pharmacy benefit managers — has contributed to rising drug prices.[505] However, for consumer welfare analysis, general industry trends are not as relevant as market-specific analysis. As noted, numerous therapeutic markets feature only a few competitors,[506] which suggests that further consolidation can harm price and choice. Furthermore, commentators note that concentration in the specialized capabilities of obtaining regulatory approval — a downstream function — can harm competition.[507]

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499 Grullon et al., *supra* note 9, at 699.

500 COUNCIL OF ECON. ADVISORS, *supra* note 9, at 3.

501 Hovenkamp & Shapiro, *supra* note 221, at 2004. Additionally, concentrated markets are more susceptible to cartelization and its associated harms. Shapiro, *Antitrust*, *supra* note 9, at 737.

502 Paradise, *supra* note 271, at 35.

503 Richman et al., *supra* note 92, at 789.

504 *See id.* at 796.

505 *Id.*; David Dayen, *The Hidden Monopolies that Raise Drug Prices*, AM. PROSPECT (Mar. 28, 2017), https://prospect.org/health/hidden-monopolies-raise-drug-prices/ [https://perma.cc/FX35-PU2D].

506 *See supra* notes 111–114 and accompanying text; *see, e.g.*, Complaint at 1, King Pharm., Inc., No. C-4246, F.T.C. (2009) (discussing high concentration in the market for oral long-acting opioids).

507 *See* Richman et al., *supra* note 92, at 818.

The evidence is much clearer that concentration has harmed consumer welfare in agricultural biotechnology.[508] Concentration has led to supracompetitive pricing of genetically modified seeds and fewer choices for growers.[509] Due in part to consolidation, the price of commodity seeds has increased as much as 30% annually in recent years.[510] Incumbents have aggressively marketed genetically engineered seeds, which have driven dramatic price increases for corn, soybean, and cotton seeds.[511] The recent mergers of Monsanto with Bayer and Dow with DuPont are expected to create highly concentrated markets in corn, soybean, and cotton seed.[512] Economists estimate that Bayer's acquisition of Monsanto will increase prices for cotton seed by 18.2%, corn seed by 2.3%, and soybean seed by 1.9%.[513] In addition to increasing price, industry concentration also decreases consumer choice.[514] Because of the dominance of genetically modified seeds, it is increasingly difficult for farmers to find conventional seeds.[515] As large corporations displace small, local seed breeders, global monocultures have come to dominate corporate farming.[516]

The impact of software industry consolidation on consumer welfare is more difficult to assess. Consolidation reduces consumer choice[517] and competition, thus resulting in higher prices.[518] Furthermore,

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[508] *See* COUNCIL OF ECON. ADVISORS, *supra* note 9, at 1; Oehmke & Naseem, *supra* note 18, at 19; *cf.* Reich, *supra* note 9 (describing how Facebook's concentrated power leads to "political clout" that can be easily abused).

[509] Moss & Taylor, *supra* note 243, at 338; Varinsky, *supra* note 469 ("[G]reater market dominance was correlated with higher corn seed and chemical prices.").

[510] Howard, *supra* note 119, at 2490.

[511] BARKER ET AL., *supra* note 173, at 8.

[512] *Hearing*, *supra* note 130, at 7.

[513] Sullivan, *supra* note 344; *see also Bayer-Monsanto Affect*, *supra* note 498 (quoting Professor Michael H. Grote).

[514] *See* Moss & Taylor, *supra* note 243, at 349.

[515] BARKER ET AL., *supra* note 173, at 9; *see* Michael E. Gray, *Relevance of Traditional Integrated Pest Management (IPM) Strategies for Commercial Corn Producers in a Transgenic Agroecosystem: A Bygone Era?*, 59 J. AGRIC. FOOD CHEM. 5852, 5855-56 (2011) (finding that 40% of farmers in Illinois did not have access to nontransgenic high-yielding corn varieties).

[516] BARKER ET AL., *supra* note 173, at 20.

[517] Weier, *supra* note 496.

[518] *See, e.g.*, Vauhini Vara & Ben Worthen, *As Software Firms Merge, Synergy Is Elusive — Shareholders May Prosper from Trend, but Customers See Scant Benefits So Far*, WALL ST. J. (Nov. 20, 2007, 12:01 AM ET), https://www.wsj.com/articles/SB119551706770298528 [https://perma.cc/D2QL-Z7WS] (discussing one such example). *But see* Yap, *supra* note 479 (stating that the onset of cloud delivery can allow small software vendors to move their innovations to market at lower costs for consumers).

integrating new and legacy systems is notoriously difficult and can increase costs for consumers.[519] However, innovation is an important component of consumer welfare,[520] and as discussed above, industry concentration within certain parameters can enhance innovation.[521] Concentration can arise due to network effects, and the welfare dimensions of such effects are indeterminate. While consumers derive value from utilizing widely used, interoperable programs,[522] network effects can harm welfare by facilitating higher prices, creating deadweight loss, and locking in inferior technologies.[523] For similar reasons, the welfare analysis of large incumbents acquiring innovative companies to broaden their integrated suite of products is also equivocal. Integrating complementary products within a single software suite helps customers,[524] but it may produce lock in and reduce parallel sources of innovation.

D. Political Leverage

Industry concentration also has important and negative political implications. While an extensive examination of these dynamics lies beyond the scope of this Article, some preliminary observations are in order. Powerful incumbents push for more favorable laws and judicial rulings, creating an environment where "the big get bigger and even more powerful."[525] In technological industries, holders of large patent portfolios get a "seat at the table" during legislative discussions of patent law.[526] Pharmaceutical Research and Manufacturers of America ("PhRMA"), which lobbies on behalf of major research-based pharmaceutical companies, spent a record $27.5 million in 2018 to

519 *See, e.g.*, Vara & Worthen, *supra* note 518 (stating that it often takes years for software makers to integrate all of the products they've bought).

520 *See* Katz & Shelanski, *supra* note 428, at 2-3.

521 *See supra* notes 479–481 and accompanying text.

522 Katz & Shapiro, *Software*, *supra* note 24, at 33.

523 *See* Paul D. Klemperer, *Competition When Consumers Have Switching Costs: An Overview with Applications to Industrial Organization, Macroeconomics, and International Trade*, 62 REV. ECON. STUD. 515, 536 (1995).

524 *See* SLAUGHTER, *supra* note 133, at 70.

525 Howard, *supra* note 119, at 2490; *see* Robert P. Merges, *Intellectual Property Rights and the New Institutional Economics*, 53 VAND. L. REV. 1857, 1869 (2000) (describing "legislative capture" by rent-seeking firms); Reich, *supra* note 9 (observing that property holders have long sought to influence politics); *cf.* Phillips, *supra* note 9 (describing the "vast social and political influence" wielded by large technology companies).

526 Parchomovsky & Wagner, *supra* note 165, at 36-37; *see* Michele Boldrin & David K. Levine, *The Case Against Patents*, 27 J. ECON. PERSP. 3, 4 (2013).

influence legislation.[527] Concentration in the agricultural industry has led industry heavyweights to influence legislation aimed at enhancing competition;[528] in 2016, Monsanto alone spent $4.6 million on lobbying.[529] Trade groups representing the software industry, such as the Business Software Alliance, the Software and Information Industry Association, the Computer and Communications Industry Association, and the Coalition for Patent Fairness, are also active lobbyists.[530]

Notably, however, on at least one issue — patent reform — software groups have opposed the biopharmaceutical industry. Whereas life sciences firms seek to maintain strong patent protection, large software incumbents (which are frequently sued for patent infringement) have pushed to make it more difficult to obtain and easier to challenge patents and to lower damages from patent infringement.[531] While the opposition of these two industry heavyweights on patent reform somewhat negates their influence, on other issues, such as antitrust, they are likely to jointly resist greater enforcement. In this manner, industry concentration can generate significant political power, which alters legal landscapes to further entrench market dominance.[532]

VII. PRESCRIPTIONS

This study of the forces shaping the commercialization of patented technologies leads to several prescriptions for patent law and industrial policy more broadly.

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[527] Bill Allison, *Big Pharma Lobby Group Spent Record Amount as Reform Push Grows*, BLOOMBERG (Jan. 22, 2019, 3:19 PM PST), https://www.bloomberg.com/news/articles/2019-01-22/big-pharma-lobby-group-spent-record-amount-as-reform-push-grows [https://perma.cc/JLC2-M7EC]. This is a complicated landscape, as PhRMA does not represent all pharmaceutical companies, and it even recently publicly criticized two (non-member) pharmaceutical companies for misbehavior. Additionally, there is internal disagreement among PhRMA's members. Dylan Scott, *Under Siege over Prices, Drug Makers Ready Their Counterpunch*, STAT NEWS (Nov. 6, 2015), https://www.statnews.com/2015/11/06/siege-drug-makers-ready-counterpunch-pricing-debate/ [https://perma.cc/7PRJ-CEBQ].

[528] Moss & Taylor, *supra* note 243, at 356.

[529] Sullivan, *supra* note 344.

[530] Jonathan A. Barnett, *Property as Process: How Innovation Markets Select Innovation Regimes*, 119 YALE L.J. 384, 440 n.134 (2009).

[531] *Id.* at 434-38.

[532] *See* McGowan, *supra* note 254, at 778-79.

A. Integrating Considerations of Industry Structure into Patent Law and Policy

While policymakers should understandably focus on patents as mechanisms for promoting innovation, they must also consider the impact of patents on industry structure. Formulating broad prescriptions in this arena is difficult, and distinctions are in order. In industries where patents are critical to sustaining business models, such as biopharmaceuticals, well-intentioned proposals to "weaken" patents can have the unintended consequence of triggering industry consolidation. For example, commentators have suggested weakening drug patents through compulsory licenses and other mechanisms to promote access to patented medicines, an area of intense public policy concern.[533] While the objectives of such proposals are laudable, taken too far they could have the unintended consequence of triggering greater industry concentration. As discussed above, patent expirations in the biopharmaceutical industry have led to mergers and acquisitions between competitors, which may undermine aggregate innovation.[534] A significant complicating factor is major pharmaceutical companies' large marketing and sales infrastructure, which requires significant revenue to sustain; streamlining such operations would be helpful but would require significant changes to the biopharmaceutical business model. In the present landscape, policymakers seeking to enhance access to drugs must try to find a "sweet spot" where mitigating exclusive rights does not unduly hamper innovation incentives or trigger industry consolidation.

The centrality of patents to driving innovation, however, differs by industry. In other fields — particularly ones where patents are not as critical to promoting innovation — the threat of consolidation comes not from weak patents but from too many of them. For example, in software, and to a certain extent in agricultural biotechnology, broad patent thickets raise barriers to entry and contribute to concentration. To foster entry in these fields, this Article offers a new gloss on several interventions that have already been advanced to promote innovation: enhancing patent quality, discouraging undue patent agglomeration, and encouraging wide licensing of key technologies. While these

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[533] *See, e.g.*, Hannah Brennan, Amy Kapczynski, Christine H. Monahan & Zain Rizvi, *A Prescription for Excessive Drug Pricing: Leveraging Government Patent Use for Health*, 18 YALE J.L. & TECH. 275 (2016) (discussing one approach for bringing about transformative reductions in drug pricing); Peter Lee, *Toward a Distributive Agenda for U.S. Patent Law*, 55 HOUS. L. REV. 321 (2017) (describing the contours of a distributive agenda for U.S. patent law).

[534] *See supra* Part II.A.

proposals seek to enhance innovation directly, this Article highlights their indirect effect of lowering barriers to entry and deconcentrating innovative industries. In this light, recent legislative reforms creating new post-grant proceedings[535] to challenge issued patents and recent decisions heightening the requirements of patentability[536] are promising developments for increasing thresholds for protection and enhancing patent quality. Additionally, proposals to increase maintenance fees would help decrease the long-term stockpiling of huge numbers of patents.[537] Finally, focusing on the software industry, enhancing the enforceability of commitments to license standards-essential patents on fair, reasonable, and nondiscriminatory ("FRAND") terms would lessen the exclusionary effects of patented standards.[538] This Article offers a new justification for these existing proposals, which not only enhance innovation directly but also create more competitive industry structures.

B. A Holistic Framework for Promoting Entry

Shifting to industrial policy more broadly, this Article suggests several approaches to mitigate excessive concentration. While focused on the commercialization of patented technologies, these approaches would also help address concentration in other industries as well. Again, due to the diversity of industries considered, this Part will propose principles at a high level of generality, leaving more precise prescriptions for future studies. This Part proposes a holistic approach to enhancing industry entry that spans private ordering, federal innovation policy, and antitrust enforcement.

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[535] Leahy-Smith America Invents Act, Pub. L. No. 112-29, § 6, 125 Stat. 284, 299-312 (2011).

[536] Focusing just on patentable subject matter, the Supreme Court has recently issued four decisions constraining patent eligibility. *See* Alice Corp. v. CLS Bank Int'l, 573 U.S. 208, 226-27 (2014); Ass'n for Molecular Pathology v. Myriad Genetics, Inc., 569 U.S. 576, 595 (2013); Mayo Collaborative Servs. v. Prometheus Labs., Inc., 566 U.S. 66, 92 (2012); Bilski v. Kappos, 561 U.S. 593, 612 (2010).

[537] *See, e.g.*, Love, *supra* note 190, at 1356-58 (discussing maintenance fee reform).

[538] *See, e.g.*, Jorge L. Contreras, *A Market Reliance Theory for FRAND Commitments and Other Patent Pledges*, 2015 UTAH L. REV. 479 (proposing a "market reliance" theory for enforcing patent pledges). Antitrust enforcement can also play a role in ensuring adequate access to standards-essential patents. *See* USPTO, DOJ & NIST, POLICY STATEMENT ON REMEDIES FOR STANDARDS-ESSENTIAL PATENTS SUBJECT TO VOLUNTARY F/RAND COMMITMENTS 1 (2019).

First, private ordering can help deconcentrate technological industries.[539] As noted, the theory of the firm predicts that the efficiencies of ever-increasing size eventually fall prey to the costs of managing large bureaucracies.[540] This phenomenon is reflected in market valuations, which tend to reward specialization rather than overly diversified conglomerates.[541] The proliferation of mergers and acquisitions in the face of such poor market performance raises the question of why so many deals proceed. Here, rather than market failure, there appears to be cognitive failure on the part of executives, directors, and shareholders in not recognizing the long-term value of specialization. Support for mergers and acquisitions may arise from biased estimates of their likelihood of success[542] or principal-agent problems due to executives focusing on quarterly gains rather than long-term market value.[543] Greater attention to the market benefits of specialization can help bloated companies voluntarily divest units falling outside of their focus and refrain from ill-advised mergers and acquisitions. Private ordering can also approximate some of the benefits of fragmentation even within formally concentrated industries. Decentralized corporate structures can maintain multiple sources of innovation, such as parallel research and development centers within the same biopharmaceutical company.[544] By increasing the number of internal decision nodes, large companies can enjoy certain benefits of parallel innovation while still keeping valuable assets under one corporate roof.

Second, federal innovation policy can promote entry and competition in fields that commercialize patented technologies. As discussed above, technological advances can contribute to industry fragmentation, though depending on context their effects may be greater in upstream regions of the value chain focused on research and development. Long-

[539] *Cf.* McGowan, *supra* note 254, at 734 ("As a general matter, markets almost certainly do correct market failures faster and more surely than courts.").

[540] *See supra* notes 49–51 and accompanying text.

[541] *See supra* note 498 and accompanying text.

[542] *See* Schief et al., *supra* note 235, at 425 (identifying managerial hubris as a driver of mergers and acquisitions).

[543] *See* Robert Anderson IV, *The Long and Short of Corporate Governance*, 23 GEO. MASON L. REV. 19, 29-30 (2015); Lucian A. Bebchuk, *The Myth That Insulating Boards Serves Long-Term Value*, 113 COLUM. L. REV. 1637, 1658-60 (2013); Lynn A. Stout, *The Toxic Side Effects of Shareholder Primacy*, 161 U. PA. L. REV. 2003, 2016-18 (2013). Additionally, there is anecdotal evidence that consultants, investment bankers, lawyers, and other professionals involved in mergers and acquisitions push for such transactions, which financially benefit them.

[544] Lee, *Innovation*, *supra* note 37, at 1452 n.89.

term investments in scientific and technological research can pay large dividends in innovation and industry entry.[545] The fundamental techniques of recombinant DNA technology arose from federally funded, academic research at Stanford and University of California, San Francisco ("UCSF").[546] Additionally, government support was essential to the development of the software industry.[547] Beyond funding upstream academic research, federal support plays an important role in traversing the "valley of death" from academic discoveries to commercial prototypes.[548] Given the considerable cost and risk of commercializing technology, the federal government can encourage firm formation and industry entry by expanding research and startup funding through Small Business Innovation Research and Small Business Technology Transfer grants.[549] Additionally, efficient capital markets are critical to funding new ventures, overcoming cost barriers to entry, and ensuring robust competition.[550] Large firms with internal cash reserves enjoy a significant advantage over small firms that must rely on external financing.[551] Congress should consider expanding its funding for the Small Business Investment Company program, which provides financing to venture capital entities that invest in promising businesses.[552] While many venture capital-backed startups will be absorbed by incumbents,[553] at the margin, robust federal funding for

545 *See* Peter Lee, *Democratic Engagement and the Republic of Science*, 51 UC DAVIS L. REV. 617, 630-36 (2017); Mariana Mazzucato, *The Innovative State: Governments Should Make Markets, Not Just Fix Them*, FOREIGN AFF. Jan.–Feb. 2015, at 61.

546 Hughes, *supra* note 352, at 541-42.

547 *See generally* David C. Mowery & Richard N. Langlois, *Spinning Off and Spinning On(?): The Federal Government Role in the Development of the US Computer Software Industry*, 25 RES. POL'Y 947 (1996) (discussing the role of the federal government in the development of the U.S. computer software industry).

548 *See, e.g.*, Arti K. Rai, Jerome H. Reichman, Paul F. Uhlir & Colin Crossman, *Pathways Across the Valley of Death: Novel Intellectual Property Strategies for Accelerated Drug Discovery*, 8 YALE J. HEALTH POL'Y L. & ETHICS 1, 12-13 (2008) (describing a National Institutes of Health program that uses "public funding to advance research on targets to a stage that would elicit industry interest").

549 *See* Bryan K. Ford, Erik Sander, Kathleen J. Shino & J. Michael Hardin, *SBIR and STTR Programs: The Private Sector, Public Sector and University Trifecta*, 39 J. RES. ADMIN. 58, 58-59 (2008); Mazzucato, *supra* note 545, at 65-66 (discussing the impact of SBIR grants).

550 *See* COUNCIL OF ECON. ADVISORS, *supra* note 9, at 14; Porter, *The Five Competitive Forces*, *supra* note 23, at 27; *see also* Richman et al., *supra* note 92, at 818-19 (discussing the importance of venture capital to the biopharmaceutical industry).

551 *See* Baker, *supra* note 429, at 578.

552 *See* Mazzucato, *supra* note 545, at 66.

553 *See* Lemley & McCreary, *supra* note 339, at 10.

technology and innovation can promote sustained entry and competition.

Third, while private ordering and public innovation policy can enhance entry, the most direct tool for remedying concentration is antitrust law.[554] While this Article has focused on forces shaping industry-wide concentration, such forces can produce concentration at the level of individual markets, the traditional focus of antitrust analysis. In considering the potential application of antitrust law to address market concentration, it is worth noting that the normative objectives of antitrust law are multifaceted and contested.[555] The dominant Chicago school of antitrust emphasizes efficiency and consumer welfare.[556] While these are laudable goals, this Article adopts the consensus view that promoting innovation is also a key objective of antitrust law.[557] Finally, expanding beyond the Chicago school's preoccupation with efficiency,[558] this Article joins others in arguing for a renewed interest in protecting competitive industry structure.[559]

With these normative considerations in mind, this Article proposes several principles to guide antitrust enforcement. First, context matters.[560] Courts and regulators must consider not only the fact of industry concentration but also why it has arisen and its effects on

[554] COUNCIL OF ECON. ADVISORS, *supra* note 9, at 1, 10 (indicating the importance of antitrust enforcement to block consolidation that reduces competition). Among other benefits, antitrust law is perceived to be less influenced by interest groups than intellectual property law. Hovenkamp, *supra* note 428, at 750.

[555] *See* Carrier, *supra* note 240, at 808 (noting that the legislative history of the Sherman Act reveals several potential goals, including promoting consumer welfare, small businesses, competition, and economic fairness); Khan, *supra* note 9, at 734-44.

[556] ROBERT H. BORK, THE ANTITRUST PARADOX: A POLICY AT WAR WITH ITSELF 91 (1978); Daniel A. Crane, *The Tempting of Antitrust: Robert Bork and the Goals of Antitrust Policy*, 79 ANTITRUST L.J. 835, 835 (2014); Maurice E. Stucke, *Reconsidering Antitrust's Goals*, 53 B.C. L. REV. 551, 563-64 (2012). Within the dominant Chicago approach, there has been some debate over whether antitrust law should maximize total or consumer welfare. *See* Stucke, *supra*, at 566.

[557] U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, *supra* note 22, at 2; Baker, *supra* note 429, at 576; Carrier, *supra* note 240, at 801; *see* Gilbert & Sunshine, *supra* note 428, at 594; Katz & Shelanski, *supra* note 428, at 2-3; Khan, *supra* note 9, at 739; Waller & Sag, *supra* note 329, at 2240.

[558] Khan, *supra* note 9, at 737; Richard A. Posner, *The Chicago School of Antitrust Analysis*, 127 U. PA. L. REV. 925, 932 (1979).

[559] *See* Khan, *supra* note 9, at 737-46; McGowan, *supra* note 254, at 742-43. Indeed, antitrust laws protected small firms against the greater efficiency of large corporate combinations. *Id.*

[560] *See* Baker, *supra* note 429, at 601.

welfare and innovation.[561] In agricultural biotechnology, horizontal mergers of large competitors have produced markets characterized as "highly concentrated."[562] While incumbents like Bayer and Monsanto tout the efficiency gains of such combinations, empirical evidence indicates that they do not enhance innovation and can significantly harm consumer welfare.[563] In other contexts, however, large firms have emerged from efficiency gains, and breaking up such firms may have deleterious consequences.[564] For instance, concentration in certain software markets, such as operating systems, may be salutary due to the benefits of network effects.[565]

Second, antitrust authorities should be mindful of the significant barriers to entry in markets commercializing patented technologies. Even highly concentrated markets may not raise competitive concerns because the *threat* of new entry can discipline incumbents.[566] However, as this Article has revealed, barriers to entry can be formidable, thus lessening this mitigating force. In particular, while the software industry — and its constituent markets — is often characterized by low barriers to entry, a host of barriers, from patent thickets to high fixed costs to network effects, hinder entry in that field.

Third, precise market definition is critical to assessing competitive harms and determining appropriate antitrust enforcement.[567] An industry that appears fragmented due to numerous participants can obscure significant concentration in individual markets defined by product lines or geography.[568] Determining the relevant market is an uncertain task, as it is not obvious what goods and services consumers

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[561] *Cf.* United States v. Aluminum Co. of Am., 148 F.2d 416, 430 (2d Cir. 1945) ("The successful competitor, having been urged to compete, must not be turned upon when he wins."); Demsetz, *Industry Structure*, *supra* note 56, at 3 (distinguishing between high profits arising from superior performance and those arising from collusion).

[562] *Hearing*, *supra* note 130, at 7.

[563] *See supra* Parts VI.A and VI.C.

[564] Demsetz, *Industry Structure*, *supra* note 56, at 5; Hovenkamp & Shapiro, *supra* note 221, at 2005.

[565] *See* McGowan, *supra* note 254, at 774, 776; *supra* notes 247–255 and accompanying text. The benefits of such network effects, however, must be weighed against the costs of inefficient lock-in.

[566] *See supra* notes 450–452 and accompanying text.

[567] *See* Andrew Chin, *Antitrust Analysis in Software Product Markets: A First Principles Approach*, 18 HARV. J.L. & TECH. 1, 1 (2004) (exploring the importance of market definition in software antitrust actions).

[568] KING, *supra* note 179, at 3.

consider to be economic substitutes.[569] However, this task is highly important, for the industries profiled here span dozens if not hundreds of individual markets. While the biopharmaceutical industry contains a large number of players, it is highly differentiated and features numerous markets; diabetes medications are simply not an economic substitute for cancer treatments. Furthermore, as noted, one analysis of the software industry identified 114 distinct product markets.[570]

Fourth, given the centrality of mergers and acquisitions to industry concentration, this Article argues for greater scrutiny of such transactions.[571] Established precedent applying the Clayton Act holds that Congress intended to block anticompetitive mergers in their "incipiency" before they "gathered momentum."[572] As Jonathan Baker notes, "antitrust promotes innovation by challenging horizontal mergers that reduce the number of likely innovators when there are few, absent countervailing innovation efficiencies."[573] While acknowledging the efficiency gains of some mergers and acquisitions, this Article argues for a more nuanced conception of efficiency.[574] Reflecting the influence of the Chicago school, regulators are likely to view the elimination of redundancies as an "efficiency" that weighs in favor of approving a merger or acquisition.[575] However, a macroscopic perspective reveals

[569] Carrier, *supra* note 240, at 791; Shapiro, *Antitrust*, *supra* note 9, at 722. *See generally* Katz & Shapiro, *Software*, *supra* note 24, at 39 (discussing the use of SSNIP analysis to define antitrust markets).

[570] Marotta-Wurgler & Taylor, *supra* note 26, at 252; s*ee supra* notes 24–27 and accompanying text. Software markets in particular tend to be highly differentiated, so even programs with partially overlapping functionality may be in different markets. Katz & Shapiro, *Software*, *supra* note 24, at 39; s*ee also* Abdela & Steinbaum, *supra* note 27, at 4 (noting that the concentration in particular antitrust markets will typically be much higher than concentration in an industry overall).

[571] *See* Shapiro, *Antitrust*, *supra* note 9, at 738; *cf.* Katz & Shelanski, *supra* note 428, at 6 (calling for greater consideration of innovation in merger review, though with a presumption that a merger's effects on innovation are neutral unless the merger produces a monopoly, where there would be a rebuttable presumption of harm). From 2004–2014, the DOJ and FTC challenged 250 transactions, alleging harm to innovation in eighty-four (33.6%) of them. Gilbert & Greene, *supra* note 436, at 1933; s*ee also* Waller & Sag, *supra* note 329, at 2240-45 (proposing recommendations for merger analysis to promote innovation).

[572] Brown Shoe Co. v. United States, 370 U.S. 294, 317-18 (1962); U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, *supra* note 22, at 1, 25.

[573] Baker, *supra* note 429, at 592.

[574] Further advancing the practicality of this proposal, there is significant flexibility to enhance merger enforcement without requiring new legislative reforms. *See* Hovenkamp & Shapiro, *supra* note 221, at 2021.

[575] *See* U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, *supra* note 22, at 23; Moss & Taylor, *supra* note 243, at 358-59; Pitofsky, *supra* note 240, at 915.

that certain redundancies, such as parallel research and development units, can valuably increase sources of innovation.[576] The likelihood that a consolidation deal would significantly reduce aggregate resources for research, development, and discovery should weigh against such a transaction.

CONCLUSION

This Article has explored the forces that shape the commercialization of patented technologies in three key industries: biopharmaceuticals; agricultural biotechnology, seeds, and agrochemicals; and software. While theories exploring the impact of patents on industry structure offer helpful insights, a more holistic approach reveals myriad forces that shape such fields. This Article has argued that such industry segments feature several concentration drivers, including direct barriers to entry based on exclusivity and cost, indirect barriers to entry based on efficiencies of size, and significant merger and acquisition activity. Although countered by several fragmentation drivers, including technology-based entry, specialization and divestures, and antitrust enforcement, these concentration drivers produce significant consolidation in the commercialization of drugs, genetically modified seeds, and software. This Article further reveals that while technological industries are subject to the same general economic and strategic forces affecting all other industries, technology and its protection by patents can amplify concentration and fragmentation drivers in underappreciated ways. Turning to normative considerations, while concentration can enhance innovation and efficiency to a point, ultimately it undermines innovation, efficiency, consumer welfare, and democratic representation. This Article argues that patent policy must be more attentive to the impact of exclusive rights on industry structure, and it proposes a holistic approach spanning private ordering, federal innovation policy, and antitrust enforcement to mitigate excessive concentration.

[576] *See* U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, *supra* note 22, at 31; Kattan, *supra* note 428, at 116; *see supra* note 463 and accompanying text.