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# Innovation and the Firm: A New Synthesis

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**Abstract.** Recent scholarship highlights the prevalence in high-technology industries of vertical disintegration, in which separate entities along a value chain transfer knowledge-intensive assets between them. Patents play a critical role in this process by lowering the cost of transactions between "upstream" technology generators and "downstream" parties that further develop technologies, thus promoting vertical disintegration.

This Article challenges that prevailing narrative by arguing that vertical integration pervades patent-intensive fields. In biopharmaceuticals, agricultural biotechnology, information technology, and even university-industry technology transfer, firms are increasingly integrating under a common organizational framework rather than remaining separate and licensing patents between distinct entities.

This Article explains the surprising persistence of vertical integration by retheorizing the relationship between innovation and the firm. It therefore sheds new light on a longstanding debate over whether innovation should be organized within a hierarchical organization—the firm—or coordinated through market exchanges among separate entities. Synthesizing previously disconnected lines of theory, this Article first argues that the challenge of aggregating tacit technical knowledge—which patents do not disclose—leads high-tech companies to vertically integrate rather than simply rely on licenses to

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transfer technology. Relatedly, the desire to obtain not just discrete technological assets but also innovative capacity, in the form of talented engineers and scientists, motivates vertical integration. Finally, strategic imperatives to achieve rapid scale and scope also lead firms to integrate with other entities rather than simply license their patents. Tacit knowledge, innovative capacity, and strategic considerations explain not only why firms vertically integrate but also why they do so by acquiring preexisting organizations and granting them significant autonomy, an underappreciated phenomenon this Article describes as "semi-integration." The result, contrary to theory, is a resurgence of vertical integration in patent-intensive fields. This Article concludes by evaluating the costs and benefits of vertically integrated innovative industries, suggesting private and public mechanisms for improving integration and tempering its excesses.

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## Introduction

*"Companies are buying innovation."*
—Peter Levine[1]

Merck had a problem, and Afferent Pharmaceuticals offered a solution. Recent and upcoming patent expirations on key drugs like Remicade and Nasonex were severely threatening Merck's revenues.[2] Seeking promising drugs to fill its pipeline, in 2016 Merck looked to Afferent, a small biotechnology firm that develops drugs to treat various neurogenic conditions including chronic cough.[3] Afferent had two promising compounds undergoing clinical trials, both of which were subject to patents or patent applications.[4] Merck's interest in developing these compounds into marketable drugs was not surprising, and a well-established law and economics literature suggests that Merck should have simply licensed Afferent's intellectual property.[5] After all, patents represent a relatively low-cost means of transferring technology.[6]

But Merck did not just license Afferent's patents; it purchased the entire company in a deal worth up to $1.25 billion,[7] which is presumably much more than the value of the patents alone. Merck's acquisition of Afferent illustrates a significant trend, as major pharmaceutical firms have been vertically integrating by acquiring small biotech firms instead of simply licensing their patents. It also raises broader questions about the role of patents and technical knowledge in driving vertical integration and the impact of such industrial organization on innovation.

1. Victor Luckerson, *How Google Perfected the Silicon Valley Acquisition*, TIME (updated Apr. 21, 2015), https://perma.cc/QYT3-YM4B (quoting Peter Levine, general partner at venture capital firm Andreessen Horowitz).
2. *See* Peter Loftus & Jonathan D. Rockoff, *Merck Sees Acquisitions as Beneficial Amid Biotech Slump*, WALL ST. J. (updated Oct. 27, 2015, 12:36 PM ET), https://perma.cc/T7AS-NQCH; Maggie McGrath, *Merck Sales Slide on Expiring Drug Patents but Shares Lifted by Cancer-Fighting Collaboration*, FORBES (Feb. 5, 2014, 9:51 AM), https://perma.cc/6288-FZ3P; Ned Pagliarulo, *Merck Sales Hit by Generic Competition in US, Europe*, BIOPHARMA DIVE (May 5, 2016), https://perma.cc/F94C-SPN2. The "patent cliff" also threatens other global pharmaceutical companies. *See* Duff Wilson, *Drug Firms Face Billions in Losses in '11 as Patents End*, N.Y. TIMES (Mar. 6, 2011), https://perma.cc/8H67-FK29.
3. *See* Sarah Pringle, *Merck to Bulk Up with Afferent*, THESTREET (June 9, 2016, 6:37 PM EDT), https://perma.cc/TSK9-53NM.
4. *See* Megan Cully, *Merck Bets on Purine Receptor Revival*, 15 NATURE REVS. DRUG DISCOVERY 525, 525 (2016). At the time, Afferent had several patents and patent applications covering its compounds. *See* U.S. Patent No. 9,724,346 (filed Feb. 2, 2016); U.S. Patent No. 9,284,279 (filed Aug. 22, 2014); U.S. Patent Application Serial No. 15/323,619 (filed July 2, 2015).
5. *See infra* Part I.
6. *See infra* Part I.B.
7. Cully, *supra* note 4, at 525.

A striking pattern has emerged in patent-intensive industries: vertical integration. In a vertically integrated value chain, a single company combines two or more stages of production, such as basic research and further development of some technology, ordinarily performed by separate companies. In several fields, "upstream" technology suppliers (those that generate a foundational technology) like Afferent and "downstream" technology users (those that develop and add value to existing technologies) like Merck are integrating under common ownership rather than simply licensing patents between them.

This pattern is especially notable given substantial academic commentary emphasizing the *decline* of vertical integration in patent-intensive industries.[8] According to these accounts, patents facilitate market-based technology transactions between separate upstream and downstream entities. These accounts emphasize that such separation promotes efficiency by enabling specialization along vertically disintegrated value chains. To illustrate this trend, scholars have explored a proliferation of vertically disintegrated organizational forms, such as contracts for innovation, networks, and the commons. According to one commentator, "The day of the vertically integrated company has come to a close . . . ."[9]

This Article challenges that conventional wisdom by subjecting the theory of the firm to the realities of modern industrial organization. Drawing on empirical accounts, this Article argues that in several key patent-intensive fields, firms are increasingly resorting to vertical integration rather than market exchanges (or other nonhierarchical mechanisms) to transfer and develop patented technologies. While industrial landscapes are, of course, complex and multifaceted, this development is evident in a spate of vertical acquisitions in the biopharmaceutical, agricultural biotechnology, and information technology industries. It is even evident to a lesser extent in a high degree of institutional meshing between universities and companies licensing academic patents.

The striking resurgence of vertical integration sheds new light on the relationship between innovation and the firm. It therefore intersects with a longstanding academic debate over whether productive activity—such as innovation—should be organized within a hierarchical organization—the firm—or coordinated through market exchanges among separate entities. This Article does not disclaim that patents lower transaction costs, thus promoting market exchanges and vertical disintegration, as the academic literature has demonstrated. Rather, this Article contends that countervailing forces pushing

8. *See infra* Part I.

9. ORLY LOBEL, TALENT WANTS TO BE FREE: WHY WE SHOULD LEARN TO LOVE LEAKS, RAIDS, AND FREE RIDING 130 (2013).

toward vertical integration often overwhelm the disintegrating force of patents.

Synthesizing and extending previously disconnected theories, this Article presents a novel framework for understanding such integration. First, it argues that the challenges of aggregating technical knowledge—particularly tacit knowledge not disclosed in patents—play a significant role in driving firms to acquire companies rather than simply license their intellectual property. Even when patents and licenses are available to transfer a technology, interaction with the original inventive entity is often necessary to unlock the full potential of that technology and commercialize it. Second and relatedly, it argues that the desire to obtain not just discrete technological assets but also innovative capacity, in the form of talented engineers and scientists, motivates vertical integration. Third, it argues that strategic imperatives to achieve rapid scale and scope, exclude competitors, and appease investors also lead firms to vertically integrate rather than contract with independent parties. Patents may promote vertical disintegration, but knowledge, human capital, and strategic demands often push harder in the opposite direction—toward vertical integration.

To elucidate this phenomenon, this Article draws on the sociology of knowledge to introduce the novel concept of "semi-integration." While vertical integration offers several benefits, it is not immediately clear why technology firms are absorbing preexisting companies and institutions rather than vertically integrating by simply hiring individual scientists and engineers in the labor market. This Article argues, however, that tacit knowledge and innovative capacity are socially embedded properties that inhere not only in individuals but also in organizations. The particular culture, processes, and modes of operation of a startup or university laboratory are critical to cultivating tacit knowledge and producing innovations; to gain the full benefit of such knowledge, a company must integrate with that entire organization rather than just cherry-pick individuals. The socially embedded nature of tacit knowledge and innovative capacity, however, poses a challenge for acquisitions. While a startup is valuable for its distinctive culture, processes, and modes of operation, fully assimilating that startup into a new corporate structure may destroy those characteristics. Consequently, this Article introduces the concept of semi-integration to describe acquisitions that afford significant autonomy to acquired entities. Semi-integration is different from partial or quasi-integration, in which only *parts* of two organizations merge, such as in joint ventures or partial equity stakes between two companies. Rather, in semi-integration, one entity fully absorbs another, but the acquired entity then maintains a semiautonomous status within its new institutional home.

In a broader sense, this Article argues that there is no stark dichotomy between vertical integration and disintegration but rather a continuum of organizational forms, including semi-integration. This Article thus contributes to the literature on industrial organization by revealing that disintegrated organizational forms prevail not only between firms but also within them. Moving from theoretical to normative analysis, this Article argues that vertical integration frequently enhances efficiency and innovation, though it may produce competitive harms. Accordingly, it offers prescriptions for private parties to improve integration and for antitrust authorities to curb integration that unduly harms competition.

This Article proceeds in five Parts. Part I explores the theory of the firm and the prevailing view that patents enable market transactions, thus promoting vertical disintegration. It also explores the burgeoning literature highlighting various forms of vertical disintegration, from contracts for innovation to the commons. Part II challenges this prevailing academic narrative by introducing a theoretical framework in which tacit knowledge, innovative capacity, and strategic considerations drive vertical integration in high-tech fields. It further highlights the socially embedded nature of tacit knowledge and innovative capacity, which leads firms to semi-integrate by acquiring preexisting companies and institutions but granting them significant autonomy. Part III turns from theory to empirical reality to argue that vertical integration plays a prominent role in organizing high-tech industries. In biopharmaceuticals, agricultural biotechnology, and information technology, Part III finds considerable evidence of vertical integration, primarily via mergers and acquisitions of preexisting companies. It also observes a surprisingly high degree of organizational integration between universities and companies licensing their patents. Furthermore, it reveals the prevalence of semi-integration in patent-intensive fields. Part IV draws on these findings to retheorize the relationship between innovation, patents, and the firm. It also normatively evaluates vertical integration in high-tech industries, lauding its efficiency gains but cautioning that it may be poorly executed and harm competition. Part V provides prescriptions for private parties to improve the efficacy of vertical integration and for public parties to temper its excesses.

## I. Prevailing Accounts of Transaction Costs, Patents, and Vertical Disintegration

A substantial amount of academic commentary has heralded the prevalence of vertical *dis*integration in high-tech industries. Drawing on the theory of the firm, scholars have influentially argued that patents promote transactions between separate technology providers and users, thus facilitating vertical disintegration. Relatedly, scholars in law, economics, and sociology have fruitfully explored the emergence of a variety of nonhierarchical organizational forms, from contracts for innovation to the commons. While these arguments are compelling, this Article will later challenge and refine these influential academic accounts by exploring the persistence of vertical integration in patent-intensive fields.

### A. The Theory of the Firm

As Ronald Coase explored in the early twentieth century, firms face a "make or buy" question at the heart of vertical integration: When should a firm *buy* production inputs on the market from an independent supplier, and when should it vertically integrate and *make* those inputs in-house?[10] At first glance, gains from specialization and trade suggest that market-based production, mediated by prices, is more efficient than production within hierarchical firms.[11] However, Coase's theory of the firm famously posited that transaction costs largely explain the emergence of vertically integrated firms. Where the transaction costs of market exchanges—including calculating prices, negotiating deals, and accounting for future uncertainty—exceed those of coordinating production within hierarchical firms, vertical integration will prevail.[12]

Building on Coase's work, economists like Oliver Williamson emphasized that opportunistic behavior between contracting parties represents a significant transaction cost that pushes firms toward vertical integration. Opportunism arises when one party makes asset-specific investments in reliance on a deal, thus providing leverage to a counterparty to demand greater payment or shirk its part of the bargain.[13] Vertical integration mitigates such opportunism by bringing both parties within the same corporate fold. Relatedly, the "incompleteness" of contracts—the inability of contracts to accommodate all potential contingencies—also discourages market-based

10. *See* R.H. Coase, *The Nature of the Firm*, 4 ECONOMICA (N.S.) 386, 394-96 (1937).

11. *See* Richard N. Langlois, *The Vanishing Hand: The Changing Dynamics of Industrial Capitalism*, 12 INDUS. & CORP. CHANGE 351, 352 (2003) ("[T]he Smithian process of the division of labor always tends to lead to finer specialization of function and increased coordination through markets. . . .").

12. *See* Dan L. Burk, Essay, *Intellectual Property and the Firm*, 71 U. CHI. L. REV. 3, 5 (2004); Coase, *supra* note 10, at 390-93; Harold Demsetz, *The Theory of the Firm Revisited*, 4 J.L. ECON. & ORG. 141, 145 (1988); *see also* Arti K. Rai, *Fostering Cumulative Innovation in the Biopharmaceutical Industry: The Role of Patents and Antitrust*, 16 BERKELEY TECH. L.J. 813, 835 (2001) ("[L]icensing (even ex ante licensing) entails steep transaction costs, and movements toward vertical integration can reduce transaction costs, at least over the long term.").

13. *See, e.g.*, Oliver E. Williamson, *Transaction-Cost Economics: The Governance of Contractual Relations*, 22 J.L. & ECON. 233, 234 (1979) ("[O]pportunism is especially important for economic activity that involves transaction-specific investments in human and physical capital."); *see also* Demsetz, *supra* note 12, at 149-50.

transactions and encourages vertical integration.[14] Accordingly, property rights theorists like Oliver Hart argue that the difficulty of specifying and contracting for particular rights leads firms to seek "residual rights of control" by simply purchasing another entity outright,[15] thus achieving vertical integration.

While contractual hazards affect all market exchanges, they particularly burden technology transactions. New technologies are notoriously difficult to specify with precision, thus imbuing research contracts with a certain degree of incompleteness.[16] One hazard that particularly afflicts technology transactions is Arrow's information paradox. As economist Kenneth Arrow described, a buyer will typically insist on examining some technology before purchasing it.[17] If she does so, however, there is a risk she will simply appropriate the technology without compensating the seller.[18] In the absence of some mechanism for overcoming this information paradox, parties may prefer to vertically integrate, thus eliminating the threat of opportunistic behavior.

### B. Patents as Mechanisms to Promote Transactions and Vertical Disintegration

Drawing on the theory of the firm, an important strand of patent scholarship has explored the role of patents in promoting technology transactions

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14. *See* Benjamin Klein, *Transaction Cost Determinants of "Unfair" Contractual Arrangements*, 70 AM. ECON. REV. (PAPERS & PROC.) 356, 356, 362 (1980); Oliver E. Williamson, *The Institutions of Governance*, 88 AM. ECON. REV. (PAPERS & PROC.) 75, 76 (1998); Oliver E. Williamson, *The New Institutional Economics: Taking Stock, Looking Ahead*, 38 J. ECON. LITERATURE 595, 600-01 (2000) [hereinafter Williamson, *New Institutional Economics*].

15. *See* Sanford J. Grossman & Oliver D. Hart, *The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration*, 94 J. POL. ECON. 691, 716 (1986); *see also* Oliver Hart, *An Economist's Perspective on the Theory of the Firm*, 89 COLUM. L. REV. 1757, 1765-66 (1989); Oliver D. Hart, *Incomplete Contracts and the Theory of the Firm*, 4 J.L. ECON. & ORG. 119, 124 (1988); Oliver Hart & John Moore, *Property Rights and the Nature of the Firm*, 98 J. POL. ECON. 1119, 1120 (1990); *cf.* Williamson, *New Institutional Economics*, *supra* note 14, at 605-06 (discussing differences between the transaction-cost economics and property rights approaches to the theory of the firm). *See generally* Dan L. Burk & Brett H. McDonnell, *The Goldilocks Hypothesis: Balancing Intellectual Property Rights at the Boundary of the Firm*, 2007 U. ILL. L. REV. 575, 578-82; Michael J. Burstein, *Exchanging Information Without Intellectual Property*, 91 TEX. L. REV. 227, 244 (2012).

16. *See* Philippe Aghion & Jean Tirole, *The Management of Innovation*, 109 Q.J. ECON. 1185, 1189 (1994).

17. *See* KENNETH J. ARROW, *Economic Welfare and the Allocation of Resources for Invention*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 615 (Nat'l Bureau of Econ. Research ed., 1962).

18. *See id. But see* Burstein, *supra* note 15, at 230, 267-74 (examining instances where information exchange occurs without full or any intellectual property rights).

between separate entities, thus facilitating vertical disintegration.[19] Patents reduce several costs of technology transactions.[20] For instance, they resolve Arrow's information paradox by allowing a seller who has patented a technology to disclose it to a prospective buyer without the threat of uncompensated appropriation.[21] More broadly, codification of technical knowledge in a patent allows it to be packaged, licensed, and outsourced.[22] Because patents reduce the cost of technology transactions, they promote the existence of separate technology providers and users along a disintegrated value chain.[23] Conversely, uncertain or narrow patent rights can provide technology buyers with leverage over technology providers, thus raising transaction costs and encouraging vertical integration.[24]

19. *See, e.g.*, Jonathan M. Barnett, *Intellectual Property as a Law of Organization*, 84 S. CAL. L. REV. 785, 787 (2011); Burk & McDonnell, *supra* note 15, at 583-90; Dan L. Burk, *The Role of Patent Law in Knowledge Codification*, 23 BERKELEY TECH. L.J. 1009, 1011 (2008); Paul J. Heald, *A Transaction Costs Theory of Patent Law*, 66 OHIO ST. L.J. 473, 475-76 (2005); Robert P. Merges, *A Transactional View of Property Rights*, 20 BERKELEY TECH. L.J. 1477, 1486 (2005); *cf.* Tim Wu, Essay, *Intellectual Property, Innovation, and Decentralized Decisions*, 92 VA. L. REV. 123, 123 (2006) ("[A growing body of] scholarship suggests that the most important economic effects of intellectual property may not be effects on price, but rather on *industry structure*.").

20. *See* Jonathan M. Barnett, *Cultivating the Genetic Commons: Imperfect Patent Protection and the Network Model of Innovation*, 37 SAN DIEGO L. REV. 987, 1012-13 (2000); Heald, *supra* note 19, at 476; F. Scott Kieff, *IP Transactions: On the Theory & Practice of Commercializing Innovation*, 42 HOUS. L. REV. 727, 735-36 (2005); Merges, *supra* note 19, at 1486.

21. *See* Barnett, *supra* note 20, at 1013; Merges, *supra* note 19, at 1485; *see also* Heald, *supra* note 19, at 475 & n.16; *cf.* Oren Bar-Gill & Gideon Parchomovsky, *Law and the Boundaries of Technology-Intensive Firms*, 157 U. PA. L. REV. 1649, 1653-55 (2009) (describing Arrow's paradox and ways of resolving it); Jonathan M. Barnett, *Three Quasi-fallacies in the Conventional Understanding of Intellectual Property*, 12 J.L. ECON. & POL'Y 1, 10-17 (2016) [hereinafter Barnett, *Three Quasi-fallacies*].

22. *See* Robin Cowan & Dominique Foray, *The Economics of Codification and the Diffusion of Knowledge*, 6 INDUS. & CORP. CHANGE 595, 597-98 (1997).

23. *See* Merges, *supra* note 19, at 1517-19 (discussing the importance of property rights, including patents, to vertical disintegration).

24. *Cf.* Burk & McDonnell, *supra* note 15, at 617 ("As legal protection moves away from [the] optimal level of protection towards either weaker or stronger protection, the costs of interfirm transactions increase."); Williamson, *New Institutional Economics*, *supra* note 14, at 603 (identifying "weak property rights (especially intellectual property rights)" as a "source[] of contractual hazard").

In a related vein, David Teece has argued that vertical integration can compensate for a weak "appropriability regime" (such as weak intellectual property rights), thus enabling innovators to capture a higher proportion of profits arising from innovation. *See* David J. Teece, *Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy*, 15 RES. POL'Y 285, 296 (1986) [hereinafter Teece, *Profiting*]; David J. Teece, Profiting from Innovation in the Digital Economy: Standards, Complementary Assets, and Business Models in the Wireless World 4 (Jan. 22, 2017) (unpublished manuscript) (on file with author) [hereinafter Teece, Digital Economy]. While this Article focuses on transaction costs between firms, other

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Drawing on these observations, Ashish Arora and Robert Merges argue that patents enable the existence of small, innovative, research-intensive firms alongside larger incumbents within a common value chain.[25] These small firms produce patented assets as their primary output, and they rely on the reduced transaction costs afforded by patents to contract with larger downstream entities to commercialize these assets.[26] For instance, strong patent rights facilitate the existence of small, research-intensive biotech firms that patent biologics and then license them to large pharmaceutical firms for commercialization.[27] Similarly, Jonathan Barnett contends that patents allow industries to disaggregate vertically into inventing and manufacturing units, with intellectual property-based transactions transferring assets between them.[28] Barnett points in particular to the semiconductor industry, which features upstream "fabless" design firms that license designs to downstream chip manufacturers.[29]

According to these accounts, patents in high-technology industries promote innovation not only by providing traditional incentives to invent but also by facilitating the efficiency gains of vertical disintegration.[30] Small firms tend to be disproportionately innovative relative to large firms, in part because of their nimble management structures and proximity to high-powered market incentives as opposed to the muted, low-powered incentives within large, bureaucratic companies.[31] Within this view, an industrial ecosystem

scholars have fruitfully explored the impact of intellectual property rights on transaction costs *within* firms. *See, e.g.*, Burk & McDonnell, *supra* note 15, at 591-600.

25. *See* Ashish Arora & Robert P. Merges, *Specialized Supply Firms, Property Rights and Firm Boundaries*, 13 INDUS. & CORP. CHANGE 451, 455 (2004). Notably, the authors constrain the sweep of their thesis, stating that "in one limited context, stronger [intellectual property rights] make it possible for technology-intensive inputs to be supplied by separate firms." *Id.* at 452; *see also* Giovanni B. Ramello, *Property Rights, Firm Boundaries, and the Republic of Science—A Note on Ashish Arora and Robert Merges*, 14 INDUS. & CORP. CHANGE 1195, 1195 (2005) (recognizing this limitation).

    In response to Arora and Merges's theory, Dan Burk and Brett McDonnell caution that although strong patent rights can facilitate the emergence of small, modular firms, they can also cause anticommons effects that thwart innovation. *See* Burk & McDonnell, *supra* note 15, at 615.

26. *Cf.* Arora & Merges, *supra* note 25, at 452-56.

27. *See* Ashish Arora, *Licensing Tacit Knowledge: Intellectual Property Rights and the Market for Know-How*, 4 ECON. INNOVATION & NEW TECH. 41, 54 (1995).

28. *See* Barnett, *supra* note 19, at 838-39.

29. *See id.* at 838-53; *see also* Langlois, *supra* note 11, at 373-74 (describing a significant trend toward vertical disintegration since the 1990s).

30. *Cf.* Barnett, *Three Quasi-fallacies*, *supra* note 21, at 13-14.

31. *See* Arora & Merges, *supra* note 25, at 453 (noting that integration undermines the high-powered incentives of market-based contracting); *see also* KAUSHIK SUNDER RAJAN, BIOCAPITAL: THE CONSTITUTION OF POSTGENOMIC LIFE 23 (2006) (noting the nimble

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featuring small firms licensing patents to large companies will be more innovative than one dominated by large, vertically integrated companies.[32] More generally, patent-based vertical disintegration facilitates efficient markets for innovation, thus allowing entire industries to benefit from specialization and trade.[33]

### C. Scholarly Emphasis on Various Forms of Vertical Disintegration

In a related vein, scholars in several fields have argued that high-tech fields are moving away from vertical integration toward nonhierarchical production, a descriptive claim this Article challenges in Part III below. For example, Ronald Gilson and colleagues argue that "contract[s] for innovation," which braid together formal contracts and information control mechanisms, facilitate vertical disintegration in innovative industries.[34] They note that the perils of asset specificity and opportunism might ordinarily push technology firms to forgo contracts and opt for hierarchical coordination.[35] However, they "observe vertical disintegration in a significant number of industries."[36] They posit that a "rich braiding" of explicit contracts and implicit obligations blurs the distinction between contract-based and hierarchical organization and enables robust collaborative innovation.[37] Critiquing and extending the work of Gilson and colleagues, Matthew Jennejohn also recognizes a significant trend toward vertical disintegration and strategic alliances in innovative industries.[38] However, Jennejohn expands his focus to argue that "multivalent contracting" can mitigate exchange hazards beyond specificity and opportunism, such as spillovers and coordination entropy.[39] Despite their differences, both Gilson and colleagues and Jennejohn start from the position

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managerial structures of small biotech firms); OLIVER E. WILLIAMSON, MARKETS AND HIERARCHIES: ANALYSIS AND ANTITRUST IMPLICATIONS; A STUDY IN THE ECONOMICS OF INTERNAL ORGANIZATION 199-203 (1975) (arguing that as firms become more bureaucratic, they become less innovative).

32. For an expanded discussion of the innovation-dampening effects of vertical integration, see text accompanying notes 341-47 below.

33. *See* JOHN L. KING, U.S. DEP'T OF AGRIC., AGRICULTURE INFORMATION BULLETIN NO. 763, CONCENTRATION AND TECHNOLOGY IN AGRICULTURAL INPUT INDUSTRIES 4 (2001), https://perma.cc/N4GB-FC7Y.

34. *See* Ronald J. Gilson et al., *Contracting for Innovation: Vertical Disintegration and Interfirm Collaboration*, 109 COLUM. L. REV. 431, 435 (2009).

35. *See id.* at 433.

36. *See id.* at 434.

37. *See id.* at 435, 473, 494.

38. *See* Matthew Jennejohn, *The Private Order of Innovation Networks*, 68 STAN. L. REV. 281, 284-85 (2016).

39. *See id.* at 313-23 (capitalization altered).

that high-tech industries are highly vertically disintegrated due in large part to the robustness of contracts.

Beyond the legal literature, historians, economists, and sociologists have also argued that high-tech industries are moving toward vertical disintegration. Several decades ago, business historian Alfred Chandler famously chronicled the rise of vertically integrated, multidivisional corporations like IBM and General Electric in the late nineteenth and twentieth centuries.[40] However, more recent research by Richard Langlois has traced a shift away from Chandlerian integrated firms—"a dramatic increase in vertical specialization[,] a thoroughgoing 'de-verticalization.'"[41] Relatedly, Naomi Lamoreaux and colleagues have argued that long-term relational contracts represent an influential means to coordinate production outside of formal hierarchies.[42] Additionally, iterative processes of codesign in which suppliers and manufacturers dialogically refine production specifications represent another decentralized production modality.[43]

Scholars have also emphasized networks as another decentralized production model to aggregate and exploit technical knowledge.[44] Paul Robertson and Langlois offer a topography of networks spanning classic industrial districts of late nineteenth century Britain; cooperative networks featuring clusters of small firms and artisans, such as "Third Italy"; and centralized networks facilitating innovation, such as Silicon Valley and Route 128.[45] Sociologist Walter Powell and others have explored the importance of networks in the biopharmaceutical industry as conduits for transferring knowledge and resources between formally separate entities.[46] This "macro-level mutualism" has been dubbed "virtual integration."[47]

Beyond the market-hierarchy continuum, Yochai Benkler and others have highlighted another powerful, decentralized production system: the

40. *See* Alfred D. Chandler, *Organizational Capabilities and the Economic History of the Industrial Enterprise*, J. ECON. PERSP., Summer 1992, at 79, 82, 91, 95, 97.

41. *See* Langlois, *supra* note 11, at 352; *see also* Arora & Merges, *supra* note 25, at 454.

42. *See* Naomi R. Lamoreaux et al., *Beyond Markets and Hierarchies: Toward a New Synthesis of American Business History*, 108 AM. HIST. REV. 404, 408-09 (2003).

43. *See* Charles F. Sabel & Jonathan Zeitlin, *Neither Modularity nor Relational Contracting: Inter-firm Collaboration in the New Economy*, 5 ENTERPRISE & SOC'Y 388, 397 (2004).

44. *See* Walter W. Powell et al., *Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology*, 41 ADMIN. SCI. Q. 116, 117 (1996).

45. *See* Paul L. Robertson & Richard N. Langlois, *Innovation, Networks, and Vertical Integration*, 24 RES. POL'Y 543, 548-50 (1995).

46. *See, e.g.*, Walter W. Powell, *Inter-organizational Collaboration in the Biotechnology Industry*, 152 J. INSTITUTIONAL & THEORETICAL ECON. 197, 208 (1996); *see also* Julia Porter Liebeskind et al., *Social Networks, Learning, and Flexibility: Sourcing Scientific Knowledge in New Biotechnology Firms*, 7 ORG. SCI. 428, 429 (1996).

47. *See* Powell, *supra* note 46, at 209.

commons.[48] Longstanding sharing regimes in basic academic science and the emergence of open-source software illustrate highly productive arrangements that rely on communal norms and self-coordination rather than market exchanges or significant hierarchical control.[49] In some ways, these decentralized, self-organizing communities are the very antithesis of vertically integrated companies.

In sum, a substantial amount of contemporary scholarship portrays the classic, vertically integrated firm as passé. The theory of the firm holds that vertical integration mitigates transaction costs related to opportunism and asset specificity. However, patents also minimize many of the same costs, thus enabling the emergence of small, research-intensive firms that license patents along vertically disintegrated supply chains. Furthermore, a host of nonhierarchical organizational forms—spanning contracts for innovation, multivalent contracts, vertical specialization, relational contracting, iterative codesign, networks, and the commons—has emerged to organize production outside of large, lumbering vertically integrated firms.

This Article takes a contrary view. It extends Coase's original work on the theory of the firm to emphasize that knowledge costs of production (not just transaction costs) can also motivate vertical integration. It challenges prevailing patent scholarship to illustrate how informational deficiencies in patent-intensive industries lead to hierarchical modes of production. Furthermore, it picks up where analyses by Gilson and colleagues and Jennejohn leave off by exploring the limitations of contracts and the persistence of vertical integration in high-tech industries. Contracts, relationships, and networks can mitigate exchange hazards to a certain degree, but in many cases they are insufficient to bundle knowledge assets and achieve efficient production, thus leaving formal integration as the most viable option. The next Part provides a theoretical framework for exploring these dynamics.

## II. Tacit Knowledge, Innovative Human Capital, and Strategic Considerations Driving Vertical Integration

While the push toward specialization and vertical disintegration is strong, this Article argues that countervailing forces driving vertical integration often

48. *See, e.g.*, YOCHAI BENKLER, THE WEALTH OF NETWORKS: HOW SOCIAL PRODUCTION TRANSFORMS MARKETS AND FREEDOM 5, 320-23 (2006) (exploring the phenomenon of commons-based peer production in several domains, including open-source software).

49. There is, however, some central coordination in many commons. *See, e.g.*, CHRISTOPHER M. KELTY, TWO BITS: THE CULTURAL SIGNIFICANCE OF FREE SOFTWARE 210 (2008); Peter Lee, *Centralization, Fragmentation, and Replication in the Genomic Data Commons*, *in* GOVERNING MEDICAL KNOWLEDGE COMMONS 46, 48 (Katherine J. Strandburg et al. eds., 2017).

overwhelm it, particularly in high-tech industries. Although organizational forms and industry dynamics vary, this Part provides a theoretical framework for the notable persistence of vertical integration in patent-intensive fields. Synthesizing and refining previously disconnected theories, it argues that the difficulty of transferring technical knowledge, the value of acquiring innovative employees, and the benefits of achieving size and excluding competitors all push high-tech industries toward vertical integration. Furthermore, this framework has significant explanatory power, for it explains not only why firms vertically integrate but also why they acquire preexisting organizations and grant them significant autonomy, a phenomenon this Article characterizes as semi-integration.

### A. Tacit Knowledge Transfer

The need to integrate complementary assets to produce new innovations represents a natural starting point for understanding the persistence of vertical integration in high-tech industries.[50] Economists observe that if separate entities produce complementary assets, such as recombinant proteins and the pharmaceutical drugs that deliver them to the human body, the full value of the combined assets may not be realized.[51] Firms along a value chain thus need to coordinate the production and integration of complementary assets.[52] This can occur in a variety of ways, from market transactions between separate entities to vertical integration to any number of intermediate organizational forms.

The cost of transferring technical knowledge plays an important role in determining the appropriate organizational form.[53] In theory, patents transfer not only the legal right to practice an invention but also the technical knowledge necessary to do so. A critical function of patents, after all, is to disclose an invention and teach a technical artisan how to make and use it.[54]

50. *Cf.* Teece, Digital Economy, *supra* note 24, at 17 (noting the centrality of coordinating complements to profiting from innovation).

51. *See* Lars Schweizer, *Organizational Integration of Acquired Biotechnology Companies into Pharmaceutical Companies: The Need for a Hybrid Approach*, 48 ACAD. MGMT. J. 1051, 1069 (2005); *see also* Teece, Digital Economy, *supra* note 24, at 20 (describing technological complementarity).

52. *See* Teece, Digital Economy, *supra* note 24, at 24.

53. *Cf.* Demsetz, *supra* note 12, at 148 ("Each firm is a bundle of commitments to technology, personnel, and methods, all contained and constrained by an insulating layer of information that is specific to the firm, and this bundle cannot be altered or imitated easily or quickly.").

54. *See* 35 U.S.C. § 112(a) (2016) (requiring that patent specifications "contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it

*footnote continued on next page*

Such codification allows for the "exteriorization" of technical knowledge from the inventor's mind.[55] Accordingly, early economic accounts of licensing assumed that "all technical knowledge is contained in patents or formulae, and that technology transfer has no real cost and amounts to little more than the permission to infringe patents."[56] The knowledge-encapsulating nature of patents is critical to their ability to transfer technology between separate entities, thus lowering transaction costs and facilitating vertical disintegration.

However, patent disclosure and codification is often incomplete. Although patents require technical disclosure, some amount of invention-related knowledge necessarily remains tacit and personal to the inventor.[57] As philosopher of science Michael Polanyi observed, "[W]e can know more than we can tell."[58] Indeed, much "non-codified, disembodied know-how" is not communicated in a patent.[59] For instance, although a scientist may disclose instructions for creating recombinant DNA, the particular judgment calls, laboratory setup, and "feel" for performing this process are difficult or impossible to convey, thus remaining tacit and "sticky" to the inventor herself.[60] Even patents that satisfy the statutory requirements of written description and enablement do not disclose this degree of knowledge.[61] Furthermore, while an inventor's tacit knowledge may be valuable for practicing a basic version of a patented invention, it is particularly critical to

pertains . . . to make and use" the invention); Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1028-30 (1989).

55. *See* Burk, *supra* note 19, at 1010-12; Partha Dasgupta & Paul A. David, *Toward a New Economics of Science*, 23 RES. POL'Y 487, 493 (1994).

56. *See* Arora, *supra* note 27, at 41; *cf.* Nathan Rosenberg, *Why Do Firms Do Basic Research (with Their Own Money)?*, 19 RES. POL'Y 165, 171 (1990) (describing the perception that scientific knowledge is "'on the shelf' and costlessly available to all comers").

57. *See* Dasgupta & David, *supra* note 55, at 493-94.

58. MICHAEL POLANYI, THE TACIT DIMENSION 4 (1966) (emphasis omitted).

59. Jeremy Howells, *Tacit Knowledge, Innovation and Technology Transfer*, 8 TECH. ANALYSIS & STRATEGIC MGMT. 91, 92 (1996); *see also* Paul A. David & Dominique Foray, *Economic Fundamentals of the Knowledge Society*, 1 POL'Y FUTURES EDUC. 20, 25 (2003) (describing tacit knowledge). For an intellectual history of the concept of tacit knowledge in a variety of related academic disciplines, see Robin Cowan et al., *The Explicit Economics of Knowledge Codification and Tacitness*, 9 INDUS. & CORP. CHANGE 211, 217-24 (2000).

60. *See* Margaret Chon, *Sticky Knowledge and Copyright*, 2011 WIS. L. REV. 177, 179-80; Cowan & Foray, *supra* note 22, at 598; Eric von Hippel, *"Sticky Information" and the Locus of Problem Solving: Implications for Innovation*, 40 MGMT. SCI. 429, 431 (1994). Furthermore, patentees may deliberately refrain from disclosing technical knowledge for strategic reasons. *See* Chon, *supra*, at 196.

61. *See* CFMT, Inc. v. YieldUp Int'l Corp., 349 F.3d 1333, 1338 (Fed. Cir. 2003) ("Title 35 does not require that a patent disclosure enable one of ordinary skill in the art to make and use a perfected, commercially viable embodiment . . . ."); *cf. In re* Gay, 309 F.2d 769, 774 (C.C.P.A. 1962) ("Not every last detail is to be described, else patent specifications would turn into production specifications, which they were never intended to be.").

adapting that invention to market conditions and scaling up industrial production. As Merges observes, "[T]he aggregate value of all the 'minor' improvements, tweaks, and accumulated operational wisdom often exceeds the value of the basic invention itself."[62] Thus, transferring tacit knowledge is critical not only to transferring a basic invention but also to commercializing it effectively.[63]

Transferring invention-related tacit knowledge is costly[64] and often requires direct interaction between the inventor and user.[65] For instance, on-site training of personnel, visits from the patentee's engineers, and ongoing technical services are common mechanisms for transferring tacit knowledge.[66] Interpersonal interactions with the inventor herself are particularly important.[67] Indeed, sophisticated licensees often negotiate for the transfer of tacit knowledge (usually in the form of consulting arrangements) in parallel to patent rights.[68] Ultimately, the challenges of transferring tacit technical knowledge can render arm's length patent licensing insufficient for coordinating production between separate entities. As transferring tacit knowledge between separate entities becomes more difficult, parties are more likely to simply internalize complementary intellectual assets via vertical integration.[69] As a stylized example, if Merck cannot glean how to effectively

62. Merges, *supra* note 19, at 1501.

63. *See* Barry Bozeman, *Technology Transfer and Public Policy: A Review of Research and Theory*, 29 RES. POL'Y 627, 642 (2000); Burstein, *supra* note 15, at 261; Howells, *supra* note 59, at 91, 97; Teece, *Profiting*, *supra* note 24, at 288.

64. *See* Dasgupta & David, *supra* note 55, at 494; Howells, *supra* note 59, at 93.

65. *See* David J. Teece, *Firm Organization, Industrial Structure, and Technological Innovation*, 31 J. ECON. BEHAV. & ORG. 193, 196 (1996) ("[T]echnology transfer is often difficult without the transfer of key individuals."); *see also* Jennejohn, *supra* note 38, at 320.

66. *See* Arora, *supra* note 27, at 43; Howells, *supra* note 59, at 95; *cf.* H.M. Collins, *The TEA Set: Tacit Knowledge and Scientific Networks*, 4 SCI. STUD. 165, 177 (1974) (finding that laboratories learned how to build TEA lasers "by contact with a source laboratory either by personal visits and telephone calls or by transfer of personnel").

67. *See* Ajay Agrawal, *Engaging the Inventor: Exploring Licensing Strategies for University Inventions and the Role of Latent Knowledge*, 27 STRATEGIC MGMT. J. 63, 65 (2006); Edwin Mansfield, *Academic Research Underlying Industrial Innovations: Sources, Characteristics, and Financing*, 77 REV. ECON. & STAT. 55, 64 (1995) ("[I]n many kinds of applied R&D, it is very useful for academic and firm personnel to interact and work together on a face-to-face basis . . . ."); *see also* Liza Vertinsky, *Universities as Guardians of Their Inventions*, 4 UTAH L. REV. 1949, 1970 (2012) (describing a hypothetical technology transfer arrangement predicated on tacit knowledge transfer and the ongoing involvement of university inventors).

68. *See* Burk, *supra* note 19, at 1021; *see also* Ashish Arora, *Contracting for Tacit Knowledge: The Provision of Technical Services in Technology Licensing Contracts*, 50 J. DEV. ECON. 233, 234 (1996).

69. *See* Gregory D. Graff et al., *Agricultural Biotechnology's Complementary Intellectual Assets*, 85 REV. ECON. & STAT. 349, 351 (2003).

develop and commercialize Afferent's biologics from reading its patent disclosures, it has greater motivation to simply bring Afferent in-house.

The need to aggregate technical knowledge informs an alternative theory of the firm that differs from classic articulations of the make-or-buy dilemma.[70] Within a "capabilities" or "knowledge-based" theory of the firm, the integrated firm emerges in significant part to economize on the costs of aggregating and exploiting knowledge.[71] In short, the difficulties of transferring knowledge (even with the aid of patents) between separate firms via market transactions weigh in favor of integrating those firms and allowing information to flow within a unified organization.[72] Importantly, while the knowledge-based theory of the firm implicates costs, these costs are different from the transaction costs at the heart of the traditional theory of the firm.[73] While the traditional theory of the firm focuses on transaction costs arising from incentive misalignment and opportunism, the knowledge-based theory of the firm emphasizes costs associated with the knowledge demands of production.[74] Thus, a knowledge-based theory of the firm predicts vertical integration even where patents and other mechanisms alleviate traditional transaction costs and strategic behavior.

### B. Innovative Human Capital

Beyond the desire to obtain a discrete technological *asset* (and related tacit knowledge), this Article also argues that firms vertically integrate to expand their innovative *capacity*.[75] Theories of the firm (both classic and knowledge-based) are rather static in that they focus on the acquisition of a single technical input over a particular time. However, the dynamic benefits of making an

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70. *See supra* text accompanying note 10.

71. *See* Demsetz, *supra* note 12, at 157; Érica Gorga & Michael Halberstam, *Knowledge Inputs, Legal Institutions and Firm Structure: Towards a Knowledge-Based Theory of the Firm*, 101 NW. U. L. REV. 1123, 1140 (2007); Bruce Kogut & Udo Zander, *Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology*, 3 ORG. SCI. 383, 384 (1992) ("In our view, the central competitive dimension of what firms know how to do is to create and transfer knowledge efficiently within an organizational context."); Jack A. Nickerson & Todd R. Zenger, *A Knowledge-Based Theory of the Firm—The Problem-Solving Perspective*, 15 ORG. SCI. 617, 617 (2004).

72. *See* Gorga & Halberstam, *supra* note 71, at 1203; *see also* Demsetz, *supra* note 12, at 159 ("Roughly speaking . . . , the vertical boundaries of a firm are determined by the economics of conservation of expenditures on knowledge.").

73. *See* Bruce Kogut, *Joint Ventures: Theoretical and Empirical Perspectives*, 9 STRATEGIC MGMT. J. 319, 323 (1988).

74. *See* Richard N. Langlois & Nicolai J. Foss, *Capabilities and Governance: The Rebirth of Production in the Theory of Economic Organization*, 52 KYKLOS 201, 202, 206 (1999).

75. *See* Schweizer, *supra* note 51, at 1051.

input in-house rather than buying it on the market are particularly important in rapidly innovating industries and push toward vertical integration.

In short, what a firm may desire is not just another company's invention or tacit knowledge, but its employees. Within a dynamic conception of the knowledge-based theory of the firm, a firm acquires scientists and engineers not simply for their tacit knowledge of a particular (patented) invention, but for their tacit creative and problem-solving capabilities going forward. Licensing a startup's patents—and even discrete consulting contracts with the startup's engineers—does not bring such innovative talent in-house. Thus, the original decision to contract or vertically integrate to obtain a technological input is not an apples-to-apples comparison. Rather, it's like deciding whether to buy apples or an experimental fruit orchard. While both provide access to apples, only the latter offers the possibility of extending one's capabilities to produce fruit whose existence is currently unpredictable. As we will see, this desire to obtain innovative employees helps drive vertical integration in patent-intensive industries.

In a sense, all instances of vertical integration through acquisition are "acqui-hires." The phenomenon of acqui-hiring has attracted significant attention, most notably in the context of Silicon Valley companies buying entire startups instead of hiring away individual software engineers.[76] While a pure acqui-hire entails obtaining a startup for its employees with little regard for its intellectual property, this Article argues that vertical integration via acquisition often embodies a hybrid objective of obtaining both talented workers and the patented technologies of the target firm.

### C. Strategic Factors

In addition to tacit knowledge and human capital considerations, related strategic factors also drive vertical integration in patent-intensive industries.[77] As a schematic, these strategic factors can be grouped into two categories: competitive considerations and noncompetitive considerations. Making inputs in-house via vertical integration rather than buying them on the market offers a host of strategic advantages the classic theory of the firm tends to underappreciate.

#### 1. Competitive considerations

Vertical integration often serves competitive objectives of enhancing performance and imposing burdens on industry rivals. First, vertical

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

77. *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, 347.

integration—particularly through acquiring preexisting companies—allows firms to exploit economies of scale and scope. High-tech industries are particularly well suited to such efficiencies because the most critical input—technical knowledge—is nonrivalrous and capable of unconstrained exploitation. For example, if a social networking company acquires certain facial recognition technology, it is relatively easy to bring that technology to scale by integrating it throughout the entire network. Just as patent-intensive industries promote economies of scale, they also promote economies of scope, which are characterized as "efficiencies wrought by variety, not volume."[78] For example, if an agricultural biotechnology firm genetically engineers a particular trait, say for drought resistance, it has an incentive to integrate with various downstream seed companies to insert this trait into different types of seeds. While in theory a technology company could simply license these assets and attempt to exploit these efficiencies, we have seen that vertical integration offers a superior means for acquiring and exploiting patented technologies.

Furthermore, the "double marginalization" problem, which this Article explores in greater detail below,[79] also weighs in favor of vertical integration. The double marginalization phenomenon arises when upstream and downstream parties in a value chain both exercise market power. Each of those parties will charge a noncompetitive price for its outputs, thus leading to a double markup and creating a "vertical externality."[80] However, "a vertical merger has the potential to reduce costs and increase efficiency by eliminating a double monopoly markup on input costs."[81] Antitrust scholars and regulators have cited the elimination of double marginalization as an important justification for vertical integration.[82]

Additionally, vertical integration (particularly of a preexisting company) confers the advantage of speed. In theory, a company licensing a patent may, over time, figure out how to fully exploit that technology without direct tacit knowledge transfer from the patentee. After all, the tacitness of knowledge tends to diminish over time as pathbreaking innovations become accepted

78. Joel D. Goldhar & Mariann Jelinek, *Plan for Economies of Scope*, HARV. BUS. REV. (Nov. 1983), https://perma.cc/TLG6-XAQD.

79. *See infra* text accompanying notes 391-93.

80. *See* 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).

81. Michael H. Riordan & Steven C. Salop, *Evaluating Vertical Mergers: A Post-Chicago Approach*, 63 ANTITRUST L.J. 513, 518 (1995).

82. *See, e.g.*, Gerald F. Masoudi, Deputy Assistant Attorney Gen., Antitrust Div., U.S. Dep't of Justice, Reflections on the Antitrust Modernization Commission Report and Recommendations, Remarks to the Silicon Flatirons Telecommunications Program 11 (Sept. 5, 2007), https://perma.cc/NC4L-YZSD; *infra* text accompanying note 326.

conventions.[83] Furthermore, a firm could build innovative capacity over time by hiring individual scientists and engineers in the labor market. But the competitive need to deploy a new technology quickly (particularly before any rivals) counsels in favor of absorbing an entire technology supplier all at once.[84]

Achieving size simultaneously benefits vertically integrated entities and imposes costs on competitors. In general, "[b]ecause economies of scale and scope mean that larger and diversified firms have lower average costs, there is clearly an incentive for firms to get large."[85] Vertical acquisition of upstream suppliers can advance an "escalation strategy" through which a company rapidly invests in research and development (R&D) and acquires other firms "to leapfrog its competitors to become the dominant firm."[86] The flip side of size is that such acquisitions also prevent other industry participants from enjoying similar competitive benefits. Vertical integration thus represents an exclusionary strategy that keeps particular technological knowledge (as well as the people who produce it) away from competitors.[87] Furthermore, achieving size forces rivals to face higher average production costs and raises barriers to entry.[88]

#### 2. Noncompetitive considerations

In addition to explicit competitive pressures, firms are subject to a host of market and political forces that can also push them toward vertical integration. For instance, the need to show strong quarterly growth rates creates constant pressure on publicly traded companies to increase revenues. Vertical integration of positive cash-flow businesses thus responds to the very pragmatic need for companies to achieve consistent growth.[89] Additionally,

83. *See* Lynne G. Zucker et al., *Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises*, 88 AM. ECON. REV. 290, 291 (1998) (describing how knowledge that was once naturally excludable eventually diffuses over time in biotechnology).

84. *See* Valerie Bannert & Hugo Tschirky, *Integration Planning for Technology Intensive Acquisitions*, 34 R&D MGMT. 481, 481 (2004) (explaining how the desire to obtain knowledge and expertise quickly leads firms to acquire technology companies); *see also* Schweizer, *supra* note 51, at 1051 ("Acquirers can gain immediate access to technologies, products, distribution channels, and desirable market positions.").

85. Murray Fulton & Konstantinos Giannakas, *Agricultural Biotechnology and Industry Structure*, 4 AGBIOFORUM 137, 142 (2001).

86. *See id.* at 143.

87. *Cf.* Julia Porter Liebeskind, *Knowledge, Strategy, and the Theory of the Firm*, 17 STRATEGIC MGMT. J. (WINTER SPECIAL ISSUE) 93, 104 (1996) (arguing that organizing production in firms rather than markets may better protect knowledge from expropriation).

88. *See* Herbert Hovenkamp, *Antitrust Policy After Chicago*, 84 MICH. L. REV. 213, 278 (1985).

89. *Cf.* RAJAN, *supra* note 31, at 24-25 (discussing investors' preference for consistent increases in earnings per share and the difficulty in achieving such growth for large

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the accumulation of cash on hand creates conditions conducive to acquiring other companies.[90] In particular, shareholders may question why companies amassing large cash reserves are not paying higher dividends, thus creating pressure to reinvest that cash in acquisitions. In the pharmaceutical industry, for instance, the accumulation of cash on hand is helping to drive greater merger and acquisition activity.[91]

While much of the foregoing discussion explains why large companies prefer vertical integration to patent licensing, small firms often prefer it as well. Small firms may desire the ability to transfer tacit knowledge and bring their innovations to market by exploiting the resources of a much larger company. Furthermore, business pressures also lead small firms to seek to be acquired. It is, quite simply, the deliberate exit strategy of many small and medium-sized technology firms to be acquired by a larger company.[92] Notwithstanding the freedom of remaining independent, acquisition by a larger company brings significant resources, prestige, and financial rewards. Relatedly, venture capitalists, banks, and other financiers often pressure startup founders to accept acquisition bids from larger companies,[93] thus enhancing returns on investment and the likelihood of repaying debt. Furthermore, a small technology firm may doubt the ability of a licensee to effectively commercialize the firm's patented inventions, thus calling into question the amount of royalties the firm would receive.[94] Small firms may prefer to hedge their bets by accepting the certainty of an immediate, lump-

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pharmaceutical companies). Notably, the need to show quarterly gains encourages business decisions that privilege short-term profits over long-term performance. *See, e.g.*, Lucian A. Bebchuk, Essay, *The Myth That Insulating Boards Serves Long-Term Value*, 113 COLUM. L. REV. 1637, 1658, 1678 (2013); Lynn A. Stout, Response, *The Toxic Side Effects of Shareholder Primacy*, 161 U. PA. L. REV. 2003, 2017 (2013).

90. *See* Anna Son, M&A Focus: Biotechnology 3 (2013), https://perma.cc/8GNB-P6K7.

91. *See M&A Deals May Pick Up for BioPharma in 2017*, MORGAN STANLEY (Jan. 11, 2017), https://perma.cc/Z5MW-8V39.

92. *See* 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 by another company is a more common "exit" than an initial public stock offering for venture capital-backed startups).

93. *See id.* at 1325 (finding that venture capitalists frequently provide incentives to induce executives to cooperate in selling their firms).

94. *Cf.* Rachael E. Goodhue et al., *Biotechnology, Intellectual Property and Value Differentiation in Agriculture* 12 (Dep't of Agric. & Res. Econ. & Policy, Univ. of Cal. at Berkeley, Working Paper No. 901, 2002), https://perma.cc/3EEY-F57N (presenting a formal model in which a trait developer doubts the ability of a potential downstream partner to realize the value of a joint product, thus leading to vertical integration of the trait developer and downstream entity); Teece, Digital Economy, *supra* note 24, at 22 ("[A]n upstream innovator has no guarantee that the downstream users of the technology (and the providers of complements) will make the investments needed to generate the largest value, and vice-versa.").

sum payment for acquisition of their entire businesses rather than risk long-term exclusive licensing agreements with dim prospects of success.[95] In sum, both small firms and large incumbents often prefer vertical integration to patent licensing.

### D. Organizational Structures of Innovation and Semi-integration

Tacit knowledge, innovative capacity, and strategic factors help explain not only why high-tech firms vertically integrate but also why high-tech firms engage in a particular *type* of vertical integration that has become quite prevalent. This Subpart introduces the concept of semi-integration to describe a significant amount of vertical integration in patent-intensive industries. Semi-integration is characterized by two components: acquiring previously existing firms and granting significant autonomy to such acquisitions in their new institutional homes. The desire to preserve organizational structures conducive to innovation informs both aspects of semi-integration.

As a schematic, vertical integration can take one of two forms: endogenous growth of a firm through hiring individual employees in the labor market or outright acquisition of a preexisting company. Thus, for instance, a pharmaceutical company seeking to build upstream biotechnology capability could hire individual genetic engineers in the market, or it could acquire an existing biotech firm. While it may seem that firms would be agnostic between the two, tacit knowledge, innovation, and strategic considerations clearly favor outright acquisition of preexisting companies.

It is important to emphasize that tacit knowledge and innovative capacity are emergent properties that reside not only in individuals but also in social structures. According to Richard Nelson and Sidney Winter, "skills" (such as the ability to execute a difficult experimental protocol) inhere in individuals while "routines" (such as workflow processes in a laboratory) inhere in organizations.[96] Similarly, other commentators note that tacit knowledge is embodied not just in people but also in processes, routines, and institutions.[97] Indeed, "distributed" tacit knowledge of a multistep process may exist only at the level of an organization.[98] Given that innovative companies represent

95. *Cf.* Goodhue et al., *supra* note 94, at 12-15 (demonstrating circumstances in which firms prefer to be acquired for a lump-sum payment rather than exclusively license an asset to a downstream entity because of concerns over that entity's commercialization abilities).

96. *See* RICHARD R. NELSON & SIDNEY G. WINTER, AN EVOLUTIONARY THEORY OF ECONOMIC CHANGE 14, 72-73 (1982).

97. *See, e.g.*, Cowan & Foray, *supra* note 22, at 596.

98. *See* Langlois & Foss, *supra* note 74, at 207 ("[K]nowledge about production is often essentially *distributed* knowledge, that is to say, knowledge that is only mobilized in the

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social structures of knowledge production with particular cultures, processes, and modes of operation, merely cherry picking particular scientists and engineers would not capture the institutional milieu that generates tacit knowledge and produces innovation on an ongoing basis. As such, simply hiring individuals from some technology supplier is less desirable than acquiring the entire supplier, its employees, and its organizational processes.

However, the decision to acquire an entire preexisting company leads to another question: Should the acquiring company fully assimilate that acquisition into its institutional fabric, or should that acquisition enjoy some degree of autonomy? As further demonstrated in Part III below, many technology companies have opted for the latter approach of extending significant autonomy to their acquisitions, thus illustrating the second prong of semi-integration. Here again, tacit knowledge and innovative capacity considerations have robust explanatory power; full assimilation of an innovative firm into a large incumbent could kill the goose that lays golden eggs. To preserve the social and cultural milieu that drives innovation, acquired entities often maintain a high degree of autonomy within their new institutional homes.

Notably, the law of covenants not to compete partially undergirds this preference for vertical integration via semi-integration. In many states, employees in high-tech companies may be contractually prohibited from working for competitors, thus rendering acquisition of an entire company more attractive than hiring away those individuals. Importantly, however, the enforceability of covenants not to compete is highly limited in California,[99] a place of significant employee mobility and innovative activity.[100] Thus, for instance, noncompete clauses would not prevent Merck from hiring individual scientists from Afferent (which is based in California[101]) or Google from poaching individual engineers from a Silicon Valley startup. However, an exception in California law renders covenants not to compete enforceable in connection with the sale of a company.[102] A large incumbent could therefore

context of carrying out a multi-person productive task; [it] is not possessed by any single agent . . . .").

99. *See, e.g.*, CAL. BUS. & PROF. CODE § 16600 (West 2018); *see also* Yifat Aran, Note, *Beyond Covenants Not to Compete: Equilibrium in High-Tech Startup Labor Markets*, 70 STAN. L. REV. 1235, 1252 & n.84 (2018).

100. *Cf.* Ronald J. Gilson, *The Legal Infrastructure of High Technology Industrial Districts: Silicon Valley, Route 128, and Covenants Not to Compete*, 74 N.Y.U. L. REV. 575, 607-09 (1999) (describing the relative lack of enforcement of covenants not to compete in California and observing that "employers learned that they could not prevent high velocity employment and the resulting knowledge spillover").

101. Pringle, *supra* note 3.

102. *See* CAL. BUS. & PROF. CODE § 16601 (West 2018).

prevent the founders of a startup from leaving and working for a competitor if it purchased the startup, thus enhancing the attractiveness of vertical integration. While covenants not to compete help explain the drive to acquire entire companies, they do not explain why these acquisitions frequently enjoy significant autonomy in their new institutional home. Such autonomy is better explained by a desire to preserve social, cultural, and operational structures conducive to innovation, a dynamic addressed more fully in Part III below.

In sum, the make-or-buy question at the heart of vertical integration is more complicated than classic conceptions of the theory of the firm suggest. While patents reduce transaction costs, thus making contractual exchanges more viable, other considerations push toward vertical integration. In particular, the difficulty of transmitting tacit knowledge, the desire to absorb not just new technologies but also creative talent, and the business benefits of scale, scope, and competitive exclusion all weigh in favor of vertical integration. Notably, these factors also favor a particular kind of vertical integration: semi-integration of existing companies that grants them significant autonomy in their new institutional home. The next Part explores these developments in greater empirical detail.

## III. Vertical Integration in Patent-Intensive Industries

This Part draws on the previous theoretical account to explore the persistence of vertical integration in four core patent-intensive contexts. Contrary to prevailing scholarship, it finds a high degree of vertical integration (and institutional meshing more generally) in biopharmaceuticals, agricultural biotechnology, information technology, and university-industry technology transfer. While sensitive to the unique histories and dynamics that shape particular industrial landscapes,[103] this Article argues that these industries are bound by a striking commonality: organizational integration as a means of transferring and developing patented technologies.

### A. Biotechnology and Pharmaceuticals

While many organizational forms permeate the biopharmaceutical industry, this field features a substantial degree of vertical integration. Examining this interplay is particularly appropriate given that the biopharmaceutical industry has provided influential examples of patent-enabled vertical *dis*integration.[104] Previous accounts have focused on the downstream contractual relationships between pharmaceutical companies and

103. *See infra* Part IV.A.

104. *See, e.g.*, Arora & Merges, *supra* note 25, at 468 (noting significant growth in vertical supply transactions in pharmaceuticals).

specialized product manufacturers as examples of such disintegration.[105] This Subpart, however, explores the upstream vertical integration of biotech firms and pharmaceutical companies. It argues that tacit knowledge, human capital, and strategic considerations are driving a significant amount of vertical integration in this patent-intensive sector.

At a schematic level, biotech firms and pharmaceutical companies occupy upstream and downstream positions on a common value chain. Biotech firms utilize technologies such as recombinant DNA and monoclonal antibodies to produce biologic drugs or drug precursors, which they routinely patent.[106] These firms, however, typically lack the resources and infrastructure to develop such assets into marketable products, particularly given the significant expense and complexity of clinical trials. Such activities fall within the complementary capabilities of much larger pharmaceutical firms, which have traditionally focused on producing and commercializing chemistry-based, small-molecule drugs.[107] The complementary capabilities of upstream biotech firms and downstream pharmaceutical companies seem well suited to market-based patent licensing. Indeed, one model of industry organization has involved biotech firms licensing patented biologics to pharmaceutical companies, which then commercialize them. However, this Subpart focuses on a notable trend toward vertical integration, in which pharmaceutical companies are acquiring biotech firms instead of merely licensing their patents.

The biopharmaceutical industry has evolved considerably over its history. Throughout most of the twentieth century, the pharmaceutical industry featured large, vertically integrated companies combining drug discovery, development, marketing, and distribution.[108] The biotechnology industry emerged from scientific advances in the 1970s, and in its first decades it

105. *See id.* at 469.

106. *See* Iain M. Cockburn, *The Changing Structure of the Pharmaceutical Industry*, HEALTH AFF., Jan./Feb. 2004, at 10, 15; Gary P. Pisano, *The Governance of Innovation: Vertical Integration and Collaborative Arrangements in the Biotechnology Industry*, 20 RES. POL'Y 237, 239 (1991); Esteban Burrone, *Patents at the Core: The Biotech Business*, WORLD INTELL. PROP. ORG. (2006), https://perma.cc/CH6A-XB9A.

107. *See* RAJAN, *supra* note 31, at 22-23; William S. Comanor & F.M. Scherer, *Mergers and Innovation in the Pharmaceutical Industry*, 32 J. HEALTH ECON. 106, 111 (2013); Powell, *supra* note 46, at 203; Toby E. Stuart et al., *Vertical Alliance Networks: The Case of University-Biotechnology-Pharmaceutical Alliance Chains*, 36 RES. POL'Y 477, 477-78 (2007); Nicole Fisher & Scott Liebman, *Are M&A Replacing R&D in Pharma?*, FORBES (Apr. 22, 2015, 6:14 AM), https://perma.cc/4W5R-Q39X (noting that pharmaceutical companies historically focused on small-molecule, chemistry-based drugs).

108. *See* Cockburn, *supra* note 106, at 13-14; *see also, e.g.*, ALFRED D. CHANDLER, JR., SHAPING THE INDUSTRIAL CENTURY: THE REMARKABLE STORY OF THE EVOLUTION OF THE MODERN CHEMICAL AND PHARMACEUTICAL INDUSTRIES 183 (2005) (describing vertical integration at Merck).

operated largely independently from pharmaceutical companies.[109] New biotech firms were typically small entrepreneurial ventures spun out of academic research, and they differed significantly in culture and size from pharmaceutical incumbents. As early as the 1990s, however, some biotech firms integrated forward into drug manufacturing,[110] and some pharmaceutical companies integrated backward to cultivate R&D capabilities in biotechnology.[111]

Notwithstanding these early attempts at integration, the dominant organizational paradigm was vertical disintegration in which biotech firms licensed patented drug precursors to pharmaceutical companies.[112] Indeed, such alliances provided significant funding for early biotechnology firms.[113] In one of the earliest agreements, Eli Lilly essentially outsourced some of its R&D to Genentech, a biotech pioneer.[114] Toward the end of the 1990s, some of the largest pharmaceutical firms had about twenty collaborative projects with smaller biotech firms.[115] Consistent with vertical disintegration, many large pharmaceutical companies continue to specialize in late-stage drug testing and development while outsourcing early-stage research to biotech firms.[116] Indeed, as of the mid-2000s, most pharmaceutical firms "derive[d] 25 to 50 percent of their product pipelines from external sources."[117]

In the past decade or so, however, the biopharmaceutical industry has experienced a significant wave of vertical integration as pharmaceutical

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109. *See* Pisano, *supra* note 106, at 239; Rai, *supra* note 12, at 815.

110. *See* Mark G. Edwards, *Biotechnology and Pharmaceutical Commercialization Alliances: Their Structure and Implications for University Technology Transfer Offices*, *in* 2 INTELLECTUAL PROPERTY MANAGEMENT IN HEALTH AND AGRICULTURAL INNOVATION: A HANDBOOK OF BEST PRACTICES 1227, 1227-28 (Anatole Krattiger et al. eds., 2007); Pisano, *supra* note 106, at 238.

111. *See* Pisano, *supra* note 106, at 238. As far back as 1978, Monsanto, DuPont, and Eli Lilly had developed in-house biotechnology research programs. *Id.* at 239.

112. *See id.* at 240; *see also* Josh Lerner & Robert P. Merges, *The Control of Technology Alliances: An Empirical Analysis of the Biotechnology Industry*, 46 J. INDUS. ECON. 125, 127 (1998) (exploring the contractual complexity of such deals); *cf.* RAJAN, *supra* note 31, at 24 ("[P]harmaceutical companies almost act like the investment banks of the drug development enterprise.").

113. *See* Lerner & Merges, *supra* note 112, at 127.

114. *See* Gary P. Pisano, *Can Science Be a Business?: Lessons from Biotech*, HARV. BUS. REV. (Oct. 2006), https://perma.cc/93Q4-PB9T.

115. *See* Barnett, *supra* note 20, at 1015-16.

116. *See* Robert Weisman, *While Big Pharma Gets Bigger, Local Biotechs Innovate*, BOS. GLOBE (Nov. 24, 2015), https://perma.cc/BSK3-5MRG ("It makes more sense for them to sit on the sidelines and watch what we're doing and then swoop in and write a check." (quoting Michael Gilman, venture partner at Atlas Venture and chief executive of Padlock Therapeutics Inc.)).

117. Edwards, *supra* note 110, at 1228.

companies have purchased biotech firms. For instance, in 2007, AstraZeneca bought biotech firm MedImmune for $15.6 billion "in perhaps the most emphatic sign yet of the push by big drug makers into biotechnology."[118] In 2009, Roche Holding AG acquired Genentech for $46.8 billion.[119] In 2015, Merck purchased biotech firm Cubist Pharmaceuticals, and in 2016, it purchased Afferent.[120] In 2016, Bristol-Myers Squibb bought biotech firms Padlock Therapeutics and Cormorant Pharmaceuticals.[121] Indeed, as shown in Table 1 below, Bristol-Myers Squibb's recent vertical acquisitions of biotech firms demonstrate a decided push toward bringing such upstream sources of new drugs in-house. Vertical mergers and acquisitions in the biopharmaceutical industry have increased steadily, and analysts predict that large industry players will continue acquiring small firms through 2018.[122]

118. Andrew Pollack, *AstraZeneca Acquires a Biotech Company*, N.Y. TIMES (Apr. 24, 2007), https://perma.cc/G8NY-L6PE.

119. Son, *supra* note 90, at 1; *see also* Myoung Cha & Theresa Lorriman, *Why Pharma Megamergers Work*, MCKINSEY & CO. (Feb. 2014), https://perma.cc/9HHP-8ZFN (discussing Roche's acquisition of Genentech).

120. Pringle, *supra* note 3 (Afferent); Weisman, *supra* note 116 (Cubist Pharmaceuticals).

121. Ben Adams, *Bristol-Myers Squibb Buys Cancer, Rare Disease Biotech Cormorant*, FIERCEBIOTECH (July 5, 2016, 7:20 AM), https://perma.cc/573F-SW36.

122. *See, e.g.*, Ben Hirschler, *$11 Billion Biotech Binge Fuels Forecasts of 2018 M&A Surge*, REUTERS (Jan. 8, 2018, 7:12 AM), https://perma.cc/27RX-J8RM.

**Table 1**
Selected Vertical Acquisitions of Biotech Firms
by Bristol-Myers Squibb, 2011-2016[123]

| Acquired Company | Field of Business Within Biotechnology | Year of Acquisition |
|---|---|---|
| Cormorant Pharmaceuticals | Cancer and rare diseases | 2016 |
| Padlock Therapeutics | Autoimmune diseases | 2016 |
| Cardioxyl Pharmaceuticals | Cardiovascular disease | 2015 |
| Promedior | Fibrotic diseases | 2015 (option) |
| Flexus Biosciences | Cancer | 2015 |
| Galecto Biotech AB | Pulmonary fibrosis | 2014 (option) |
| F-star Alpha | Cancer | 2014 (option) |
| iPierian | Neurodegenerative diseases | 2014 |
| Amylin Pharmaceuticals | Diabetes | 2012 |
| Inhibitex | Infections | 2012 |
| Amira Pharmaceuticals | Inflammatory and fibrotic diseases | 2011 |

Many factors have helped push pharmaceutical companies' vertical integration into biotechnology. The pharmaceutical industry faces a well-documented "patent cliff" that has substantially eroded revenues upon key patent expirations.[124] In addition, decreased R&D efficiency, increased costs of drug development, enhanced regulatory requirements, and government cost-

123. I identified these acquisitions by searching Bloomberg Law's Deal Analytics database for mergers and acquisitions in which "Bristol-Myers Squibb Co (U.S.)" was an acquirer. To gather more information about each deal presented in Table 1, I then reviewed Bristol-Myers Squibb's press release announcing the acquisition. *See Press Releases*, BRISTOL-MYERS SQUIBB, https://perma.cc/7A75-5WGP (archived Mar. 6, 2018).

124. *See, e.g.*, Son, *supra* note 90, at 2 (capitalization altered); *cf.* Anna Jagger, *Pharmaceutical Companies Seek Biotech Acquisitions to Boost Drug Pipelines*, ICIS (Feb. 12, 2010, 12:00 AM), https://perma.cc/X2AE-YT92 (noting that patent expirations have led pharmaceutical companies to acquire biotechnology companies to expand their drug pipelines).

cutting measures have all constrained profits.[125] The prospect of declining revenues has fueled widespread biotech acquisitions as pharmaceutical companies seek to refresh their drug pipelines.[126] Biotechnology firms are particularly attractive to pharmaceutical companies because sophisticated biologics are more complex and more expensive to develop than traditional small-molecule drugs and can generate profit margins of up to 40%.[127] Furthermore, with the demise of the "blockbuster" model of drugs, pharmaceutical companies are focusing more on niche areas such as cancer and rare diseases, which biologics are well suited to address.[128] Moreover, the complexity of manufacturing (and copying) biologics offers pharmaceutical firms a natural bulwark against copying upon patent expiration, thus mitigating revenue erosion from generic competition.[129]

Implicit in these empirical trends is a theoretical question: While pharmaceutical firms have an understandable desire to develop biologic drugs, why are they buying entire biotech firms instead of simply licensing their patents? Put differently, why are they choosing vertical integration instead of market-based transactions? Again, the benefits of specialization would seem to render contracting more efficient than outright acquisition of entire biotech firms.

This Article argues that knowledge considerations—particularly the challenge of exploiting tacit technical knowledge—significantly inform pharmaceutical companies' drive to vertically integrate with biotech firms. Creating biologics and developing them into marketable drugs requires a high degree of technical knowledge. As noted, biologics are more complex and require more specialized expertise than producing traditional small-molecule drugs.[130] For a pharmaceutical firm, merely licensing a biotech patent is often insufficient to use the technology without the tacit knowledge related to its

125. *See* Ashish Kumar Kakkar, Editorial, *Patent Cliff Mitigation Strategies: Giving New Life to Blockbusters*, 25 EXPERT OPINION ON THERAPEUTIC PATS. 1353, 1355 (2015).

126. *See* Josh Beckerman, *Merck to Acquire Biotech Company Afferent*, WALL ST. J. (updated June 9, 2016, 6:37 PM ET), https://perma.cc/NE7G-TUE3; Wilson, *supra* note 2.

127. *See* Jagger, *supra* note 124 (discussing the complexity and cost of developing biologics); Pollack, *supra* note 118 (same); Nigel Walker, *Biologics: Driving Force in Pharma*, PHARMA'S ALMANAC (June 5, 2017, 12:21:28 PM), https://perma.cc/UB2P-AK6C (discussing profit margins).

128. *See* PWC, FROM VISION TO DECISION: PHARMA 2020, at 10, 38 (2012), https://perma.cc/LW94-JPQM ("[The pharmaceutical industry has] been concentrating on biologics for cancer and rare diseases."); Son, *supra* note 90, at 3 ("With fewer blockbuster acquisitions expected in coming years, Big Pharma companies are seeking to acquire small and mid-sized companies focused on developing drugs for more targeted populations and rare diseases.").

129. *See* Jagger, *supra* note 124; Pollack, *supra* note 118.

130. *See* Kakkar, *supra* note 125, at 1353.

underlying characteristics.[131] Furthermore, there is a wide gulf between merely producing a biologic compound in a laboratory (which a patent would presumably disclose) and manufacturing a biologic drug in industrial quantities.[132] For large-scale production, factors such as cell culture medium, oxygen levels, and temperature can affect output characteristics and costs.[133] The tacit, experiential knowledge necessary to optimize production may not be disclosed in a patent or transferred by a license.[134] However, a pharmaceutical company can obtain that knowledge by acquiring a biotech firm and its scientists.[135] Notably, "[i]n the absence of well-defined and well-understood scale-up recipes, ensuring product integrity requires extensive interaction between the scientists who designed a cell in the laboratory and bioprocessing engineers charged with developing the production process."[136] Vertical integration helps ensure this continuity. Although such integration can be understood as reducing costs, it economizes on costs of knowledge exploitation rather than the costs of opportunism and asset specificity at the heart of the traditional theory of the firm.

Indeed, the natural excludability of biologic drugs heightens the attractiveness of vertical integration relative to market-based production. In the traditional theory of the firm, high transaction costs and opportunism motivate parties to vertically integrate.[137] In the technology sphere, one significant kind of opportunism is expropriation risk—the risk that a potential contracting party will insist on seeing some technology before buying it, and then simply take it for free. Patents mitigate such opportunism by providing the patentee with the legal right to exclude a prospective buyer from using its technology without authorization. The natural excludability of (patented) biologics, which are difficult to manufacture and copy, would seem to provide additional assurance against expropriation, thus providing even greater

131. *See* Liebeskind, *supra* note 87, at 95 (noting that direct observation of production must often supplement codified knowledge); Pisano, *supra* note 106, at 247 (describing the challenges of transferring "idiosyncratic" knowledge in biotechnology R&D); *see also* Burstein, *supra* note 15, at 252-53 (noting that biotechnology-related tacit knowledge is difficult to transfer).

132. *See* Pisano, *supra* note 106, at 244 (describing the technical challenges of "develop[ing] a large scale process which preserves the desirable characteristics of the product produced in the lab").

133. *Id.*

134. *Cf.* Pisano, *supra* note 114 ("Much of the knowledge in the diverse disciplines that make up the biopharmaceutical sector is intuitive or tacit, rendering the task of harnessing collective learning especially daunting.").

135. *See* Gary P. Pisano, *Using Equity Participation to Support Exchange: Evidence from the Biotechnology Industry*, 5 J.L. ECON. & ORG. 109, 115 (1989).

136. Pisano, *supra* note 106, at 244.

137. *See supra* notes 11-12 and accompanying text.

safeguards for market-based contracting. However, the natural excludability of patented biologics works *too* well, such that even an authorized licensee would be excluded from optimally practicing and mass-producing the licensed technology.[138] Biologics are highly individualized assets, and tacit knowledge from the scientists and engineers who generated a particular biologic is critical for ramping up industrial production. As such, it is precisely the highly excludable nature of biologics that leads pharmaceutical companies to vertically integrate with biotech firms instead of simply licensing biotech firms' patents.

People are crucial to these biotech acquisitions for not only their current tacit knowledge but also their ability to drive further innovations in the future. In a survey of biotech acquisitions, pharmaceutical respondents all cited the desire to shore up innovative capacity as a long-term motivation for acquisitions.[139] For instance, a representative from Pharmacia & Upjohn justified its acquisition of biotech firm Sugen as reflecting a strategy of supplementing existing R&D with "external innovation."[140] The representative further characterized Sugen's attractiveness as deriving from its "absolutely unique combination of competence, knowledge, and intellectual protection."[141] Along similar lines, one of Merck's reasons for acquiring biotech firm Lexigen was to improve Merck's position in oncology and gain "access to the Boston research community and to valuable biotech know-how and technologies."[142] Such acquisitions seek to obtain not only a discrete technology and related tacit knowledge but also innovative capacity.

In addition to facilitating access to tacit knowledge and innovative people, vertical integration serves other strategic objectives. Large pharmaceutical companies have realized economies of scale by strategically acquiring small biotech firms in particular disease areas.[143] Such acquisitions also exploit economies of scope by providing more avenues for pharmaceutical companies to exercise their core competencies in clinical testing, marketing, and distribution. Size confers not only economic benefits but political benefits as well. As has been well documented, large corporations are better able to

138. *Cf.* Teece, Digital Economy, *supra* note 24, at 4 (characterizing "strong" appropriability regimes as those where "innovations are easy to protect because knowledge about them is tacit and/or they are well protected legally").

139. *See* Schweizer, *supra* note 51, at 1057 tbl.2, 1057-59.

140. *Id.* at 1057 tbl.2 (quoting an unnamed interviewee).

141. *Id.* (quoting an unnamed interviewee).

142. *See id.* at 1058.

143. *See* EY, FIREPOWER FIREWORKS: FOCUS, SCALE AND GROWTH DRIVE EXPLOSIVE M&A 7 (2015), https://perma.cc/JA9U-3HLZ.

capture rents through legislative influence,[144] and incumbent pharmaceutical firms have actively promoted their interests through litigation and lobbying.[145] As noted, the patent cliff of recent and upcoming expirations creates greater pressure to increase revenues, and fast-growing biotech firms are attractive acquisition targets.[146] Furthermore, many pharmaceutical companies have amassed large reserves of cash, fueling shareholder pressure to spend it toward productive ends, such as acquiring other firms.[147] For their part, venture capitalists routinely pressure portfolio biotech firms to accept acquisition offers from pharmaceutical companies.[148] Relatedly, declining valuations for biotech firms, coupled with historically low interest rates, have rendered such firms relatively cheap to acquire.[149] Thus, an evaluation of the merits of the make-or-buy decision cannot be based simply on the efficiencies of market-based versus hierarchical production but must also consider the additional business, political, and strategic benefits of enlarging one's corporate footprint.[150]

Importantly, many of these vertical acquisitions reflect semi-integration. In general, cultural differences can render integration highly difficult. Biotech firms typically exhibit an "entrepreneurial, creative, and risk-taking culture"

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144. *See* Robert P. Merges, *Intellectual Property Rights and the New Institutional Economics*, 53 VAND. L. REV. 1857, 1869 (2000); Robert B. Reich, Opinion, *Big Tech Has Become Way Too Powerful*, N.Y. TIMES (Sept. 18, 2015), https://perma.cc/MFS6-CUAW ("Economic and political power can't be separated because dominant corporations gain influence over how markets are maintained and enforced, which enlarges their economic power further."); *see also* Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. PA. L. REV. 1, 36-37 (2005) (noting that companies holding large patent portfolios "are viewed by regulators and legislators as 'players' in the patent debates").

145. *See, e.g.*, Rachel Sachs, *The New Model of Interest Group Representation in Patent Law*, 16 YALE J.L. & TECH. 344, 379 (2014) (noting the involvement of pharmaceutical companies in the passage of the Hatch-Waxman Act). For the Hatch-Waxman Act, see 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 the U.S. Code).

146. *See* EY, *supra* note 143, at 9 (reporting that from 2009 through 2014, biotech firms delivered cumulative growth that was more than five times that of large pharmaceutical firms); *see also supra* text accompanying note 124.

147. Bristol-Myers Squibb, for instance, had almost $8 billion in cash when it purchased Cormorant. *See* Max Nisen, *Bristol-Myers Brings Back One That Got Away*, BLOOMBERG GADFLY (updated July 6, 2016, 12:35 PM PDT), https://perma.cc/RMJ3-TLU6.

148. *See* Barnett, *supra* note 20, at 1036; *see also* Jagger, *supra* note 124 ("[V]enture capitalists, who control much of the biotechnology sector, are always looking for exit strategies . . . .").

149. *See* Ken Kam, *Sanofi and Celgene Are the Latest to Acquire Promising Biotechs*, FORBES (Jan. 23, 2018, 3:23 PM), https://perma.cc/5Y8G-M58P; Jagger, *supra* note 124; Loftus & Rockoff, *supra* note 2.

150. Of course, growth can incur several costs as well, such as agency costs of monitoring and managing a sprawling organization as well as decreased incentives to innovate. *See infra* Part IV.B.

that often clashes with the formal structures, bureaucracies, and risk aversion of large pharmaceutical companies.[151] To address the challenges of integration, companies can pursue a variety of acquisition approaches ranging from preservation (in which the acquired entity retains significant autonomy) to absorption (reflecting full assimilation of the acquired entity).[152] Tacit knowledge considerations and the socially embedded nature of innovative capacity have led pharmaceutical companies to pursue integration strategies closer to the preservation end of the spectrum, thus maintaining significant autonomy for acquired biotechnology firms.

In significant part, when pharmaceutical companies acquire small biotech firms, the research functions of those acquired firms maintain a largely autonomous existence within the larger company. Such semi-integration is evident in several biopharmaceutical acquisitions. For example, Eli Lilly "acquired ImClone but left it as a standalone business, as Roche did with Genentech."[153] Furthermore, a representative of Pharmacia noted: "With Sugen, we also gained a number of very talented scientists—absolutely world-class. Putting that together is actually quite difficult . . . . We will keep Sugen as an entity and continue with its identity."[154] Such semi-integration may offer the best of both worlds, combining the innovativeness of a small, autonomous firm with the resources of a larger company.

A common pattern is for the R&D functions of an acquired biotech firm to become a semiautonomous "center of excellence"—a specialized research unit—within the pharmaceutical company.[155] However, management, clinical trials, sales, administrative, and marketing functions of the biotech firm, which are less tied to innovation, are assimilated into the larger company.[156] For example, when Bayer acquired Chiron Diagnostics, it afforded a high degree of autonomy to Chiron's R&D operations.[157] Furthermore, a person with knowledge of Sandoz's acquisition of Genetic Therapy said that Genetic Therapy's "research unit should retain [its] autonomy . . . and will be maintained at full strength."[158] Rather than fully digesting and diffusing the contents of the acquired biotech firm, the acquiring company maintains the

151. *See* Schweizer, *supra* note 51, at 1054.

152. *See* PHILIPPE C. HASPESLAGH & DAVID B. JEMISON, MANAGING ACQUISITIONS: CREATING VALUE THROUGH CORPORATE RENEWAL 145-46 (1991).

153. PWC, *supra* note 128, at 25.

154. Schweizer, *supra* note 51, at 1059 tbl.3 (alteration in original) (quoting an unnamed interviewee).

155. *See id.* at 1060, 1062 tbl.4.

156. *See id.* at 1061.

157. *See id.* at 1059 tbl.3.

158. *Id.* (second alteration in original) (quoting an unnamed interviewee).

research functions of the biotech firm as an encapsulated organelle that floats within the larger corporate cell.

In a rather radical way, this model of semi-integration sheds new light on the role of technical knowledge transfer in motivating vertical acquisitions. While in a broad sense such integration facilitates knowledge transfer, in a technical sense, these acquisitions reflect the reality that tacit knowledge *cannot* be transferred, at least not without enormous effort and expense. Indeed, the stickiness and nontransferability of tacit knowledge help explain why the research functions of acquired biotech firms continue to operate autonomously within pharmaceutical companies. While acquisitions help transfer biotechnological *knowledge* (such as explicit scientific findings), studies indicate that acquisitions in this industry involve "no explicit biotech *know-how* transfer," referring to the tacit knowledge retained by scientists and innovative organizations.[159] These acquisitions are valuable precisely because they eliminate the need for tacit knowledge transfer; researchers at the formerly independent biotech firms continue their work with familiar colleagues and routines, but now it takes place within new corporate boundaries. Along these lines, a person familiar with Sandoz's acquisition of SyStemix said, "You can acquire people with their knowledge and technology, but both are very closely related to a specific site."[160] Similarly, when Bayer acquired Chiron, it did not transfer Chiron's scientists or biotech know-how from Chiron's California location because of the company's highly site-specific character.[161] In this sense, it is the *inability* to transfer tacit knowledge that renders acquisitions—coupled with semi-integration—so valuable within the biopharmaceutical industry.[162]

While highlighting the trend toward vertical integration, it is important to acknowledge the diverse array of organizational forms in the biopharmaceutical industry. Of course, the traditional market-based model of patent licenses between upstream biotech firms and downstream pharmaceutical companies still holds significant sway.[163] Within companies, diminished productivity of in-house R&D units at large pharmaceutical companies has led these companies to experiment with new, disaggregated research structures. In this regard, GlaxoSmithKline established several Centres of Excellence for

159. *See, e.g., id.* at 1062 (emphasis added).

160. *Id.* at 1062 tbl.4.

161. *See id.* at 1063.

162. *See id.* at 1069.

163. *See* Asiya Giniatullina et al., *Building for Big Pharma*, 31 NATURE BIOTECHNOLOGY 284, 284 (2013) (noting the increasing "in-licensing of early clinical stage drug candidates" by pharmaceutical companies). *See generally* David T. Robinson & Toby E. Stuart, *Financial Contracting in Biotech Strategic Alliances*, 50 J.L. & ECON. 559 (2007) (examining strategic alliance contracts between biotechnology and pharmaceutical firms).

Drug Discovery to spur a more entrepreneurial character within the company,[164] thus reflecting another instance of internal semi-integration. Going further, Abbott split off its research arm as a separate company, and Pfizer concentrated its R&D resources by divesting other units.[165] Toward the downstream end, several pharmaceutical and biotech firms are outsourcing various functions to contract research organizations, which perform research, conduct clinical trials, manage data, assist with regulatory compliance, and help develop new products.[166] Additionally, large pharmaceutical companies are not the only players acquiring other companies: Specialty pharmaceutical firms have become active acquirers, and larger biotechs are poised to do so as well.[167] Furthermore, the industry has long featured intermediate forms of integration, including knowledge networks[168] and partial equity investments in the form of joint ventures or minority equity investments.[169] In sum, industry players are experimenting with varying organizational forms along the value chain to optimize productivity.[170]

Notwithstanding this organizational heterogeneity, the biopharmaceutical industry reveals more vertical integration than theory would suggest, and current trends predict more to come. Interestingly, early commentators were skeptical of pharmaceutical companies' acquisitions of biotech firms, largely because of the perceived difficulty of managing new acquisitions.[171] These concerns proved to be overblown, however, perhaps because of the significant autonomy afforded to acquired biotech firms via semi-integration. Although recent academic commentary has highlighted the shift toward vertical disintegration in high-tech industries, "[f]ar from being dead, vertical integration has an important role to play in the pharmaceutical industry's future."[172]

### B. Agricultural Biotechnology, Seeds, and Chemicals

Similar knowledge, human capital, and strategic considerations have also fueled significant vertical integration in the agricultural biotechnology

164. *See* PWC, *supra* note 128, at 24.

165. *Id.* at 25.

166. Son, *supra* note 90, at 4; *see also* Comanor & Scherer, *supra* note 107, at 111.

167. *See* EY, *supra* note 143, at 2-3, 6.

168. *See, e.g.*, Liebeskind et al., *supra* note 46, at 429; Powell, *supra* note 46, at 208.

169. *See* Pisano, *supra* note 135, at 109.

170. *Cf.* Pisano, *supra* note 106, at 244 (discussing the relative advantages of firms vertically integrating versus contracting with external sources of innovation).

171. *See, e.g.*, *id.* at 247-48.

172. Pisano, *supra* note 114, at 123.

industry. Modern industrial agriculture spans several related functions along a common value chain. Companies with biotechnology capabilities genetically engineer specific traits such as resistance to herbicides, insects, or drought.[173] Seed companies, which develop high-quality germplasm (living genetic resources that facilitate plant breeding), often incorporate engineered traits into their seeds, sometimes "stacking" several traits into a single seed.[174] Additionally, companies produce agrochemicals, such as herbicides, pesticides, and fertilizers, which they design to work with specific traits. For example, Monsanto's Roundup is a broad-spectrum herbicide that kills weeds but not crops containing the Roundup Ready trait.[175]

All along the value chain, intellectual property rights protect several crucial assets: engineered traits, "transformation" tools for inserting genes into plants, high-quality crop germplasm, and agrochemicals.[176] In theory, this patent-intensive industry could adopt a vertically disintegrated structure, with separate biotech, seed, and chemical companies licensing assets to each other. However, a spate of mergers and acquisitions has led to substantial vertical integration.

Increasingly, companies are integrating biotechnology, seed, and chemical activities within a single organization.[177] Several decades ago, large chemical firms like Monsanto, Dow, and DuPont began moving aggressively into agriculture.[178] These companies invested significantly in agricultural biotechnology companies, which had largely emerged in the 1980s from university startups.[179] The mid-1980s through the 2000s saw intensive merger

173. *See* Diana L. Moss, *Competition, Intellectual Property Rights, and Transgenic Seed*, 58 S.D. L. REV. 543, 543 (2013); *see also* Paul Christou, *Plant Genetic Engineering and Agricultural Biotechnology 1983-2013*, 31 TRENDS BIOTECHNOLOGY 125, 125 (2013).

174. *See* Moss, *supra* note 173, at 544; Goodhue et al., *supra* note 94, at 2. For background information on germplasm, see *Germplasm*, U.C. DAVIS SEED BIOTECHNOLOGY CTR., https://perma.cc/SH8Z-C9E9 (archived Apr. 5, 2018).

175. *See Glyphosate: Supporting Plant Health and Controlling Weeds*, MONSANTO, https://perma.cc/QDE5-GVVL (archived Apr. 25, 2018).

176. *See* Graff et al., *supra* note 69, at 349; GianCarlo Moschini, *Competition Issues in the Seed Industry and the Role of Intellectual Property*, CHOICES 1-3 (2010), https://perma.cc/PJP8-DX49.

177. *See* Fulton & Giannakas, *supra* note 85, at 141; Nicholas Kalaitzandonakes et al., *A Worrisome Crop?: Is There Market Power in the U.S. Seed Industry?*, REGULATION, Winter 2010-2011, at 20, 22.

178. *See* Graff et al., *supra* note 69, at 349. This activity was spurred by the Plant Variety Protection Act of 1970, which increased public and private investment. *See* Kalaitzandonakes et al., *supra* note 177, at 21; *see also* Plant Variety Protection Act, Pub. L. No. 91-577, 84 Stat. 1542 (1970) (codified as amended in scattered sections of 7 and 28 U.S.C.).

179. *See* Graff et al., *supra* note 69, at 349; Keith Fuglie et al., *Rising Concentration in Agricultural Input Industries Influences New Farm Technologies*, U.S. DEP'T AGRIC.: AMBER WAVES (Dec. 3, 2012), https://perma.cc/JE5P-A2S3.

and acquisition activity as several large players absorbed small and medium-sized biotech enterprises.[180] The Big 6 companies (Syngenta, Bayer, Dow, DuPont, Monsanto, and BASF)—or firms acquired by those companies—were responsible for 20 of the 27 acquisitions of small and medium-sized agricultural biotechnology enterprises that occurred between 1985 and 2009.[181]

In parallel to acquiring upstream biotech firms, these conglomerates also acquired downstream seed companies. Such companies possess high-quality germplasm, which is "an essential complementary asset for delivering new biotechnologies."[182] Between 1995 and 1998, life sciences companies—primarily ag-bio corporations—purchased or entered into joint ventures with approximately sixty-eight seed companies.[183] Ultimately, large companies acquired the most significant seed firms in North America, including Pioneer, DeKalb, Asgrow, Garst, and Holden's Foundation Seeds.[184] "During the late 1990s through the 2000s, . . . Monsanto alone acquired almost forty companies."[185]

As shown in Table 2 below, Monsanto's recent vertical acquisitions reveal a strategy of integrating upstream biotechnology firms, which produce genetically modified traits, and downstream seed companies, which develop germplasm into which such traits can be placed, within one major chemical company. As Gregory Graff and colleagues observe, "The emergent industry structure—with a relatively small number of tightly woven alliances, each organized around a major life-sciences firm, each vertically integrated from basic R&D through to marketing—stands in contrast to the more diffuse structure of twenty years ago."[186] The agricultural biotechnology and seed industry thus provides another counterexample to the perception that vertical disintegration pervades patent-intensive industries.

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180. *See* William Lesser, *Intellectual Property Rights and Concentration in Agricultural Biotechnology*, 1 AGBIOFORUM 56, 56 (1998); Moss, *supra* note 173, at 548; Fuglie et al., *supra* note 179.

181. Fuglie et al., *supra* note 179; *see also* Graff et al., *supra* note 69, at 349 (discussing widespread acquisitions of seed and agricultural biotechnology firms by what were originally large chemical companies).

182. Kalaitzandonakes et al., *supra* note 177, at 22; *see also* Nicholas Kalaitzandonakes, *Biotechnology and the Restructuring of the Agricultural Supply Chain*, 1 AGBIOFORUM 40, 40 (1998).

183. *See* KING, *supra* note 33, at 6 ("A remarkable trend in the U.S. commercial seed industry in the 1990's was rapid consolidation as smaller seed companies and plant-breeding operations were purchased by large agricultural concerns."); *see also* Kalaitzandonakes et al., *supra* note 177, at 22 (describing "a wave of strategic mergers and acquisitions" in the 1990s).

184. *See* Graff et al., *supra* note 69, at 349; *see also* Moschini, *supra* note 176.

185. Moss & Taylor, *supra* note 77, at 362.

186. Graff et al., *supra* note 69, at 349.

**Table 2**
Selected Vertical Acquisitions by Monsanto, 1997-2016[187]

| Acquired Company | Field of Business | Year of Acquisition |
|---|---|---|
| Divergence | Biotechnology (pest control) | 2011 |
| WestBred | Wheat germplasm | 2009 |
| MDM Sementes de Algodao | Seeds | 2009 |
| CanaVialis | Sugarcane germplasm | 2008 |
| Alellyx | Biotechnology | 2008 |
| Semillas Cristiani Burkard | Seeds | 2008 |
| De Ruiter Seeds | Seeds | 2008 |
| Peotec Seeds | Seeds | 2008 |
| Agroeste Sementes | Seeds | 2007 |
| Fielder's Choice Direct | Seeds | 2006 |
| Delta & Pine Land | Seeds | 2006 |
| Diener Seeds | Seeds | 2006 |
| Sieben Hybrids | Seeds | 2006 |
| Kruger Seed | Seeds | 2006 |
| Trisler Seed Farms | Seeds | 2006 |
| Campbell Seed | Seeds | 2006 |
| Gold Country Seed | Seeds | 2006 |
| Heritage Seeds | Seeds | 2006 |
| Fontanelle Hybrids | Seeds | 2005 |
| Steward Seeds | Seeds | 2005 |
| Trelay Seed Company | Seeds | 2005 |
| Stone Seed Farm | Seeds | 2005 |
| Specialty Hybrids | Seeds | 2005 |
| NC+ Hybrids | Seeds | 2005 |
| Emergent Genetics | Seeds | 2005 |
| Seminis | Seeds | 2005 |
| Channel Bio | Seeds | 2004 |
| DeKalb Genetics | Biotechnology | 1998 |
| Calgene | Biotechnology | 1997 |

187. I identified these acquisitions by searching Bloomberg Law's Deal Analytics database for mergers and acquisitions in which "Monsanto Co (U.S.)" was an acquirer. I then reviewed press releases and news reports to gather more information about each deal presented in Table 2.

This Article argues that in addition to classic transaction costs and contractual hazards,[188] the need to aggregate tacit knowledge and innovative human capital has contributed significantly to vertical integration. Agriculture biotechnology is an interesting case study because patented assets and related tacit knowledge appear at various points along the value chain. First, biotechnology research yields both patented traits and patent-related tacit knowledge, which is extremely valuable because "the precise timing of the steps or subtle nuances in how the steps are performed can affect the results in important and significant ways."[189] In a dynamic similar to that in the biopharmaceutical industry, the knowledge demands of effectively exploiting agricultural biotechnology render patents alone insufficient as mechanisms of technology transfer.

Second and further downstream, the need to access tacit knowledge pertaining to seed germplasm has also contributed to vertical integration. Seed companies are valuable not only for their high-quality germplasm but also for their tacit knowledge of how to handle and manipulate such germplasm. Indeed, the "old line skills of seed breeding" are highly valued, thus rendering firms with such expertise prime targets for acquisition.[190] Given the difficulty of transferring such tacit knowledge via contracts alone, agricultural biotechnology companies have acquired entire seed companies, which is more efficient than trying to replicate such expertise in-house.[191]

While separate biotechnology and seed companies exist, the perceived efficiencies of producing both assets in-house have motivated significant vertical integration.[192] Graff and colleagues have empirically studied genetically engineered traits, transformation, and germplasm before and after periods of intense consolidation, finding "support for a model of endogenous industry restructuring that emphasizes complementarities and transaction costs in the coordination of intellectual assets."[193] Their analysis reveals that aggregation of assets under common ownership, as opposed to contracting between separate parties, "has realized, or unlocked, a greater degree of complementarity in these intellectual assets."[194]

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188. *See* Fulton & Giannakas, *supra* note 85, at 144-45 (noting that uncertainty regarding early biotech patents and asset specificity have contributed to vertical integration); Kalaitzandonakes et al., *supra* note 177, at 22 (contending that expropriation risk and long time horizons have contributed to vertical integration).

189. *See* Fulton & Giannakas, *supra* note 85, at 145.

190. *See* Lesser, *supra* note 180, at 58-59.

191. *See* KING, *supra* note 33, at 7.

192. *See* Moss, *supra* note 173, at 549.

193. *See* Graff et al., *supra* note 69, at 350.

194. *See id.* at 360 (emphasis omitted).

Additional business factors, such as economies of scale and scope, have also contributed to vertical integration.[195] After the initial costs of R&D and regulatory approval are incurred for a genetically engineered trait, ramping up production involves relatively low marginal cost, thus allowing firms to exploit economies of scale.[196] Such rapid expansion can support an "escalation strategy" that allows integrated companies to dominate competitors.[197] Similarly, once a company has engineered a specific gene, say for pest resistance, relatively little cost is required to adapt that gene to other crops.[198] In this context, vertical integration with seed companies also promotes economies of scope.[199] Another type of economy of scope arises from "stacking" traits—that is, combining more than one genetically engineered trait within the same seed. Indeed, Monsanto has pursued such a strategy to great effect.[200] Vertical integration of multiple biotechnology and seed assets creates opportunities for diversified product offerings, thus conferring a competitive advantage.[201]

Relatedly, complementarity has contributed to integration between producers of genetically modified seeds and chemicals.[202] Agricultural biotechnology companies engineer traits to work in tandem with specialized chemicals such as herbicides and pesticides.[203] Given strong demand complementarities, a single integrated firm producing both genetically modified seeds (such as Roundup Ready soybean seeds) and chemicals (such as the Roundup herbicide) may be more profitable than separate firms.[204]

Monsanto offers a compelling case study of both vertical integration and the specific strategy of semi-integration. As Monsanto itself has observed, "[M]any biotech trait providers are vertically integrated with seed companies, enabling them to directly take on the risk of quickly introducing new traits in

195. For instance, in the 1980s, many large corporations sold their chemical units, thus freeing up capital for vertical acquisitions. See KING, *supra* note 33, at 6. Furthermore, large ag-bio companies such as Monsanto have received high valuations, thus enabling more acquisitions. See LESSER, *supra* note 180, at 59.

196. *See* Fulton & Giannakas, *supra* note 85, at 143.

197. *See id.*

198. *See id.*

199. *See id.*

200. *See* Moss, *supra* note 173, at 554 ("Monsanto traits appear in 91% of intra-firm stacks.").

201. *See* Moss & Taylor, *supra* note 77, at 345.

202. Technically, this type of integration is lateral rather than vertical, but similar principles of knowledge coordination apply.

203. *See* Fulton & Giannakas, *supra* note 85, at 144.

204. *See id.*

the seed they sell."[205] And as noted above, what originally started out as a chemical company has acquired large numbers of agricultural biotechnology and seed companies.[206] Importantly, much of this consolidation reflects semi-integration. For instance, many of Monsanto's acquisitions operate as separate brands within the company.[207] Through these acquisitions, Monsanto obtains access to the valuable distribution channels and customer relationships of formerly separate companies.[208] For instance, when Monsanto acquired regional seed firm NC+ Hybrids, it maintained NC+ as an autonomous brand that continued to market through its existing channels.[209] Another Monsanto acquisition, Channel Bio Corp., manages three independent brands: Crow's Hybrid Corn, Midwest Seed Genetics, and Wilson Seeds.[210] Monsanto has aggressively acquired numerous parties in its value chain, but it has granted many of them a high degree of autonomy in their new home.

The picture that emerges is more complicated than what the traditional theory of the firm would predict. Patents promote market exchanges between separate entities, thus facilitating vertical disintegration. However, classic transaction costs borne of uncertain patent rights and opportunism push in the opposite direction. Going further, the need to aggregate tacit knowledge (as well as the people embodying it) related to biotechnology and germplasm also encourages vertical integration. Additionally, the strategic objectives of exploiting economies of scale and scope as well as achieving rapid growth also push toward consolidation. The result is a high degree of vertical integration, much of which takes the form of semi-integration to maintain the autonomy and innovativeness of acquired entities.

### C. Information Technology and Startups

The peculiar dominance of vertical integration over licensing patents is also evident in the acquisition practices of major Silicon Valley technology companies. Scholars have argued that "[f]irms have not vertically integrated because smaller start-ups could provide parts more cheaply and effectively."[211] Challenging this descriptive claim, this Subpart finds ample evidence of vertical integration in the information technology sector.

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205. *Observations on Competition in the U.S. Seed Industry*, MONSANTO (Apr. 6, 2017), https://perma.cc/W9UE-Z8PE.

206. *See supra* Table 2; *see also* Graff et al., *supra* note 69, at 349.

207. *See Our Brands*, MONSANTO, https://perma.cc/3GCX-JCMY (archived Mar. 7, 2018).

208. *See* Monsanto Co., Annual Report (Form 10-K), at 51 (Oct. 19, 2016).

209. *See* Dick Piersol, *Monsanto Buys NC+ Hybrids*, LINCOLN J. STAR (Feb. 28, 2005), https://perma.cc/Y4VH-JY5R.

210. *See id.*

211. *E.g.*, Gilson, *supra* note 100, at 591.

In general, Google, Facebook, and other large incumbents have been on a buying spree. Recent high-profile acquisitions include Google's purchases of social mapping firm Waze for $1 billion and home maintenance developer Nest for $3.24 billion as well as Facebook's acquisitions of social media company WhatsApp for $16 billion and photo sharing firm Instagram for $1 billion.[212] While these deals have attracted significant media attention, these companies have also engaged in hundreds of less scrutinized acquisitions, primarily of startups. Between Google's launch in 1998 and 2015, it acquired more than 170 companies.[213] In its first decade, Facebook acquired nearly 50 companies.[214] In fiscal year 2014 alone, Apple bought at least 30 companies.[215]

While many of these acquisitions represent horizontal integration, extension into new markets, or mere acqui-hires,[216] many of them are also vertical technology plays, in which an incumbent in a value chain seeks to acquire some upstream or downstream technology in that chain.[217] For instance, the data generated by Waze and Nest represent potential upstream inputs into Google's core search and analytics businesses.[218] Additionally, as shown in Table 3 below, recent vertical acquisitions by Facebook show a pattern of bringing upstream software and technical providers in-house to integrate with its social network. These acquisitions raise a make-or-buy question: Why are technology companies buying startups outright instead of licensing or buying their intellectual property?

212. *See* Steven Davidoff Solomon, *New Buying Strategy as Facebook and Google Transform into Web Conglomerates*, N.Y. TIMES: DEALBOOK (Aug. 5, 2014, 5:26 PM), https://perma.cc/ZZ7G-7FUU.

213. *See* Jillian D'Onfro, *Google's Ten Biggest Acquisitions*, BUS. INSIDER (Jan. 20, 2015, 12:22 PM), https://perma.cc/H7NX-8LCE.

214. *See* Ivana Kottasova, *Zuckerberg Goes Shopping: Facebook's Top 10 Purchases*, CNN (updated Mar. 26, 2014, 2:42 PM ET), https://perma.cc/VHX9-TH6N.

215. *See* Luckerson, *supra* note 1; *cf.* Teece, Digital Economy, *supra* note 24, at 26 ("Apple has, to a large extent, 'solved' the coordination problem by integrating most of the innovation-intensive elements of its value chain—the microprocessor and the handset hardware.").

216. *See* LOBEL, *supra* note 9, at 24-26; Coyle & Polsky, *supra* note 76, at 283-84; Victoria Stunt, *Why Google Is Buying a Seemingly Crazy Collection of Companies*, CBC NEWS (updated Feb. 19, 2014), https://perma.cc/9HX4-X9VX.

217. *Cf.* Jaewon Kang, *Facebook Gets the Last Laugh as Savvy Acquisitions Start to Pay Off*, THESTREET (Apr. 17, 2016, 11:20 AM EDT), https://perma.cc/VL9P-BPT8 (describing Facebook's ambitious strategy of obtaining innovative technologies by acquiring outside companies); Solomon, *supra* note 212 (noting technology incumbents' strong drive to acquire novel, disruptive technologies).

218. *See* Solomon, *supra* note 212.

**Table 3**
Selected Vertical Acquisitions by Facebook, 2014-2016[219]

| Acquired Company | Field of Business | Year of Acquisition |
|---|---|---|
| The Eye Tribe | Software (eye tracking) | 2016 |
| FacioMetrics | Software (emotion detection) | 2016 |
| CrowdTangle | Software (content tracking) | 2016 |
| Nascent Objects | Software (modular manufacturing) | 2016 |
| Two Big Ears | Software (immersive audio) | 2016 |
| Masquerade Technologies | Software (video filter) | 2016 |
| Offerpop | Software (social marketing platforms) | 2015 |
| Pebbles Interfaces | Virtual reality | 2015 |
| TheFind | Shopping search engine | 2015 |
| QuickFire Networks | Software (video compression) | 2015 |
| Wit.ai | Natural language solutions | 2015 |
| Nimble VR | Hand-tracking camera | 2014 |
| 13th Lab | Computer vision and augmented reality | 2014 |
| PrivateCore | Secure server technology | 2014 |
| LiveRail | Video advertising solutions | 2014 |
| Pryte | Mobile data | 2014 |
| ProtoGeo | Software (fitness and activity tracking) | 2014 |
| Oculus | Virtual reality | 2014 |
| WhatsApp | Communication services | 2014 |
| Branch Media | Social media platforms | 2014 |
| Little Eyes Labs | Mobile application analysis tools | 2014 |

This Subpart argues that considerations of tacit knowledge, innovative capacity, and business strategy help drive these acquisitions. It contends that even in the presence of patents, technology transfer is more efficient when achieved through organizational integration. In particular, absorbing the software engineers who invented a patented technology can presumably accelerate the technology's incorporation, development, and commercialization.[220] Furthermore, acquiring creative talent provides the prospect of generating new and unforeseen innovations in the future. In a sense, the

219. I identified these acquisitions by searching Bloomberg Law's Deal Analytics database for mergers and acquisitions in which "Facebook Inc Class A (U.S.)" was an acquirer. I then reviewed news reports to gather more information about each deal presented in Table 3.

220. The challenge then emerges of how to retain such talented employees. *See infra* notes 361-67 and accompanying text.

benefits of acqui-hiring inform incumbents' decisions to purchase entire startups rather than simply license their patents. Strategic considerations favoring size and scale also weigh in favor of vertical integration.

For instance, Google's 2015 acquisition of Jibe Mobile reveals the knowledge and human capital benefits of acquiring a startup rather than merely licensing its patents. Founded in 2006, Jibe developed a new standard for mobile messaging called RCS (Rich Communication Services), which offers greater functionality relative to the prevailing SMS (Short Message Service) standard.[221] Rather than a pure acqui-hire aimed at hiring engineers and then jettisoning their projects, Google clearly sought to integrate Jibe's technology into its own messaging platform.[222] Notably, Jibe holds several patents covering its technology,[223] but Google did not simply license or acquire these patents. Rather, Google bought the company and announced that "the Jibe Mobile team is joining Google to help us bring RCS to a global audience."[224] Full acquisition allowed Google to work closely with Jibe engineers and jointly "build on the great work that they've already done."[225] Rather than simply acquiring a discrete technological input, Google acquired the dynamic engineers who could adapt this technology and develop related ones in the future.

The benefits of vertical integration are also evident in Facebook's acquisition of Face.com, an Israeli firm that makes patented mobile facial recognition technology.[226] In 2012, Facebook acquired the company for somewhere between $55 million and $100 million.[227] Notably, this deal was "absolutely not an acqui-hire," as Facebook sought to incorporate Face.com's face detection technology to facilitate mobile tagging of photos.[228] According to one

221. *See* Drew Olanoff, *Google Acquires Jibe Mobile to Help Adopt New Standard for Carrier Messaging*, TECHCRUNCH (Sept. 30, 2015), https://perma.cc/R4PK-U99Z; Steven Tweedie, *Google Is Buying a Messaging Startup*, BUS. INSIDER (Sept. 30, 2015, 1:39 PM), https://perma.cc/RX4L-CM4D.

222. *See* Natasha Lomas, *After Jibe Mobile Buy, Google to Provide Carriers with Android RCS Client*, TECHCRUNCH (Feb. 22, 2016), https://perma.cc/4KGB-7GJH.

223. *See, e.g.*, U.S. Patent No. 8,327,006 (filed Oct. 18, 2011); U.S. Patent No. 8,327,005 (filed Oct. 18, 2011); U.S. Patent No. 8,321,566 (filed Oct. 18, 2011).

224. Mike Dodd, *Committing to RCS, the Latest Standard in Carrier Messaging*, ANDROID: OFFICIAL BLOG (Sept. 30, 2015), https://perma.cc/8SBX-F293.

225. *See id.*

226. *See* Alexia Tsotsis, *Facebook Scoops Up Face.com for $55-60M to Bolster Its Facial Recognition Tech*, TECHCRUNCH (June 18, 2012), https://perma.cc/D26P-3XFW; *see also* U.S. Patent No. 8,666,198 (filed Mar. 19, 2009).

227. Kottasova, *supra* note 214; *see also* Tsotsis, *supra* note 226.

228. Tsotsis, *supra* note 226; *see also* Mike Isaac, *Facebook Acquires Facial Recognition Technology Company Face.com for Nearly $60 Million*, ALLTHINGSD (updated June 18, 2012, 1:37 PM PST), https://perma.cc/A3L9-8T47 ("It's a complete acquisition, which
*footnote continued on next page*

observer, "[I]t's fairly obvious that the company's heralded facial recognition IP is what Facebook is truly after."[229] While not primarily an acqui-hire, the acquisition still aimed to obtain not only Face.com's technology but also its engineers.[230] Tellingly, Facebook used the language of vertical integration to announce the acquisition, noting that "[t]his transaction simply brings a world-class team and long-time technology vendor in house."[231] While this integration transferred existing technology, it also transferred innovative employees who can develop related advances in the future. For their part, members of Face.com welcomed vertical integration as a way to exploit Facebook's vast resources and accelerate the development of their technology.[232]

In these and other transactions, the large incumbent could have licensed (or bought) the startup's patents, but it acquired the entire startup instead. Doing so serves several objectives. First, absorbing the engineers who actually created a technology greatly accelerates the absorption of that technology by the acquiring company. Second, buying an entire startup also confers the benefits of an acqui-hire and allows acquired talent to develop new technologies for the acquiring company in the future. Third, vertical integration via acquisition offers strategic benefits. Given that capital markets prize rapid growth,[233] increasing one's corporate footprint through acquisitions offers clear benefits over simply engaging in numerous licensing deals. To the extent that integrating these engineers with existing operations will accelerate the ramping up of new products and product diversification, such integration also facilitates economies of scale and scope.

Importantly, many of these acquisitions follow the semi-integration model of vertical integration. Rather than full integration into a company's management scheme and operations, many acquired startups continue to run on a quasi-independent basis. In this fashion, acquisitions in the information technology space parallel pharmaceutical acquisitions of biotech firms.[234] For

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means both talent and technology will now become Facebook's in the deal."); John D. Sutter, *Why Faces Matter to Facebook*, CNN (updated June 20, 2012, 7:09 AM ET), https://perma.cc/JK86-KBTX.

229. Darren Murph, *Face.com Acquired by Facebook for an Estimated $80 Million+, Facial Tagging Clearly at the Forefront*, ENGADGET (June 18, 2012), https://perma.cc/V2HG-S8LC.

230. *Cf.* Luckerson, *supra* note 1 ("It's important to Google and other tech giants that the founders behind ideas worth paying for stick around as well.").

231. *See* Sutter, *supra* note 228 (quoting a statement by Facebook).

232. *See id.* ("By working with Facebook directly, and joining their team, we'll have more opportunities to build amazing products that will be employed by consumers—that's all we've ever wanted to do." (quoting Gil Hirsch, CEO of Face.com)).

233. *See supra* note 89 and accompanying text.

234. *See supra* text accompanying notes 153-62.

instance, Nest operated as a separate entity from Google until February 2018,[235] and the head of DoubleClick, another Google acquisition, continued to lead that unit for the first eight years after its acquisition.[236] Similarly, in 2014 Google acquired Skybox Imaging, a satellite maker, thus vertically integrating with an upstream provider of a technological input to Google Earth.[237] Skybox, which is now known as Terra Bella, maintained a "semi-autonomous" status within Google before its sale in 2017.[238] Furthermore, Jibe continues to operate as a separately branded platform within Google.[239] Facebook similarly grants considerable autonomy to many of the companies it acquires.[240] Such semi-integration preserves the tacit, socially embedded innovative capacities of startups while coupling them with the resources of a much larger company. While the moniker of vertical integration accurately describes these acquisitions, they depart from full assimilation by affording significant independence to acquired entities.

Notably, technology incumbents routinely buy patents separate from the companies that created them, but this practice only corroborates the notion that technology transfer proceeds best when both a company and its patents are acquired. Technology companies obtain huge numbers of patents, and some spend more on patents than on R&D.[241] In 2011, Google bought 1023 patents from IBM to protect its Android operating system against patent lawsuits.[242] In

235. *See* Paresh Dave, *Alphabet Shifts Thermostat Maker Nest into Google*, REUTERS (Feb. 7, 2018, 1:30 PM), https://perma.cc/5LGY-4Q85 (reporting that Google's parent company Alphabet moved Nest into Google's hardware group but that Nest and Google would keep separate offices); *see also* Luckerson, *supra* note 1 (noting that retaining Nest's brand identity was critical to Nest CEO Tony Fadell).

236. *See* Tim Peterson, *Google Display Ad Chief Neal Mohan Is YouTube's New Product Boss*, ADAGE (Nov. 18, 2015), https://perma.cc/M2NT-4ZME; *see also* Larry Kim, *Why Google's Larry Page Only Buys Companies That Pass His Crazy Toothbrush Test*, INC. (Aug. 28, 2014), https://perma.cc/MWP3-D5CT (reporting that Google "let[] Neal Mohan continue to lead DoubleClick after its acquisition" while also "putting him in charge of AdSense").

237. *See* Luckerson, *supra* note 1.

238. *See id.* (quoting Ching-Yu Hu, co-founder of Skybox Imaging); *see also* Darrell Etherington, *Google Selling Terra Bella Satellite Imaging Business to Planet*, TECHCRUNCH (Feb. 3, 2017), https://perma.cc/M6FF-3R8R.

239. *See* JIBE, https://perma.cc/DLR4-6X6U (archived Apr. 6, 2018).

240. *See* James B. Stewart, *Microsoft-LinkedIn Deal Ignites Twitter Speculation*, N.Y. TIMES (June 16, 2016), https://perma.cc/NC6L-UPVW.

241. *See* Reich, *supra* note 144 ("White House intellectual property adviser Colleen V. Chien noted in 2012 that Google and Apple were spending more money acquiring patents (not to mention litigating them) than on doing research and development.").

242. *See* Susan Decker & Brian Womack, *Google Buys 1,023 IBM Patents to Bolster Defense of Android*, BLOOMBERG TECH. (Sept. 14, 2011, 1:36 PM PDT), https://perma.cc/XL82-P5K9.

2012, Google purchased Motorola Mobility for $12.5 billion, primarily for its 17,000 patents and 7000 patent applications.[243] In 2013, Google bought an undisclosed number of patents from Foxconn, mainly to ensure freedom to operate for wearable technologies like Google Glass.[244] Google even launched a Patent Purchase Promotion marketplace in 2015 through which it fielded offers to buy patents from other entities.[245]

Significantly, however, these large patent purchases are made more for defensive reasons—namely to keep patents away from trolls and maintain freedom to operate—than as a way of transferring technologies.[246] For instance, when Facebook acquired 650 AOL patents from Microsoft for $550 million, it sought not technology transfer but to shore up its litigation position in a dispute with Yahoo.[247] Earlier the same year, Facebook had purchased 750 patents from IBM for similar reasons.[248] And in 2011, Apple joined Microsoft, Research in Motion, and other technology companies to purchase over 6000 patents and patent applications from Nortel Networks for $4.5 billion, thus keeping those patents away from Google.[249]

An interesting irony thus emerges: When companies seek meaningful technology transfer, they often purchase the entire patentee firm, which includes both the patents and the people who developed the relevant technology. But when technology companies acquire large numbers of patents—which are touted for their technology transfer capabilities—they typically do so not to practice a technology but to maintain freedom to operate

243. *See* Antonio Regalado, *Google's Growing Patent Stockpile*, MIT TECH. REV. (Nov. 29, 2013), https://perma.cc/8V6N-WCTE; *see also* J. Jonas Anderson, *Patent Dialogue*, 92 N.C. L. REV. 1049, 1062 & n.55 (2014) ("Major companies now make corporate acquisitions largely for the patent portfolios involved.").

244. *See* Henry Mance & Tim Bradshaw, *Google Buys Wearable Display Patents from Foxconn*, FIN. TIMES (Aug. 23, 2013), https://perma.cc/N3SY-7562.

245. *See Announcing the Patent Purchase Promotion*, GOOGLE PUB. POL'Y BLOG (Apr. 27, 2015), https://perma.cc/ARL3-Q97Y (announcing that the submission period would run from May 8 through May 22, 2015). Similar programs have since followed Google's lead, including the Industry Patent Purchase Promotion "launched by Google and a consortium led by defensive aggregator Allied Security Trust." *See* Jack Ellis, *Uber Follows in Footsteps of Google and AST with New Patent Purchase Promotion*, IAM MARKET (Apr. 19, 2017), https://perma.cc/23W2-ESVE.

246. *See* Davey Alba, *Google Wants to Buy Your Patent to Keep It Away from Trolls*, WIRED (Apr. 27, 2015, 5:57 PM), https://perma.cc/PNT2-C95E; Regalado, *supra* note 243.

247. *See* Shira Ovide & Geoffrey A. Fowler, *Facebook Buys AOL Patents from Microsoft for $550 Million*, WALL ST. J. (updated Apr. 23, 2012, 2:45 PM ET), https://perma.cc/49FX-W5QY.

248. *See* Dan Levine & Alexei Oreskovic, *Facebook Buys 750 Patents from IBM: Source*, REUTERS (Mar. 22, 2012, 8:20 PM), https://perma.cc/5DQA-458A.

249. *See* Steven Church et al., *Apple Joins Microsoft, RIM in $4.5 Billion Buy of Nortel Patents*, BLOOMBERG TECH. (July 1, 2011, 9:18 AM PDT), https://perma.cc/2DG8-UMXE.

and to defend against competitors. In many contexts, vertical integration is a superior conduit for technology transfer than mere patent licensing alone.

## D. University-Industry Technology Transfer

Finally, the knowledge, human capital, and strategic advantages of vertical integration over mere patent licensing are evident in a rather surprising context: university-industry technology transfer. Universities patent thousands of inventions a year, from biological compounds to electronic components, and they typically license these technologies to companies for commercialization.[250] Universities and commercializing firms thus occupy upstream and downstream positions on a common value chain. Indeed, declining internal R&D budgets coupled with continued government support for university research programs are leading many companies to rely increasingly on academic technology transfer for new innovations.[251] In theory, this situation is well suited to patent-mediated market exchanges between universities and companies.[252] And based in large part on the Bayh-Dole Act of 1980,[253] which allowed universities to take title to patents arising from federally funded research, universities have significantly increased their patenting and licensing activities.[254] In surprising ways, however, universities and their licensees are engaged in varying degrees of organizational integration to transfer and develop patented academic technologies.

At the outset, one should acknowledge the seeming incongruity of universities vertically integrating with companies to commercialize academic inventions. Beyond efficiencies inhering in specialization and trade, the stark normative and institutional differences between universities and private companies suggest that vertical integration would be wholly inappropriate. The traditional normative character of nonprofit universities, which value objectivity, academic freedom, and the disinterested pursuit of knowledge,

250. *See* Peter Lee, *Patents and the University*, 63 DUKE L.J. 1, 4 (2013) (noting that in fiscal year 2011, universities received 4700 U.S. patents and executed 4899 licenses).

251. *See Glass Half Full?*, WORLD INTELL. PROP. REV. (Jan. 2, 2011), https://perma.cc/TG9U-7G4G ("[L]arger corporations are returning to tech transfer as a means of compensating for reductions in their own research budgets." (quoting Michael Greenbaum, partner at Blank Rome LLP)).

252. *See* Scott Shane, *Selling University Technology: Patterns from MIT*, 48 MGMT. SCI. 122, 122-24 (2002).

253. Pub. L. No. 96-517, § 6(a), 94 Stat. 3015, 3018-27 (codified as amended at 35 U.S.C. §§ 200-212 (2016)).

254. *See* 35 U.S.C. §§ 201-202; Lee, *supra* note 250, at 28-49 (discussing the Bayh-Dole Act and the growth of university patenting). *But see* David C. Mowery et al., *The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980*, 30 RES. POL'Y 99, 100 (2001) (noting that university patenting was already increasing prior to the Bayh-Dole Act's enactment).

contrasts sharply with the profit-maximizing mission of corporations.[255] While universities have certainly grown more commercial,[256] these enduring normative differences suggest that vertical integration would be not only logistically difficult but also institutionally infeasible. It would be odd, after all, for Merck to merge with a university's department of molecular and cellular biology to produce drugs. However, the knowledge demands of transferring scientifically complex inventions are driving a meaningful amount of vertical integration between universities and companies that license their patents. Although an enormous amount of technical knowledge diffuses out of universities through informal channels,[257] this Subpart focuses on formal technology transfer via university patenting and licensing. Even in the presence of patents, companies often seek some kind of human or institutional connection to the university in order to transfer patent-related tacit knowledge.

The knowledge demands of commercializing university inventions are particularly high given the generally embryonic nature of cutting-edge academic inventions.[258] One 2001 study found that only 12% of university patented inventions were ready for commercial use at the time of licensing, and the feasibility of manufacturing was known for only 8%.[259] Another study found that 74.5% of university inventions were either proofs of concept or prototypes when they were licensed.[260] For such embryonic inventions, tacit knowledge is highly relevant, as a significant amount of invention-related knowledge resides, uncodified, in the inventor's mind.[261] Accessing such tacit knowledge is a high priority for firms licensing university inventions.[262]

255. *See* Lee, *supra* note 250, at 4-5, 7-20, 35-49 (describing the traditional noncommercial nature of universities and their more recent commercial orientation).

256. *See* Annetine C. Gelijns & Samuel O. Thier, *Medical Innovation and Institutional Interdependence: Rethinking University-Industry Connections*, 287 JAMA 72, 72 (2002); Lee, *supra* note 250, at 4; Richard R. Nelson, *Observations on the Post-Bayh-Dole Rise of Patenting at American Universities*, 26 J. TECH. TRANSFER 13, 17 (2001).

257. *See* Ajay Agrawal, *University-to-Industry Knowledge Transfer: Literature Review and Unanswered Questions*, 3 INT'L J. MGMT. REVS. 285, 285-86 (2001).

258. *See* Richard Jensen & Marie Thursby, *Proofs and Prototypes for Sale: The Licensing of University Inventions*, 91 AM. ECON. REV. 240, 240-41 (2001).

259. *Id.* at 243.

260. *See* Jerry G. Thursby & Marie C. Thursby, *Are Faculty Critical?: Their Role in University-Industry Licensing*, 22 CONTEMP. ECON. POL'Y 162, 167 & tbl.4 (2004).

261. *See* Dasgupta & David, *supra* note 55, at 517; Fiona Murray, *The Role of Academic Inventors in Entrepreneurial Firms: Sharing the Laboratory Life*, 33 RES. POL'Y 643, 645 (2004); Lynne G. Zucker et al., *Commercializing Knowledge: University Science, Knowledge Capture, and Firm Performance in Biotechnology*, 48 MGMT. SCI. 138, 141 (2002).

262. *See* Agrawal, *supra* note 257, at 291; Robert A. Lowe, *Who Develops a University Invention?: The Impact of Tacit Knowledge and Licensing Policies*, 31 J. TECH. TRANSFER 415, 420 (2006).

Empirical studies reveal that firms that engage the faculty inventor increase the likelihood and degree of success of commercializing university inventions.[263] One study reported that "roughly 40% of all licenses require faculty involvement" and that businesses and their employees that license university inventions attributed 18% of failures of licensed technologies to the failure of an inventor to deliver tacit knowledge or cooperate in development.[264]

Several case studies underscore the value of directly involving academic inventors in transferring patented technologies. For instance, faculty inventors were critical to developing the Fluorescence-Activated Cell Sorter, which Becton-Dickinson licensed from Stanford University.[265] Similarly, a faculty inventor helped drive the commercialization of Xalatan, a glaucoma medication Pharmacia licensed from Columbia University.[266] In some instances, faculty inventors express significant interest in working with licensee firms and help prod them into commercializing academic technologies.[267]

University scientists are helpful not just in practicing some basic (patented) invention but also in developing marketable products and ramping up manufacturing.[268] For instance, a professor and a graduate student at the University of British Columbia invented a system to measure the weight of a load while it was being transported in a bucket.[269] While the technology worked in the laboratory, the licensee sought the inventors' help to scale up the system, minimize instrumentation, and adapt it to commercial use.[270] Among other implications, the importance of interpersonal interaction in tacit knowledge exchange helps explain the tendency of academic licensees to cluster geographically around universities.[271]

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263. *See* Agrawal, *supra* note 67, at 63, 77; Jensen & Thursby, *supra* note 258, at 241; Stuart et al., *supra* note 107, at 484; Thursby & Thursby, *supra* note 260, at 170.

264. *See* Thursby & Thursby, *supra* note 260, at 164, 167-68, 168 tbl.5, 170.

265. *See* Peter Lee, *Transcending the Tacit Dimension: Patents, Relationships, and Organizational Integration in Technology Transfer*, 100 CALIF. L. REV. 1503, 1531-32 (2012).

266. *See id.* at 1532-33.

267. *See, e.g.*, DAVID C. MOWERY ET AL., IVORY TOWER AND INDUSTRIAL INNOVATION: UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER BEFORE AND AFTER THE BAYH-DOLE ACT IN THE UNITED STATES 166-69 (2004) (detailing the prominent role of the faculty inventor in promoting the commercialization of Xalatan).

268. *See* Agrawal, *supra* note 67, at 65 ("[I]n the process of creating their invention, the inventors develop intuition[s] that enable them to better predict how the invention will behave under various circumstances and thus increase the efficiency of the trial-and-error process that often characterizes new product development.").

269. *See id.* at 66.

270. *See id.* at 66-68.

271. *See* Agrawal, *supra* note 257, at 294-97; Lowe, *supra* note 262, at 415.

The objective of accessing tacit knowledge and the faculty inventors embodying it has motivated a range of integration strategies between scientists and universities, on the one hand, and licensee firms, on the other. Such integration holds real economic and strategic value, for it optimizes the exploitation of technical knowledge, thus giving commercial ventures the best chance to succeed and expand. In exploring these arrangements, this Subpart uses the term "integration" in a liberal sense. Many of these arrangements do not reflect actual integration such as the outright mergers and acquisitions explored in the previous Subparts. Indeed, the significant autonomy maintained by universities in these agreements reflects principles of semi-integration. However, these case studies illustrate that mere arm's length licensing is frequently insufficient to transfer patented academic technologies, thus necessitating more intensive organizational meshing between patentees and licensees.

Starting at the most informal end of the spectrum, firms actively cultivate relationships with the academic research community. High-tech firms "must be connected to the open science community by being actively involved in sharing research results (publishing) and also engaged in research collaboration."[272] Companies routinely monitor academic research and exploit links with the scientific community to learn about new discoveries.[273] Among other benefits, such academic connections enhance the absorptive capacity of companies that license university patents.[274] Professional networks play an important role in transferring knowledge, resources, and technology,[275] particularly in biotechnology. "The cross-traffic between universities and biotech companies is so extensive and reciprocal that it is appropriate to consider them part of a common technological community."[276] Beyond intellectual connections, academic and industry scientists frequently occupy a common social milieu, which also facilitates technology transfer.[277] While

272. Agrawal, *supra* note 257, at 287.

273. Jeannette Colyvas et al., *How Do University Inventions Get Into Practice?*, 48 MGMT. SCI. 61, 66-67 (2002).

274. *See* Agrawal, *supra* note 257, at 289.

275. *See* Albert N. Link et al., *An Empirical Analysis of the Propensity of Academics to Engage in Informal University Technology Transfer*, 16 INDUS. & CORP. CHANGE 641, 644-45 (2007); Walter W. Powell & Jason Owen-Smith, *Universities and the Market for Intellectual Property in the Life Sciences*, 17 J. POL'Y ANALYSIS & MGMT. 253, 266 (1998); Ammon J. Salter & Ben R. Martin, *The Economic Benefits of Publicly Funded Basic Research: A Critical Review*, 30 RES. POL'Y 509, 523 (2001).

276. Powell, *supra* note 46, at 200; *see also* Liebeskind et al., *supra* note 46, at 430-33; Powell et al., *supra* note 44, at 139.

277. *See* Wesley David Sine et al., *The Halo Effect and Technology Licensing: The Influence of Institutional Prestige on the Licensing of University Inventions*, 49 MGMT. SCI. 478, 494 (2003).

these networks are not necessarily commercial in a direct sense, they augment commercial transactions and allow knowledge transfers that exceed the capabilities of market exchanges.[278]

More formally, tacit knowledge exchange also arises through layering multiple types of contractual relationships. In parallel to licensing a university patent, companies may hire faculty inventors as consultants to transfer tacit knowledge and aid in commercialization.[279] Longer-term engagements are also common where academic scientists serve on scientific advisory boards for licensee companies.[280] While such contracts do not represent outright vertical integration, they represent a thickening of relationships between upstream scientists and downstream companies motivated in significant part to transfer knowledge.

In parallel with direct relationships with faculty inventors, companies also develop institutional linkages with universities themselves. The signature form of such linkage is sponsored research, in which companies fund academic research in exchange for exclusive licenses or options on any resulting patents.[281] Such sponsored research often gives the corporate sponsor authority to influence the type and scope of research performed.[282] Starting in the 1980s, there was an increase in personnel exchanges, common research projects, and even joint ventures between companies and universities.[283] Among other benefits, such connections facilitate tacit knowledge transfer between academic scientists and corporations funding their research (and licensing their patents).[284]

These arrangements blur the lines between contractual relationships and institutional meshing. As far back as 1980, pharmaceutical firm Hoechst provided $67.6 million to establish a molecular biology department at the Harvard-affiliated Massachusetts General Hospital in exchange for exclusive licensing rights on any resulting intellectual property.[285] The degree of

278. *See* Liebeskind et al., *supra* note 46, at 431.

279. *See* Agrawal, *supra* note 67, at 78; Nicholas S. Argyres & Julia Porter Liebeskind, *Privatizing the Intellectual Commons: Universities and the Commercialization of Biotechnology*, 35 J. ECON. BEHAV. & ORG. 427, 450 (1998); Lowe, *supra* note 262, at 415.

280. *See* Fiona Murray, *Innovation as Co-evolution of Scientific and Technological Networks: Exploring Tissue Engineering*, 31 RES. POL'Y 1389, 1395-96 (2002); Shane, *supra* note 252, at 127.

281. *See* Argyres & Liebeskind, *supra* note 279, at 444.

282. *See* Jensen & Thursby, *supra* note 258, at 252.

283. *See* Karen Seashore Louis et al., *Entrepreneurs in Academe: An Exploration of Behaviors Among Life Scientists*, 34 ADMIN. SCI. Q. 110, 114 (1989).

284. *Cf.* Howells, *supra* note 59, at 102 (describing personnel exchanges intended to facilitate tacit knowledge transfer between firms and universities).

285. *See* Argyres & Liebeskind, *supra* note 279, at 439-40.

managerial control in this arrangement exceeded a typical arm's length contract, as Hoechst retained the right to review research results before publication and eliminate projects that did not serve its interests.[286]

The Whitehead Institute for Biomedical Research at the Massachusetts Institute of Technology (MIT), funded by major Revlon stockholder and biotech venture capitalist Edwin Whitehead,[287] provides another example of institutional meshing. While the Whitehead Institute is administratively separate from MIT, it has at times appointed a significant fraction of the MIT biology faculty, and it retains patents on all funded research.[288] In this sense, the Institute "attempt[s] to create an inter-penetrating system of public and private research within a university setting."[289]

This trend is further illustrated in BP's funding of $500 million for alternative energy research at the University of California, Berkeley; Lawrence Berkeley National Laboratory; and the University of Illinois at Urbana-Champaign.[290] The funding agreement gave BP significant control over this initiative at the outset, including the power to appoint half of the eight members of the governing board.[291] In addition to "open research," the agreement also allows for closed proprietary research performed by BP employees at the academic institutions.[292] BP retains a nonexclusive, royalty-free license to any open-research discovery and an option on any exclusive license.[293] Additionally, BP may review research results before publication and can request delays in publication to allow time to file a patent application.[294] In a very meaningful sense, such sponsored research approaches the managerial control characteristic of vertical integration.

Universities have also engaged in forward integration to facilitate greater interpenetration with private companies. Universities frequently house proof-of-concept centers where academic researchers collaborate with startup engineers.[295] For instance, the von Liebig Center at the University of

286. *See id.*

287. *See id.* at 448.

288. *See id.*

289. *Id.*

290. Press Release, Univ. of Cal., Berkeley, BP Selects UC Berkeley to Lead $500 Million Energy Research Consortium with Partners Lawrence Berkeley National Lab, University of Illinois (Feb. 1, 2007), https://perma.cc/WSD9-QLR5.

291. *See* Charles Burress, *UC Berkeley, BP Finally Sign Contract for Research Project*, SFGATE (Nov. 15, 2007, 4:00 AM), https://perma.cc/3V4H-YR63.

292. *See id.*

293. *See id.*

294. *See id.*

295. *See* Gelijns & Thier, *supra* note 256, at 75.

California, San Diego Jacobs School of Engineering and the Deshpande Center at the MIT School of Engineering facilitate the transfer of academic inventions to industry.[296] Similarly, Georgia Tech's GA Advanced Technology Development Centers support the development of early stage research into commercial technologies.[297] In the same vein, many universities have helped establish research parks and incubators to nurture university spinoffs.[298] In fiscal year 2014, universities spun off 914 startup companies.[299] Increasingly, universities take equity stakes in companies licensing their patents,[300] thus approaching an organizational structure characteristic of vertical integration. Among other benefits, equity stakes "align the interests of the university and the firm towards the common goal of commercializing the technology."[301] Relatedly, for several decades universities have operated venture funds to invest in their spinouts.[302] Such developments reflect a growing entrepreneurial orientation of universities and reveal a high degree of structural integration with commercial firms.[303]

An organizational form that approaches classic definitions of vertical integration is the university spinout founded by an academic scientist.[304] In such arrangements, a faculty member invents a technology, which the university then patents, and the faculty member's startup licenses the patent to commercialize the invention. These spinouts integrate upstream tacit knowledge and downstream commercialization[305] and play a crucial role in transferring academic knowledge to the marketplace.[306] According to one commentator, "[I]t is always better for inventors to found firms when

296. Ewing Marion Kauffman Found., Proof of Concept Centers: Accelerating the Commercialization of University Innovation 2 (2008), https://perma.cc/H5BL-D3VD.

297. Vertinsky, *supra* note 67, at 2012.

298. *See* Jennifer L. Croissant & Laurel Smith-Doerr, *Organizational Contexts of Science: Boundaries and Relationships Between University and Industry*, *in* THE HANDBOOK OF SCIENCE AND TECHNOLOGY STUDIES 691, 697-98 (Edward J. Hackett et al. eds., 3d ed. 2008).

299. *AUTM Licensing Activity Survey: FY2014*, ASS'N U. TECH. MANAGERS, https://perma.cc/8GXM-YLRV (archived Mar. 7, 2018).

300. *See* Maryann Feldman et al., *Equity and the Technology Transfer Strategies of American Research Universities*, 48 MGMT. SCI. 105, 105 (2002).

301. *See id.* at 106.

302. *See* Shreefal Mehta, Commentary, *The Emerging Role of Academia in Commercializing Innovation*, 22 NATURE BIOTECHNOLOGY 21, 21 tbl.1, 22 (2004).

303. *See* Feldman et al., *supra* note 300, at 119.

304. *See* Murray, *supra* note 280, at 1400; Pisano, *supra* note 114.

305. *See, e.g.*, Norris F. Krueger et al., *From Traditional Tech Licensing to Entrepreneurial Tech Commercialization*, 44 LES NOUVELLES 111, 111 (2009).

306. *See* Barnett, *supra* note 20, at 998-99.

considerable effort is required to transfer their knowledge."[307] This organizational form responds directly to the difficulties of conveying tacit information, for tacit knowledge and commercial functions are integrated in the company's founder.

The importance of organizational integration and tacit knowledge transfer is evident in a field this Article has examined extensively: biotechnology.[308] A significant proportion of biotech drugs on the market are the product of university licensing, and academic scientists had founded approximately half of all biotech firms as of 2002.[309] Participation of the discovering scientist is often necessary to commercialize such cutting-edge discoveries, particularly "where knowledge is tacit and requires hands-on experience."[310]

Empirical studies confirm the crucial role that star bioscientists have played in determining the location, timing, and success of new biotechnology startups.[311] For instance, Herbert Boyer, one of the inventors of recombinant DNA technology, was a founder and later a vice president and director of Genentech.[312] Integration is quite explicit, as initial public offering prospectuses often highlight a company's star academic scientists.[313] Not surprisingly, such firms tend to be located close to universities, thus facilitating collaboration.[314] Interviews reveal that "academic scientists [were] typically being 'vertically integrated' into the firm in the sense of receiving equity compensation and being bound by exclusivity agreements."[315]

Notably, organizational meshing between universities and licensees often takes the form of semi-integration. There is significant value to allowing university scientists to continue to work independently in their familiar academic environments while being involved in commercialization.

307. Lowe, *supra* note 262, at 422.

308. *See* Gelijns & Thier, *supra* note 256, at 73; Mehta, *supra* note 302, at 23.

309. *See* Stuart et al., *supra* note 107, at 478-79, 485 (presenting the results of a study examining the period between 1972 and 2002); *see also* Nathan Rosenberg & Richard R. Nelson, *American Universities and Technical Advance in Industry*, 23 RES. POL'Y 323, 343 (1994).

310. *See* Lynne G. Zucker & Michael R. Darby, Colloquium Paper, *Star Scientists and Institutional Transformation: Patterns of Invention and Innovation in the Formation of the Biotechnology Industry*, 93 PROC. NAT'L ACAD. SCI. USA 12,709, 12,714 (1996); *see also* Stuart et al., *supra* note 107, at 484.

311. *See, e.g.*, Zucker et al., *supra* note 261, at 150-52; Zucker et al., *supra* note 83, at 296; Zucker & Darby, *supra* note 310, at 12,710.

312. *See* Pisano, *supra* note 114, at 116; Zucker et al., *supra* note 261, at 144.

313. *See* Zucker et al., *supra* note 261, at 143-44.

314. *See* Terttu Luukkonen, *Variability in Organisational Forms of Biotechnology Firms*, 34 RES. POL'Y 555, 556 (2005).

315. Zucker et al., *supra* note 261, at 151.

Accordingly, consulting arrangements, sponsored research, and proof-of-concept centers allow greater interaction between academic and industrial scientists without fully assimilating university scientists into companies' employee rolls. Furthermore, a host of institutional controls—including limits on consulting and equity stakes that faculty can take in commercial ventures[316]—attempts to preserve academic independence and maintain separation between universities and private firms. The result is semi-integration, which preserves the dynamic and innovative environment of university research but allows it to extend into downstream commercialization.

University-industry technology transfer, a realm seemingly tailor-made for patent-mediated vertical disintegration, thus exhibits a surprising degree of organizational integration. Notably, the need to transfer tacit knowledge, which patents do not disclose, and a desire to obtain the services of talented, innovative faculty members play key roles in such integration. Admittedly, this is typically not formal vertical integration in the sense of private companies acquiring or merging with universities. Rather, it is semi-integration that seeks to preserve the autonomy and innovativeness of academic scientists. Nevertheless, a range of integration approaches spanning social networks, consultancies, sponsored research, incubators, proof-of-concept centers, equity stakes, and university spinouts all serve as conduits for transferring patented technologies and accelerating their development.

## IV. Analysis and Normative Assessment

Contrary to prevailing academic accounts, vertical integration is alive and well in patent-intensive fields. This Part delves deeper to analyze this phenomenon and explore its normative implications.

### A. Industrial Dynamics, the Theory of the Firm, and Semi-integration

Of course, in elucidating the persistence of vertical integration in high-tech fields, it is important to acknowledge differing motivations and idiosyncrasies driving vertical integration in various sectors. Biotechnology firms, for instance, need the resources and infrastructure of pharmaceutical companies to perform clinical testing, development, and distribution, thus rendering them willing acquisition targets. Global agricultural biotechnology companies seek to acquire seed companies not just for their high-quality germplasm but also for their local distribution networks.[317] In the information

316. *See* Lee, *supra* note 265, at 1566.

317. *See* Fulton & Giannakas, *supra* note 85, at 141; Lesser, *supra* note 180, at 58-59.

technology sector, incumbents acquire startups substantially (but not solely) for their engineers, particularly given the fierce competition for talent in that field. And in the context of university-industry technology transfer, the highly embryonic nature of academic technologies helps drive technology transfer via institutional meshing. While it is important to acknowledge these contextual differences, they should not elide a striking commonality: All of these patent-intensive fields exhibit a substantial degree of vertical integration based on technical knowledge, innovative capacity, and strategic considerations.

This trend demands modifying prevailing conceptions of patents and the theory of the firm. Although patents are lauded as conduits of technology transfer, they are often inadequate in that regard. While patents reduce transaction costs, they are incomplete property rights that do not disclose important tacit knowledge necessary to best exploit a technology. Although commentators have long recognized that weak intellectual property rights can lead to vertical integration, they have generally focused on the uncertainty and narrow scope of such rights.[318] This Article, however, reveals an orthogonal "weakness": Deficiency in the informational content of patents can also contribute to vertical integration. Given this deficiency, it is often more efficient to simply vertically integrate and absorb that expertise directly.[319] In a sense, this brings discussion of industrial organization full circle, as this emphasis on maximizing knowledge competency accords with historical accounts of the emergence of vertically integrated, Chandlerian corporations in the nineteenth and twentieth centuries.[320]

Notably, this model inverts conventional understandings of the relationship between patents and organizational form. Traditional transaction-cost economics theory posits that firms in high-tech industries vertically integrate when it is too *easy* for outside parties to appropriate technical knowledge, perhaps because patents are weak or unavailable.[321] However, recent developments show that firms vertically integrate when it is too *difficult* to appropriate technical knowledge.[322] Due to the natural excludability of patent-

318. *See, e.g.*, Burk & McDonnell, *supra* note 15, at 603-05, 617; Jennejohn, *supra* note 38, at 317.

319. *See* Howells, *supra* note 59, at 102 ("[T]acit knowledge flows relate most directly to encouraging know-how sharing with firms that are vertically related to the sharing or providing firm.").

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

321. *See, e.g.*, Arora & Merges, *supra* note 25, at 468.

322. *See supra* Part III; *cf.* John Stuckey & David White, *When and When* Not *to Vertically Integrate*, MIT SLOAN MGMT. REV. (Apr. 15, 1993), https://perma.cc/G9DT-X5PA (indicating that human capital specificity and high frequency of transactions weigh in favor of vertical integration).

related tacit knowledge, patents and licenses are inadequate for transferring technologies, thus motivating vertical integration.

Furthermore, the socially embedded nature of knowledge and innovative capacity significantly explains the phenomenon of semi-integration. Within the sociology of knowledge, the functional unit of innovation is the organization,[323] and thus organizations (rather than individuals in the labor market) are the targets of acquisition. Furthermore, rather than fully assimilating such organizations, granting them some measure of autonomy preserves the culture, norms, and modes of operation that are critical to innovation.

### B. Normative Assessment

Having examined the persistence of vertical integration in high-tech industries, an important question arises: Does it matter? Accordingly, this Subpart engages in a normative evaluation of vertical integration in patent-intensive fields. Indeed, much is at stake here, for the shape of an industry can matter a great deal for innovation, competition, and consumer welfare.[324] This Subpart argues that while vertical integration often represents an efficient and sometimes necessary approach to technological development, it can create certain inefficiencies and barriers to entry that are worthy of further scrutiny.

As this Article has shown, vertical integration offers many benefits. Patent licensing may be inadequate to transfer and commercialize a technology, leaving vertical integration as the most efficient means of combining complementary capabilities.[325] Furthermore, vertical integration allows firms to enhance their innovative capacity by absorbing talented scientists and engineers. It also allows firms to best exploit economies of scale and scope. Additionally, vertical integration can mitigate the double marginalization problem arising when both an upstream supplier and downstream user of some input exercise power over price; in such a scenario, vertical integration can lead to lower prices than when production spans two profit-maximizing

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323. *Cf.* Burk, *supra* note 19, at 1015 ("Organizational and social systems constitute an especially important reservoir of tacit knowledge.").

324. *See* Tim Wu, *Taking Innovation Seriously: Antitrust Enforcement If Innovation Mattered Most*, 78 ANTITRUST L.J. 313, 315 (2012) ("There is good reason to think that industry structure is at least as important for innovation as the intellectual property laws.").

325. *See, e.g.*, Ludovic Dibiaggio, *Design Complexity, Vertical Disintegration and Knowledge Organization in the Semiconductor Industry*, 16 INDUS. & CORP. CHANGE 239, 245-46 (2007) (observing in the semiconductor industry that "integrating diverse bodies of knowledge into a coherent system is easier to organize in-house"). *But see id.* (cautioning that although this observation is "salient in specific industries," it "may not be general").

firms.[326] Similarly, vertical integration can mitigate the Cournot complements dynamic, in which multiple suppliers exercising market power sell complementary products (such as genetically modified seeds and herbicides), thus leading to higher aggregate prices than if an integrated firm sold them all.[327] In short, "large, vertically integrated firms are an efficient response to some serious real-world problems."[328]

However, vertical integration entails tangible costs as well. First, while it facilitates knowledge transfer, it introduces other inefficiencies into the value chain. Creating large, bulky, vertically integrated firms runs counter to classical economic theory favoring division of labor, specialization, and gains from trade.[329] Integration exhibits diminishing marginal returns, as increasing size and complexity requires a larger bureaucracy to manage it.[330] Furthermore, theorists have observed that vertical integration does not necessarily eliminate opportunistic and distortionary behavior; it merely shifts it inside the firm.[331]

Second, the task of integrating two companies with different cultures and operations is fraught with difficulty.[332] Indeed, "integration is one of the most important and difficult aspects of acquisition management in general."[333] For example, cultural differences between strict, buttoned-down Roche, a Swiss pharmaceutical company, and laid-back, California-based Genentech complicated integration and likely depressed productivity.[334] More generally,

326. *See* Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991, 2014 (2007); *see also infra* text accompanying notes 391-93.

327. *See id.*

328. Cockburn, *supra* note 106, at 18; *see also* William F. Baxter, *Conditions Creating Antitrust Concern with Vertical Integration by Regulated Industries—"For Whom the Bell Doctrine Tolls,"* 52 ANTITRUST L.J. 243, 245 (1983).

329. *See* Cockburn, *supra* note 106, at 17; *cf.* Dibiaggio, *supra* note 325, at 243 (observing that modular technological development allows independent entities to exploit specialization); F.A. Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519, 527 (1945) (arguing that market-based production promotes efficient asset allocation); Nickerson & Zenger, *supra* note 71, at 623 (discussing the advantages of market-based production and specialization).

330. *See* Graff et al., *supra* note 69, at 351; *cf.* Demsetz, *supra* note 12, at 148 ("Merged firms may be unable to duplicate the sum of what independently standing firms can accomplish for a variety of reasons . . . .").

331. *See* Grossman & Hart, *supra* note 15, at 716; *cf.* Armen A. Alchian & Harold Demsetz, *Production, Information Costs, and Economic Organization*, 62 AM. ECON. REV. 777, 793 (1972) ("The firm serves as a highly specialized surrogate market.").

332. *See, e.g.*, Schweizer, *supra* note 51, at 1063-66; *cf.* Bannert & Tschirky, *supra* note 84, at 481-82 ("[A]cquisitions in general and in particular technology driven acquisitions are associated with high risks and are vulnerable to failure." (citation omitted)).

333. Bannert & Tschirky, *supra* note 84, at 482.

334. *See* Jagger, *supra* note 124.

many mergers and acquisitions (including those involving vertical integration) fail to meet objectives or create market value due to questionable motives, valuation difficulties, and challenges of postacquisition integration.[335] In particular, a "lack of integrative decisionmaking, systemic process design, and holistic change of both companies" often leads technology acquisitions to fail.[336]

In this regard, it is useful to consider natural "breaks" where private ordering has favored disintegrated value chains.[337] In the late 1990s, a desire to spread the risks and rewards of biotechnology resulted in large life sciences companies encompassing medical biotechnology, pharmaceuticals, and agricultural biotechnology.[338] The familiar objectives of facilitating knowledge transfer, exploiting economies of scale and scope, and realizing synergies justified these instances of vertical (and lateral) integration. However, nearly all these conglomerates soon divested their agricultural operations,[339] perhaps because the expected synergies of combining human and plant biotechnology did not materialize.[340]

Third, vertical integration can also depress innovation. It is difficult to replicate the high-powered, market-based incentive to innovate within a large, integrated firm.[341] In general, large, integrated incumbents tend to be less innovative and more risk-averse than smaller firms, favoring incremental rather than revolutionary advances.[342] Such large companies may avoid novel innovations that cannibalize existing products; furthermore, they often feature bureaucracies and agency-cost distortions that depress innovation.[343] More broadly, vertical integration tends to centralize innovation and cut off

335. *See* Schweizer, *supra* note 51, at 1051; *cf.* Stuckey & White, *supra* note 322, at 24 ("The key point, again, is this: do not vertically integrate unless absolutely necessary." (emphasis omitted)).

336. Bannert & Tschirky, *supra* note 84, at 492.

337. *Cf.* Pisano, *supra* note 106, at 244 (discussing situations in which vertical integration by a biotechnology firm could damage performance in the long run).

338. *See* KING, *supra* note 33, at 1.

339. *See* Fulton & Giannakas, *supra* note 85, at 141; *see also* KING, *supra* note 33, at 1; Jorge Fernandez-Cornejo & David Schimmelpfennig, *Have Seed Industry Changes Affected Research Effort?*, U.S. DEP'T AGRIC.: AMBER WAVES (Feb. 1, 2004), https://perma.cc/47SF-HPAT.

340. *Cf.* KING, *supra* note 33, at 7 (suggesting as one of "several possible explanations for the divestitures" that "anticipated research synergies may have failed to develop").

341. *See* OLIVER E. WILLIAMSON, THE ECONOMIC INSTITUTIONS OF CAPITALISM: FIRMS, MARKETS, RELATIONAL CONTRACTING 141-44 (1985).

342. *See* Rai, *supra* note 12, at 835; *see also* NELSON & WINTER, *supra* note 96, at 279; Barnett, *supra* note 20, at 992; Cockburn, *supra* note 106, at 17.

343. *See* Barnett, *supra* note 20, at 992.

multiple research paths.[344] This is problematic given that in biomedicine as well as in other areas, "parallel R&D along similar trajectories" may best promote technological progress.[345] For instance, although it is difficult to tease apart horizontal and vertical integration, empirical analysis shows that consolidation in the agricultural biotechnology industry has reduced inventive activity.[346] Relatedly, vertical integration may also decrease technical disclosure. As an "appropriation mechanism," patenting and vertical integration can act as substitutes, and rather than disclosing an emerging technology to the public (and competitors), an integrated company may protect it as a trade secret. As such, vertical integration may decrease patent-related disclosure and associated knowledge spillovers.[347]

Fourth, as this Article has explored, companies can wield vertical integration for strategic purposes to inflate barriers to entry, thus harming competition and consumer welfare.[348] This is a fine line to draw, for vertical integration also confers certain efficiencies that can reduce prices and increase product selection. However, vertical integration can reduce access to inputs and customers for rivals, thus raising their costs.[349] And even where efficiency gains to vertical integration are minimal, companies may pursue it to increase barriers to entry against potential competitors.[350] For instance, although efficiency concerns help drive agricultural biotechnology companies to vertically integrate, these companies also integrate for strategic reasons, such as erecting barriers to entry, enhancing brand loyalty, and facilitating predatory behavior.[351]

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344. *See* Rai, *supra* note 12, at 835.

345. *See* Fabio Pammolli et al., Analysis, *The Productivity Crisis in Pharmaceutical R&D*, 10 NATURE REVS. DRUG DISCOVERY 428, 437 (2011); *see also* Rai, *supra* note 12, at 844 ("In sum, appropriate development of upstream research in the biomedical arena requires the pursuit of multiple research paths.").

346. *See* 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, 30 (2016).

347. *See* Cockburn, *supra* note 106, at 17.

348. *See* Riordan & Salop, *supra* note 81, at 517.

349. *See infra* notes 381-90 and accompanying text.

350. *See* JOE S. BAIN, INDUSTRIAL ORGANIZATION 168-69 (1959); ARTHUR ROBERT BURNS, THE DECLINE OF COMPETITION: A STUDY OF THE EVOLUTION OF AMERICAN INDUSTRY 444-45 (1936); Herbert Hovenkamp, *The Law of Vertical Integration and the Business Firm: 1880-1960*, 95 IOWA L. REV. 863, 914 (2010) (describing structuralist accounts of vertical integration as heightening barriers to entry); Stuckey & White, *supra* note 322. *But see* BURNS, *supra*, at 445 (noting that in some circumstances, vertical integration may make it more difficult to secure a monopoly position).

351. *See* Moss & Taylor, *supra* note 77, at 347. Vertical integration has other far-reaching consequences as well, such as constraining the market for patents and thus making patents more difficult to value.

Ultimately, this Article strikes a delicate normative balance. It argues that vertical integration represents an efficient and sometimes necessary means of aggregating technical knowledge and innovative capacity. It acknowledges, however, that vertical integration may be poorly executed and harm competition. The next Part explores prescriptions for enhancing the efficacy of vertical integration and tempering its excesses.

## V. Prescriptions

Although this Article primarily aims to describe and provide a theoretical framework for understanding the persistence of vertical integration in patent-intensive industries, this analysis suggests several prescriptions. At the outset, it is important to reiterate the difficulty of assessing whether vertical integration in any given case is a net efficiency positive or negative.[352] The following prescriptions aim to enhance the efficacy of vertical integration and address instances in which the competitive harms of integration outweigh its efficiency and innovation benefits.

### A. Private Ordering: Improving Vertical Integration

Individual companies engaged in private ordering play an important role in equilibrating an industry to an appropriate level of vertical integration. The context-sensitive nature of optimizing production counsels against broad, top-down regulation, particularly given that the market has incentives to move toward more efficient organizational structures.[353] Along these lines, companies themselves initiated strategic divestment of agricultural biotechnology by life sciences conglomerates and outsourcing of downstream clinical testing by biopharmaceutical firms. In exercising private ordering, managers should explore the wide range of organizational forms between and beyond the poles of pure market-based and vertically integrated production.[354] For example, formal and informal networks spanning biotech firms and pharmaceutical companies attempt to capture the best of both worlds by facilitating technical knowledge transfer while avoiding the bureaucratic rigidity of full integration.[355]

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352. *Cf.* Baxter, *supra* note 328, at 245-46 ("I know of no easy answer, conceptual much less empirical, to that question. It requires case-by-case inquiry, and one of great difficulty.").

353. *See* Robertson & Langlois, *supra* note 45, at 545, 560.

354. *Cf.* Stuckey & White, *supra* note 322 ("Long-term contracts, joint ventures, strategic alliances, technology licenses, asset ownership, and franchising tend to involve lower capital costs and greater flexibility than vertical integration.").

355. *See* Barnett, *supra* note 20, at 1010-11.

If managers choose to vertically integrate, they must carefully attend to cultural and operational cohesion.[356] It is not enough to simply acquire a company and expect the benefits of asset complementarity, synergies, and economies of scale and scope to arise automatically. Mergers and acquisitions often fail due to the complexity of postacquisition integration and cultural differences between the merged entities.[357] Managers must attend to short-term objectives, such as obtaining access to a particular drug pipeline, as well as long-term objectives, such as integrating an acquisition within a larger organizational fabric.[358] Within this process, technologists must play an important role alongside financial, legal, and strategy experts.[359] Lars Schweizer has insightfully suggested a hybrid approach in which acquiring companies adopt a "slow preservation" method regarding a biotech's R&D functions due to their highly tacit character while rapidly absorbing management, clinical trials, regulatory, marketing, and other nonresearch functions.[360] Additionally, given that people are critical assets in vertical integration, retaining talent after an acquisition is key. Affording autonomy to R&D capabilities not only preserves the innovative structures that rendered an acquisition valuable in the first place but also promotes the retention of key scientists and engineers who develop current and future innovations.[361]

Along those lines, managers should consider a semi-integration structure that preserves the autonomy and innovative capacity of the acquired entity.[362] Such a structure resembles the Chandlerian multidivisional (M-form) structure of twentieth century corporations, which achieved decentralization within vertically integrated firms.[363] For instance, Johnson & Johnson has enjoyed success with its biotech acquisitions partly because it has a decentralized organizational structure that affords significant autonomy to its acquisitions.[364] Similarly, Google takes a hands-off approach to many of its startup

356. *See* Bannert & Tschirky, *supra* note 84, at 485-92 (describing a comprehensive integration planning process for technology-intensive acquisitions).

357. *See* Schweizer, *supra* note 51, at 1052.

358. *Cf. id.* (noting the importance of both short- and long-term objectives in successful integration).

359. *See* Bannert & Tschirky, *supra* note 84, at 483 (noting the downfalls associated with insufficient participation of technologists).

360. *See* Schweizer, *supra* note 51, at 1068.

361. *See id.* at 1069; *see also* Bannert & Tschirky, *supra* note 84, at 489 (emphasizing the importance of retaining key engineers in acquisitions).

362. *See generally* Bannert & Tschirky, *supra* note 84, at 487 (noting arguments for both tight and arm's length integration).

363. *Cf.* Robertson & Langlois, *supra* note 45, at 551 (discussing the M-form structure).

364. *See* Alex K. Pavlou, *Biotechnology M&A Insight: Deals and Strategies*, 10 J. COM. BIOTECHNOLOGY 85, 88 (2003).

acquisitions.[365] Relatedly, universities should maintain institutional controls such as limitations on faculty consulting and equity stakes in commercial ventures to preserve the independence and innovative nature of academic culture. Of course, achieving decentralization within an integrated firm is difficult, as "firm coherence requires uniformity" in personnel, culture, and operations.[366] Even within Google, the constraints of corporate life can lead some founders of acquired startups to leave.[367] Nevertheless, semi-integration, which confers meaningful autonomy on acquired entities, may best preserve innovative capacity while exploiting tacit knowledge and the benefits of scale and scope.

### B. Public Ordering: Balancing Efficiency and Innovation Gains Against Competitive Harms

While this Article takes a generally salutary view of vertical integration, in some cases private ordering does not produce the optimal organizational form.[368] Industry actors may vertically integrate to harm competitors and raise barriers to entry. Even without such motivations, vertical integration may diminish innovation by overly concentrating innovative capabilities within one firm. In such cases, public intervention is warranted.

A potential—though ultimately unpromising—legal reform to prevent overreaching vertical integration would involve enhancing patent disclosure. This Article has argued that the inability of patents to disclose tacit knowledge contributes to vertical integration. In theory, Congress or the courts could heighten the disclosure requirement,[369] thus strengthening the ability of patents to promote market-based technology transfer and, ultimately, vertical disintegration. But such an approach would be unavailing. Tacit knowledge is by definition difficult or impossible to codify, and a heightened disclosure requirement would vastly increase the information costs of applying for a patent.[370] Even a requirement that patentees continue to disclose technical

365. *See* Luckerson, *supra* note 1.

366. *See* Wu, *supra* note 19, at 138.

367. *See* Luckerson, *supra* note 1 ("Oftentimes founders are rolled up inside another group inside of the company. They can't make decisions as freely as when they were entrepreneurs. That affects people's willingness to stick around." (quoting Justin Kan, partner at venture capital firm Y Combinator and co-founder of Twitch)).

368. *Cf.* Mark A. Lemley, *A New Balance Between IP and Antitrust*, SW. J.L. & TRADE AMS. 237, 237 (2007) ("[W]e are currently (and mistakenly) conditioned to think of private property and private ordering as efficient in and of themselves, rather than as efficient only in the context of robust market competition.").

369. For the current disclosure requirement, see 35 U.S.C. § 112 (2016).

370. *See* Lee, *supra* note 265, at 1559-60.

information after filing,[371] while helpful, would still be inadequate because tacit knowledge simply resists codification. Furthermore, enhanced disclosure requirements might shunt some actors to pursue trade secrecy or, ironically, vertical integration to protect technical information.[372] Additionally, it would be almost impossible for examiners at the U.S. Patent and Trademark Office to evaluate the amount of technical knowledge an applicant disclosed.[373] Finally, disclosing tacit knowledge through a patent is still a static information dump that does not provide what most acquiring companies truly desire—creative people who can adapt a technology for particular uses and generate new ones.

Rather than patent law, the most effective intervention against overreaching vertical integration is antitrust law. The key here is to balance the efficiency and innovation gains of vertical integration against competitive harms.[374] This entails difficult analyses, for the particular characteristics of an industry matter a great deal and the social optimally level of R&D in any given field is not always clear.[375] The Department of Justice recognizes that vertical integration may produce valuable efficiencies by aggregating complementary resources.[376] In this and other ways, vertical integration also enhances innovation. For instance, new entrants need the incentive of large-firm acquisition to motivate starting up in the first place.[377] While antitrust

371. *See generally* Jeanne C. Fromer, *Dynamic Patent Disclosure*, 69 VAND. L. REV. 1715 (2016) (proposing such a requirement).

372. *Cf.* Barnett, *Three Quasi-fallacies*, *supra* note 21, at 7 ("Given the high fixed costs and low marginal costs that typically characterize the development, production, and distribution of intellectual assets, a viable firm engaged in innovation over the long term *must* erect some entry barrier to generate the rents that push price above the sum of marginal plus fixed costs.").

373. *See* Lee, *supra* note 265, at 1560.

374. *See* Oehmke & Naseem, *supra* note 346 ("Responding to high concentration . . . in a knowledge-intensive industry such as agricultural biotechnology requires that the antitrust regulator not only take[] into account the efficiency impacts in the product market but also how the concentration may influence the innovation market."); *see also* U.S. DEP'T OF JUSTICE, NON-HORIZONTAL MERGER GUIDELINES §§ 4.111-.112 (n.d.), https://perma.cc/RQ8B-322V (noting that vertical mergers may harm actual and potential competition).

375. *See* Ronald W. Davis, *Innovation Markets and Merger Enforcement: Current Practice in Perspective*, 71 ANTITRUST L.J. 677, 681 (2003) (noting that there is no consensus on the form of industry structure most conducive to innovation).

376. *See* U.S. DEP'T OF JUSTICE, *supra* note 374, § 4.24; *see also* U.S. DEP'T OF JUSTICE & FTC, HORIZONTAL MERGER GUIDELINES 29-31 (2010) ("[A] primary benefit of mergers to the economy is their potential to generate significant efficiencies and thus enhance the merged firm's ability and incentive to compete . . . ."). *But cf.* U.S. DEP'T OF JUSTICE & FTC, *supra*, at 30 n.13 ("The [Department of Justice and Federal Trade Commission] will not deem efficiencies to be merger-specific if they could be attained by practical alternatives that mitigate competitive concerns, such as divesture or licensing.").

377. *See* Spencer Weber Waller & Matthew Sag, *Promoting Innovation*, 100 IOWA L. REV. 2223, 2243 (2015).

agencies should assess whether an incumbent plans to quash or delay the innovation of an acquired company, they should recognize that acquisition of startups can significantly enhance innovation.[378] Startups often blossom with the increased resources and market share of incumbent acquirers.[379] Additionally, incumbents often need such external innovations to extend their own market dominance; their aim is frequently not to quash such innovation but to extend it, as in Google's acquisition of YouTube.[380]

While vertical integration can confer efficiency and innovation benefits, it may also harm competition.[381] Competitive harms can take two forms: leverage, in which an integrated entity leverages market power in one context to enjoy market power in another,[382] and foreclosure, which encompasses both input foreclosure (preventing competitors from accessing a critical input) and customer foreclosure (refusing to buy from certain input suppliers).[383]

The current trend toward vertical integration thus intersects with evolving antitrust debates on optimal industry structure.[384] Chicago School scholars dismissed the perceived dangers of leverage by reasoning that there was only a single monopoly profit available to an integrated entity; accordingly, they concluded that vertical integration must be motivated by efficiency and not a desire to extend a monopoly.[385] More recent scholars have challenged the assumption of a single monopoly profit as based on an

378. *See* Wu, *supra* note 324, at 318-19 (observing that external innovation has long been an important source of disruptive advancements that prod incumbents to become more innovative themselves); *see also* Waller & Sag, *supra* note 377, at 2244 (suggesting that Facebook's acquisition of Instagram and Google's acquisition of Waze had less to do with extending innovation and more to do with keeping such innovations away from competitors).

379. *See* Waller & Sag, *supra* note 377, at 2243.

380. *See id.*

381. *See* Riordan & Salop, *supra* note 81, at 518.

382. *See* Herbert Hovenkamp, *Robert Bork and Vertical Integration: Leverage, Foreclosure, and Efficiency*, 79 ANTITRUST L.J. 983, 992 (2014) [hereinafter Hovenkamp, *Robert Bork and Vertical Integration*]. *But see* Herbert Hovenkamp, *Post-Chicago Antitrust: A Review and Critique*, 2001 COLUM. BUS. L. REV. 257, 267 & n.26 [hereinafter Hovenkamp, *Post-Chicago Antitrust*] ("The [leverage] theory is false because there is only a single monopoly profit to be earned in any distribution chain.").

383. *See* Riordan & Salop, *supra* note 81, at 527-28; *cf.* Hovenkamp, *Post-Chicago Antitrust*, *supra* note 382, at 324 ("[I]n the post-Chicago [antitrust] literature 'foreclosure' generally means raising rivals' costs, not outright market exclusion.").

384. For examples of works engaging in this debate, see Reza Dibadj, *Saving Antitrust*, 75 U. COLO. L. REV. 745 (2004); Hovenkamp, *Post-Chicago Antitrust*, *supra* note 382; Hovenkamp, *Robert Bork and Vertical Integration*, *supra* note 382; and Riordan & Salop, *supra* note 81.

385. *See* Richard A. Posner, *The Chicago School of Antitrust Analysis*, 127 U. PA. L. REV. 925, 927-29 (1979); *see also* Hovenkamp, *Robert Bork and Vertical Integration*, *supra* note 382, at 993-94 (discussing Robert Bork's rejection of leverage theory).

"oversimplified microeconomic model."[386] Furthermore, even if double monopoly profits are not available, vertical integration can still extend the duration of a monopoly.[387]

Regarding foreclosure, so-called post-Chicago analysis has shown that vertical mergers can lead to real foreclosure in input markets, thus enhancing monopoly profits with little or no efficiency benefits.[388] As Herbert Hovenkamp points out, "[M]any writers recognize that there can be exceptional cases in which vertical integration can facilitate the exercise of market power by making entry or rival expansion more costly, riskier, and thus less likely."[389] Even Richard Posner has cautioned that vertical integration may have monopolistic consequences.[390]

Recent antitrust scholarship has also critiqued the "double marginalization" rationale for permitting vertical integration. Chicago School scholars argue that vertical integration solves the double marginalization problem when both an upstream supplier and downstream user of some input exercise power over price.[391] According to this logic, by eliminating the double monopoly, vertical integration can increase efficiency and decrease prices for consumers.

However, it is important to qualify this analysis. Double markups will arise only when both the upstream and downstream markets are noncompetitive, which will not always be the case, and evaluating both markets requires complex competitive analyses.[392] Furthermore, even if both markets are noncompetitive and vertical integration can eliminate the double markup, antitrust authorities must still weigh those efficiency gains against the competitive harms of vertical integration.[393] Simply eliminating the double markup is not a silver bullet that should immunize vertical integration.

Ultimately, this Article argues that antitrust authorities should subject vertical integration to the rule of reason rather than a default rule of per se

386. *See* Riordan & Salop, *supra* note 81, at 517.

387. *See* Hovenkamp, *Robert Bork and Vertical Integration*, *supra* note 382, at 996.

388. *See* Riordan & Salop, *supra* note 81, at 517.

389. Hovenkamp, *Robert Bork and Vertical Integration*, *supra* note 382, at 996.

390. *See* Posner, *supra* note 385, at 937.

391. *See* Hovenkamp, *Robert Bork and Vertical Integration*, *supra* note 382, at 997; *see also supra* text accompanying notes 80-81.

392. *See* Hovenkamp, *Post-Chicago Antitrust*, *supra* note 382, at 325; Riordan & Salop, *supra* note 81, at 526-27.

393. *See* Riordan & Salop, *supra* note 81, at 527; *see also* Hamilton & Mqasqas, *supra* note 80, at 569 (noting that vertical integration in response to double marginalization does not always increase welfare and profits).

legality.[394] Again, the key inquiry is whether the formidable efficiency and innovation benefits of vertical integration outweigh any competitive harm. If they do not, antitrust authorities have numerous enforcement powers at their disposal. For example, they can condition proposed mergers and acquisitions on mandatory patent licensing or even divestitures.[395] Such ex ante conditions serve an information-forcing or screening function, as they can identify proposed mergers where efficiency gains are so great that interested parties are willing to provide competitors with access to critical assets.[396] As a further information-forcing mechanism, regulators should require the merged entity to provide ex post evidence of efficiency gains to maintain integrated status.[397]

Regulators have properly exercised these powers in several contexts. For example, in the biopharmaceutical field, the Federal Trade Commission required Roche to license its CD4 patent portfolio as a condition of acquiring Genentech, thus preventing undue concentration in HIV/AIDS research.[398] Turning to agricultural biotechnology, the federal government conditioned Monsanto's 1997 acquisition of Holden's Foundation Seeds on Monsanto's making corn germplasm available to competitors for several years.[399] Similarly, it approved Monsanto's $2.3 billion acquisition of DeKalb Genetics only after Monsanto spun off its new transformation technology to the University of California, Berkeley and agreed to license its Holden's corn germplasm widely.[400] In 2007, the Justice Department required Monsanto to divest a seed company, multiple seed lines, and other assets before approving its $1.5 billion merger with Delta & Pine Land.[401] In this fashion, antitrust

394. *See* Kevin B. Soter, Note, *Causation in Reverse Payment Antitrust Claims*, 70 STAN. L. REV. 1295, 1297 n.3 (2018) (detailing the difference between the rule of reason and the per se approach in antitrust law).

395. *See* Davis, *supra* note 375, at 702; *see also* Joseph F. Brodley, *Post-Chicago Economics and Workable Legal Policy*, 63 ANTITRUST L.J. 683, 690 (1995) (describing an example of a merger or joint venture conditioned on giving competitors access to an essential input on nondiscriminatory terms); *cf.* Baxter, *supra* note 328, at 247 (discussing whether divestiture is appropriate where vertical integration violates antitrust law).

396. *See* Brodley, *supra* note 395, at 690-91.

397. *Cf. id.* at 692-93 (making this suggestion).

398. *See* Roche Holding, 113 F.T.C. 1086, 1087, 1099 (1990), *modified in other part*, No. C-3315, 1996 WL 116250 (FTC Jan. 16, 1996).

399. *See* David E. Schimmelpfennig et al., *The Impact of Seed Industry Concentration on Innovation: A Study of US Biotech Market Leaders*, 30 AGRIC. ECON. 157, 159 (2004).

400. *See* Press Release, Dep't of Justice, Justice Department Approves Monsanto's Acquisition of DeKalb Genetics Corporation 1 (Nov. 30, 1998), https://perma.cc/H2FQ-UFTX; *see also* Davis, *supra* note 375, at 689 (describing Monsanto's spinning off of transformation technology and licensing of corn germplasm).

401. Press Release, Dep't of Justice, Justice Department Requires Divestures in $1.5 Billion Merger of Monsanto and Delta & Pine Land (May 31, 2007), https://perma.cc/Q5MV-XMHG.

regulators can police vertical integration and help ensure healthy competition in innovative industries.

This Article's study of tacit knowledge transfer, however, suggests augmenting the mandatory licensing of patents as a condition of allowing vertical integration. As several contexts demonstrate, patents do not disclose significant tacit knowledge that is valuable for practicing a technology and adapting it to commercial use. Indeed, it is precisely these knowledge deficiencies that contribute to vertical integration in patent-intensive industries. As such, if antitrust regulators seek to open up multiple lines of parallel research, mere licensing of core patents is likely to be inadequate. Such a remedy may require licensing of related tacit knowledge in order for competing firms to fully appropriate a patented technology. Although it would be difficult to monitor and evaluate the sufficiency of tacit knowledge transfer, such communications may be necessary to allow parallel development of innovative technologies.

## Conclusion

Contrary to prevailing accounts, high-tech industries feature a striking degree of vertical integration. Recent commentators have highlighted patent-driven vertical disintegration in which specialized upstream firms license patents to downstream partners. Still others have highlighted diverse, nonhierarchical organizational forms such as contracts for innovation, networks, and the commons. However, recent developments in a variety of patent-intensive industries reflect the enduring persistence of vertical integration. In biopharmaceuticals, agricultural biotechnology, information technology, and even to some extent in university-industry technology transfer, organizations are vertically integrating to transfer and develop patented technologies, typically by the outright acquisition of upstream or downstream parties.

This Article has synthesized and extended several previously disconnected theories to explain this development. It argues that the desire to aggregate tacit knowledge not disclosed in patents significantly drives vertical integration. Furthermore, companies seek not just intellectual assets but also dynamic, talented scientists and engineers to enhance their innovative capacity. Strategic incentives to exploit economies of scale and scope as well as to exclude competitors also push toward vertical integration rather than simply licensing patents. These centralizing forces often overwhelm the countervailing benefits of specialization and vertical disintegration. Given the socially embedded nature of knowledge production, high-tech companies often pursue a strategy of semi-integration by acquiring entire firms or organizations and granting them significant autonomy in their new institutional home.

While vertical integration plays a valuable and sometimes necessary role in aggregating inputs to production, this Article has warned that a nontrivial amount of vertical integration is poorly executed or unduly harms competition. Companies should consider the range of alternate organizational forms between and beyond the poles of market-based production and vertical integration. Managers should be attentive to cultural concerns in integrating new acquisitions and should consider semi-integration to maintain the innovative autonomy of acquired entities. When private ordering overreaches, antitrust authorities should step in to discipline vertical integration that unduly raises barriers to entry or concentrates innovation. In this manner, both private and public entities can continually monitor and adjust the fine balance between consolidation and autonomy at the heart of vertical integration and technological development.