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Article

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Common Ownership in the U.S. Pharmaceutical Industry: A Network Analysis

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Abstract

We investigate patterns in common ownership networks between firms that are active in the U.S. pharmaceutical industry for the period 2004–2014. Our main findings are that "brand firms"—that is, firms that have research and development capabilities and launch new drugs—exhibit relatively dense common ownership networks with each other that further increase significantly in density over time, whereas the network of "generic firms"—that is, firms that primarily specialize in developing and launching generic drugs—is much sparser and stays that way over the span of our sample. Finally, when considering the common ownership links between brands firms, on the one hand, and generic firms, on the other, we find that brand firms have become more connected to generic firms over time. We discuss the potential antitrust implications of these findings.

Keywords

common ownership networks, pharmaceutical companies, competition, innovation

Introduction

Investors' holdings in multiple firms give rise to what is known as "common ownership." Common ownership is widespread in the U.S. pharmaceutical industry. In 2014, for instance, the largest investor in the three largest pharmaceutical companies (Johnson & Johnson, Merck & Co, and Pfizer) was the same (BlackRock). This is the rule, not the exception. These three pharmaceutical companies share other large institutional investors and are thus connected to each other, as well as to numerous other pharmaceutical companies, through the so-called common ownership links.[1]

1. Institutional investors manage other people's money by buying equity in companies (such a pension funds, sovereign wealth funds, insurance companies, and investment funds). They typically seek to build diversified portfolios by investing in multiple companies, often within the same industry.

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Common ownership links between pharmaceutical companies might have important implications for competition and innovation in this crucial industry. By bringing innovative treatments to the market, or by making treatments more widely accessible, the pharmaceutical industry makes an important contribution to global health and economic development. At the same time, the industry often generates controversies related to pricing and product development. A well-functioning pharmaceutical industry in general and the consequences of common ownership in particular are thus key concerns for policymaking and antitrust.

In this article, we study the common ownership links between firms that are active in U.S. pharmaceutical markets in the period 2004–2014 and discuss the implications of our findings for innovation incentives, entry, pricing, and collusion. There is both anecdotal and empirical evidence, reported further below, showing that large institutional investors weigh in on pharmaceutical companies' strategic decision-making. Given that these investors are both influential and, as we will show, have ownership stakes in multiple firms within the same market, the common ownership links between pharmaceutical companies could have important implications for competition and innovation.

We make use of network analysis to describe the structure and characteristics of common ownership networks and calculate how central, or influential, actors are in the network.[2] We make a distinction between "brand firms," that have research and development (R&D) capabilities and launch new drugs on to the market, and "generic firms," that produce bioequivalent replications of brand-name drugs once these drugs come off patent. We study the evolution of common ownership networks between brand firms and generic firms separately, as well as the (bipartite) network of brand firms on the one hand and generic firms on the other. We make use of two common ownership measures, which determine links on the basis of individual or joint levels of ownership by common investors. An *individual* common ownership link between two companies occurs when there is *at least one investor* in both companies with an ownership stake of more than 5%. A *joint* common ownership link occurs when investors common to both firms *collectively* are the majority owners.

We find that, although brand companies are already fairly well connected at the start of our sample, they become almost fully connected through common ownership links at the end of the sample. This is true for both measures of common ownership, although we observe a less dramatic change when using the joint measure, in part because the network was already highly connected at the beginning of the sample. If large institutional investors do exert influence, as the anecdotal evidence below indicates, then this increasing connectivity may have a nonnegligible and increasing impact on innovation incentives. If institutional investors effectively assert their power in pharmaceutical companies, this increasingly dense network might further lead to a softening of competition between brand firms' products. Furthermore, as the evolution of the network partly depends on the ownership measure used, the effects of common ownership might depend on whether common investors exert individual or joint influence.

Alongside higher levels of connectivity between brand firms, the average measure of centrality, which indicates how influential individual firms are within the common ownership network, has risen. Interestingly, at the beginning of the sample, the most central firms were not necessarily the largest

2. There are surprisingly few papers that make use of network analysis to study common ownership patterns. A notable exception is Vitali, Glattfelder, and Battison, who use network analysis to study investor networks in a large sample of transnational corporations. *See* Stefania Vitali et al., *The Network of Global Corporate Control*, 10 PLoS ONE 6 (2011). Network analysis has been applied to other settings in the academic literature, for example, networks in the venture capital industry, *see* Yael V. Hochberg et al., *Whom You Know Matters: Venture Capital Networks and Investment Performance*, 62 J. FIN. 251 (2007); interorganizational ties, *see* Mark S. Mizruchi & Joseph Galaskiewicz, *Networks of Interorganizational Relations*, 22 SOC. MET'D. & RES. 46 (1993); and networks between U.S. firms that advocate for free trade, *see* Michael Dreiling & Derek Darves, *Corporate Unity in American Trade Policy: A Network Analysis of Corporate-dyad Political Action*, 116 AM. J. SOC. 1514 (2011).

(e.g., Biogen and Allergan). On the contrary, the most central firms toward the end of the sample are also the largest (e.g., Johnson & Johnson).

The network of brand companies remains, even at the end of the sample, relatively asymmetric. Indeed, some of the largest pharmaceutical companies, such as Sanofi, Novartis, and Roche, remain without any strong links in 2014. This is in part because of the presence of large noncommon investors in these companies. Although several brand companies, such as Johnson & Johnson and Pfizer, have a large and similar centrality value in 2014, several others have low values (or even zero). Thus, brand firm centrality has not only increased over time, as the common ownership network has become more connected, but it has also become more dispersed. The combination of a rise in centrality for the most connected companies and, at the same time, higher dispersion overall might result in these central players becoming even more powerful.

In comparison to the brand network, the generic firm network is much sparser and it becomes less connected over time. Further, as compared to brand companies, the size of the shareholdings of the top common investors in generic companies—although larger in 2004—is smaller in 2014. Consequently, the average level of centrality for generic firms is much lower than the average for brand firms at the end of the sample. While this is unlikely to have an impact on innovation—generic companies mainly imitate brand products—it indicates that competition between generics is less affected by common ownership.

Finally, the number of common ownership links between brand companies, on the one hand, and generic companies, on the other, has increased substantially over time. Most brand-generic pairs were not connected at the beginning of the sample, and even some of the largest brands, such as Pfizer, had zero connections with the generics. At the end of our sample, there are a number of strong connections between brands and generics. Most of the large brands, such as Johnson & Johnson and Pfizer, have a large number of links by 2014. Similarly, some of the generics, such as Impax and Perrigo, have a high number of connections with brand firms, despite having limited links between each other, and with other firms within the generic ownership network. The increased brand-generic connectivity seems to have led to a decrease in generic entry, as common investors have both an incentive and the ability to delay or block generics from entering the market of a brand.[3]

This article is structured as follows: section 2 provides a background of the pharmaceutical industry and provides anecdotal evidence of investors' influence in the pharmaceutical industry. Section 3 presents our data and a descriptive analysis. Section 4 undertakes a network analysis of the common ownership links in the pharmaceutical industry. Section 5 lays out the antitrust implications of common ownership in the pharmaceutical industry. Section 6 concludes.

Background

Before analyzing common ownership patterns and their implications, this section provides a brief overview of the typical pharmaceutical "life cycle," which is important for understanding how the industry, and thus how competition and innovation therein, works.[4] We then provide a definition of common ownership and a few examples. Finally, we report anecdotal and empirical evidence illustrating that common investors weigh in on pharmaceutical companies' strategic decisions.

3. The impact of brand-generic links through common ownership on generic entry is confirmed in Newham et al. *See* Melissa Newham et al., *Common Ownership and Market Entry: Evidence from Pharmaceutical Industry* (DIW Berlin Discussion Paper No. 1738, 2018), http://ssrn.com/abstract=3194394.
4. For a more detailed overview, *see* Darius N. Lakdawalla, *Economics of the Pharmaceutical Industry,* 56 J. Econ. Lit. 397 (2018).

Pharmaceutical Industry

To bring new drugs to the market, pharmaceutical firms must make significant investments in R&D. In the early stages of drug development, pharmaceutical companies engage in "drug discovery" to search for and discover new compounds to treat a specific disease. Given the public nature of the drug approval process, patents are typically issued on novel pharmacological compounds quite early in the drug development process. They cover the active compound in a specific formulation and for specific indications.

After many iterations, the final compound becomes a drug candidate. Thereafter, with one or more optimized compounds in hand, researchers turn their attention to extensive preclinical testing. In preclinical tests, the compound is tested for toxicity and safety. After completion of preclinical tests, pharmaceutical firms prepare for the next critical stage in the innovation process—drug development through clinical trials on humans. To be considered for Food and Drug Administration (FDA) approval, a drug must pass through three "phases" of clinical trials. This is typically a lengthy and expensive process.

In general, the R&D process for each drug is centered on its intended therapeutic area—the disease the drug should target (e.g., Diabetes type II)—and its "mechanism of action" (MoA)—the biochemical process through which the drug produces the desired effect (e.g., SGLT2 inhibitors). The combination of the MoA within a therapeutic area has been used in practice to define "relevant markets" in competition enforcement—both at the innovation and launched product stages—as drugs herein can typically be substituted by general practitioners and patients.

During the process of drug R&D, there is competition in the "innovation space." Pharmaceutical companies engage in a race with other firms who are working on compounds to treat the same disease with a similar MoA. As rivals are often working in parallel on similar targets, often applying the same fundamental knowledge sourced from open science, the solutions they come up with may be similar. Pharmaceutical companies typically want to be the first to market with a drug that uses a new type of technology in order to profit from a first-to-market advantage.

Companies that produce novel drugs must apply for FDA approval through the new drug application (NDA) procedure. Drugs that are declared safe and effective, and are successfully approved by the FDA, are then launched on the market. Novel "brand-name" drugs are afforded a number of regulatory protections, including the patent on the key compound or active ingredient, which provide the company with a monopoly for their specific drug for a period of time. Nevertheless, once in the market, the drug will compete with other treatments that are substitutable from a therapeutic perspective, although not identical ("brand-brand" and/or "intermolecular" competition).

Once the regulatory protections afforded to the drug have expired, the market is open for generic entry. Generic firms produce bioequivalent copies of brand drugs and are typically much lower in price. The process by which generic manufacturers can seek approval from the FDA is set out in the Hatch-Waxman Act. The act allows the generic applicant to apply for FDA approval by filing an abbreviated new drug application (ANDA) whereby the generic applicant can rely on the efficacy and safety data generated by the original innovator. The Hatch-Waxman Act also provides incentives for generic manufacturers to challenge patents in court, under "Paragraph IV." Once launched on the market, generic drugs compete directly with the brand drug as they are essentially the same product ("intramolecular" competition[5]). In our analysis, we distinguish between "brand firms" that have R&D capabilities and launch new drugs and "generic firms" that primarily specialize in generic drugs.

5. Tracy L. Regan, *Generic Entry, Price Competition, and Market Segmentation in the Prescription Drug Market*, 26 Int'l J. Indus. Org. 930 (2008).

Table 1. Top Five Investors in Top Brand Firms.

2004		2014	
Johnson & Johnson			
State Street Global	5%	BlackRock	6%
Barclays Global Investors	4%	Vanguard Group	6%
Fidelity Investments	3%	State Street Global	5%
Robert Wood Johnson Foundation	2%	Royal Bank of Canada	2%
Vanguard Group	2%	Fidelity Investments	2%
Merck & Co			
Barclays Global Investors	4%	BlackRock	6%
State Street Global	3%	Capital World Investors	6%
Fidelity Investments	3%	Wellington Management	5%
Vanguard Group	2%	Vanguard Group	5%
Capital Group	2%	State Street Global	4%
Pfizer			
Fidelity Investments	4%	BlackRock	7%
Barclays Global Investors	4%	Vanguard Group	5%
State Street Global	3%	State Street Global	4%
Vanguard Group	2%	Capital World Investors	2%
Wellington Management	2%	Wellington Management	2%

In the United States, drug prices are negotiated on between individual health insurance plans and the pharmaceutical company. While consumers may face some out-of-pocket expenditures for drugs, the cost of medical treatments is primarily paid by health insurance companies. High prescription drug prices are a concern for policy makers.[6] A number studies do not find that "brand-brand" competition effectively lowers list prices.[7] Generic competition, on the other hand, is crucial for lowering prices. For products with a single generic producer, the generic average market price is 39% lower than the brand average market price before generic competition. With six or more competitors, generic prices show price reductions of more than 95% compared to brand prices.[8] Accordingly, promoting generic entry is an important policy goal for the FDA.[9]

Institutional Investors and Common Ownership

Common ownership exists when an investor has a stake in two or more firms. Table 1 shows the top five investors in the three largest pharmaceutical companies—which are all brand firms—that operate in U.S. markets in the period 2004–2014 (see the data section below for more details on our sample).

6. E.g., *see*, Hannah Kuchler, *Why Prescription Drugs Cost so Much More in America*, Sept. 19, 2019. Financial Times, https://www.ft.com/content/e92dbf94-d9a2-11e9-8f9b-77216ebe1f17.
7. *See* Ameet Sarpatwari et al., *Competition and Price among Brand-Name Drugs in the Same Class: A Systematic Review of the Evidence*, 7 PLoS medicine (2019).
8. *See* FDA website, *New Evidence Linking Greater Generic Competition and Lower Generic Drug Prices,* https://www.fda.gov/about-fda/center-drug-evaluation-and-research-cder/generic-competition-and-drug-prices.
9. *See* FDA website, *Statement from FDA Commissioner Scott Gottlieb, M.D., on New Policy to Improve Access and Foster Price Competition for Drugs that Face Inadequate Generic Competition* [Press release]. Feb. 19, 2019, https://www.fda.gov/news-events/press-announcements/statement-fda-commissioner-scott-gottlieb-md-new-policy-improve-access-and-foster-price-competition.

Table 2. Top Five Investors in Top Generic Firms.

2004		2014	
Endo International			
Kelso & Company	66%	Capital Group	10%
Black Diamond Capital	8%	Janus Capital Group	9%
Royce & Associates	6%	BlackRock	7%
Barclays Global Investors	4%	Vanguard Group	6%
Fidelity Investments	3%	Blue Ridge Capital	4%
Perrigo			
Wellington Management	13%	BlackRock	7%
Royce & Associates	10%	Vanguard Group	6%
Jandernoa (Michael J)	9%	Fidelity Investments	5%
Barclays Global Investors	7%	State Street Global	4%
Perkins Investment	6%	Wellington Managment	3%
Sun Pharmaceutical			
J. P. Morgan Chase	27%	Shanghvi (Dilip Shantilal)	11%
ABF España Gestión	14%	Viditi Investment	10%
Arisaig Partners (Asia)	14%	Tejaskiran Pharmachem Industries	9%
Aberdeen Asset Management	14%	Family Investment	9%
HDFC Asset Management	4%	Quality Investment	9%

From Table 1, it is clear that there are a number of institutional investors, such as Vanguard and State Street, that are common owners with shareholdings in all three firms in both 2004 and 2014. BlackRock holds the number one position, with a stake of 5–7%, in all three companies in 2014 (in 2004, Barclays Global Investors, which was taken over by Blackrock in 2009, was number one or two in all three companies). A comparison between 2014 and 2004 also shows the growth of Vanguard, in terms of both the size of its shareholdings and position.

Table 2 shows the top five investors in the three largest generic firms that operate in U.S. markets in 2004 and 2014. Here too, we see that BlackRock is an important common owner with shareholdings in Endo International and Perrigo in 2014. However, in comparison to the relatively stable ownership structure of brand companies in Table 1, we see more changes in the identity and size of the shareholdings of the top shareholders in generic firms. We further note that, especially in 2004, the largest investor in each company has a sizable stake. For instance, Kelso & Company has a stake of 66% in Endo in 2004, and J. P. Morgan Chase has a stake of 27% in Sun Pharmaceutical in 2004. The largest shareholders in brand firms have much smaller stakes (around 5–6%). Furthermore, the identity of these top investors is different to the top investors in the largest brand firms, especially for Sun Pharmaceutical.

Institutional Investors' Influence in the Pharmaceutical Industry

Despite having shareholdings of "only" 5–7%, there is growing evidence that institutional investors such as BlackRock and Vanguard engage in active discussions with company management and boards with a view to influence companies' long-term strategies.[10] Specifically, in pharmaceutical markets,

10. S*ee, e.g.,* Joseph A. McCahery et al., *Behind the Scenes: The Corporate Governance Preferences of Institutional Investors*, 71 J. Fin. 2905 (2016); Nathan Shekita, *Interventions by Common Owners* (Working paper, 2020), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3658726.

institutional investors with common holdings can be seen to take an active interest in the strategic decisions of companies. We now provide some anecdotal evidence of this.

In 2016, a group of representatives of major U.S. institutional investors including Fidelity Investments, T. Rowe Price, and Wellington Management called a meeting with top biotech executives and pharma lobbyists to demand firm leaders do a better job defending their pricing.[11] The meeting took place at a hotel conference room in Boston.

In 2019, BlackRock stated in their annual stewardship report that they engaged with a number of pharmaceutical companies including Abbott, Abbvie, Bristol-Myers Squibb, Pfizer, Novartis, Merck, GlaxoSmithKline, Johnson & Johnson, Sanofi, Biogen, Allergan, Teva Pharmaceutical, and Takeda.[12] Similarly, State Street reported in their 2019 annual stewardship report that they engaged with sixty-four pharmaceutical companies.[13] The head of corporate governance at State Street Global Advisors stated that "Our size, experience, and long term outlook provide us with corporate access and allow us to establish and maintain an open and constructive dialogue with company management and boards."[14]

More recently, in relation to the COVID-19 crisis, institutional investors have openly pushed for firms to collaborate with rivals and share information. In April 2020, a number of asset managers, including BlackRock and Fidelity, announced that "they want drug companies to put aside any qualms about collaborating with rivals."[15] BlackRock held talks with pharmaceutical companies to discuss ways to develop and deploy treatments by "working with industry competitors." Separately, a group of fifty investors with over US$2.5 trillion in assets requested that companies share their findings related to the vaccine and agree not to enforce the relevant patents. Since then a number of alliances have formed to collaborate on treatments and vaccines for COVID-19.

Institutional investors have also been involved in merger decisions in the pharmaceutical industry. BlackRock is reported to have actively pushed for a merger between the pharmaceutical firms AstraZeneca and Pfizer. BlackRock, the largest institutional shareholder in AstraZeneca and also a top five shareholder in Pfizer at the time, "urged the British pharma giant's board to eventually re-engage in talks with Pfizer Inc. over a possible deal."[16]

Data and Descriptive Statistics

Our data comprise publicly owned pharmaceutical firms (of any country of origin) that were active in the U.S. pharmaceutical market between 2004 and 2014.[17] Information on which firms are active in the

11. *See* Caroline Chen, *Mutual Fund Industry to Drugmakers: Stand Up and Defend Yourself*, Bloomberg News, 2016, https://www.bloomberg.com/news/articles/2016-05-09/top-funds-said-to-tell-pharma-leaders-to-defend-drug-pricing.
12. *See* Investment Stewardship Annual Report, BlackRock, 2019, https://www.blackrock.com/corporate/literature/publication/blk-annual-stewardship-report-2019.pdf.
13. *See* Stewardship report, State Street, 2019, https://www.ssga.com/library-content/products/esg/annual-asset-stewardship-report-2018-19.pdf.
14. *See* Rakhi Kumar, *Passive Investment, Active Ownership*, State Street, 2014, https://www.ft.com/content/7c5f8d60-ba91-11e3-b391-00144feabdc0.
15. *See* Attracta Mooney & Donato Mancini, *Drugmakers Urged to Collaborate on Coronavirus Vaccine*, Financial Times, Apr. 2020, https://www.ft.com/content/b452ceb9-765a-4c25-9876-fb73d736f92a; Matt Levine, *Investors Want a Cure, Not a Winner*, Bloomberg, Apr. 2020, https://www.bloomberg.com/opinion/articles/2020-04-24/investors-want-a-cure-not-a-winner.
16. *See* Hester Plumridge, *AstraZeneca Shareholder Backs Board Rejection of Pfizer Bid*, Wall Street Journal, 2014, https://www.wsj.com/articles/astrazeneca-shareholder-blackrock-sides-with-board-on-rejecting-pfizer-bid-1400791061; Phil Serafin & Mary Childs, *BlackRock Is Said to Encourage Pfizer-AstraZeneca Talks*, Bloomberg, 2014, https://www.bloomberg.com/news/articles/2014-05-22/blackrock-is-said-to-encourage-pfizer-astrazeneca-talks.
17. This is the same database as used in the paper of Newham et al. (2018). *See* Newham et al., *supra* note 3. The data ends in 2014 due to the workload of dynamically assigning ultimate owners to subsidiaries; *see also* footnote 23 and references therein.

U.S. pharmaceutical market is obtained from the FDA Orange Book.[18] We obtain the ownership structure of the companies in our sample from the Thomson Global Ownership Database. This database includes holdings of each shareholder in publicly listed firms for every year-quarter. For U.S.-listed firms, Thomson Reuters collects ownership information from 13F, 13D and 13G filings, and forms 3, 4, and 5. For companies listed outside the United States, information is sourced from stock exchange filings, trade announcements, company websites, company annual reports, and financial newspapers. For each firm, for each quarter, in the period 2004–2014, we extracted data on the shareholders that own at least 1% of the shares of the firm and computed yearly ownership averages of each shareholder in each firm.

This data set has considerable advantages over to Thomson's Spectrum database used by most other papers on U.S. common ownership. The Thomson's Spectrum database is limited to 13F filings, which contains only large investors in U.S. companies, whereas some pharmaceutical companies are not listed on a U.S. stock market. Moreover, the Thomson's Spectrum database shows holdings assigned to the owner that filed the 13F. This is what is commonly referred to as an "as-filed view." Our database utilizes a "money-manager view." With this view, the database combines together one or more filings to link the holdings to the actual firm that manages the investments. In other instances, it might break apart a single filing in order to accomplish the same. The holdings would then be assigned to one or more of the managers listed on the file.[19]

We use data from the FDA Orange Book to classify firms as "brand" or "generic" firms based on the type of drug that they have launched in the past. For each company and each year, we calculate the firm's share of successful NDA applications (launched brands) relative to successful ANDA applications (launched generics). If a company operates subsidiaries, we aggregate drug counts at the parent company level. For each year, we calculate the share of generic drugs out of all drugs launched by each company. Thereafter, we calculate the average generic share of each company during the years in which the company was active, within the time span 2004–2014. We categorize companies based on this measure. Firms with an average generic share of 90% or more are classified as "generic firms." Remaining firms are classified as "brand firms."[20] Our data set also contains information on the total market value of the firm.

Table 3 presents the ten largest common shareholders for our sample of brand firms at the start of our sample (2004) and at the end of our sample (2014). Firstly, it is clear that the largest common investor in 2004 is Barclays. Barclays has a stake of at least 1% in forty-eight brand companies in 2004. In our sample, there are eighty-five brand firms in total in 2004, thus Barclays holds a stake of at least 1% in more than 50% of all brand firms in 2004. In 2009, BlackRock and Barclays merged which had an impact on BlackRock's size. BlackRock moves from being number 6 in 2004 to being number 1 in 2014 with a stake in sixty-eight brand companies in 2014.

In our sample, there are eighty-six brand firms in total in 2014, thus BlackRock holds a stake of at least 1% in 79% of all brand firms in 2014. In the firms where BlackRock has an ownership stake of at

18. The FDA Orange Book provides data on all launched pharmaceutical products in the United States. We drop conglomerates such as GE and Procter & Gamble from the sample as these firms focus on multiple markets and have launched relatively few pharmaceutical products given their large size. In total, the sample consists of 157 distinct pharmaceutical firms.
19. For a detailed explanation of our data and dynamic assignment of ultimate owners, *see* data repository: https://www.openicpsr.org/openicpsr/project/120781/version/V1/view attached to the paper Albert Banal-Estañol et al., *Diversification, Common Ownership, and Strategic Incentives*, 110 Amer. Econ. Rev. 561 (2020).
20. Our categorization aims to label "generic firms" as those firms that have limited research and development (R&D) capabilities and focus almost entirely on producing generic drugs. A number of firms engage in the production of both brand and generic drugs and may do so within the same company or may separate the activities in different subsidiaries. For example, while the company Novartis is primarily focused on developing brand drugs, its subsidiary Sandoz produces generic medications. Hybrid firms, such as Novartis, that have strong R&D capabilities and have an average generic share of less than 90%, are classified as brand firms in our analysis. Our data show that these hybrid companies show very similar common ownership patterns to the pure brand companies, which is why we classify them together.

Table 3. Top Ten Common Investors in Brand Firms.

Investor	No. of Shareholdings >1%	No. of Shareholdings >5%	Average Size of Shareholding	No. of Companies Where Investor Is the Largest
2004				
Barclays Global Investors	48	4	3%	1
Fidelity Investments	41	16	5%	11
State Street Global	41	2	2%	2
Vanguard Group	39	0	2%	0
Wellington Management	31	11	5%	6
BlackRock	25	0	2%	1
Capital Group	24	11	6%	5
Northern Trust Global	23	0	1%	0
HarbourVest Partners	23	3	4%	2
Deutsche Bank	21	0	2%	0
2014				
BlackRock	68	46	6%	14
Vanguard Group	65	32	4%	2
Fidelity Investments	53	26	5%	9
State Street Global	48	4	4%	1
Wellington Management	32	13	5%	3
Northern Trust Global	29	0	1%	0
Invesco	23	4	4%	1
T. Rowe Price	23	9	5%	3
Mellon Financial Corporation	21	0	1%	0
Royal Bank of Canada	19	1	2%	0

least 1%, the size of their stake is 2% on average in 2004 and increases to 6% in 2014. This is enough to place BlackRock as *the largest* shareholder in fourteen companies in 2014 (up from one company in 2004). It is also evident that there has been very little change in the identity of the top five largest common owners for brand firms (apart from Barclays changing into Blackrock due to its merger). The top owners are BlackRock (Barclays), Fidelity Investments, State Street Global, Vanguard Group, and Wellington Management.

Table 4 presents the ten largest common shareholders for our sample of generic firms at the start of our sample (2004) and at the end of our sample (2014). Comparing Table 4 with Table 3, we can see some clear differences in terms of the identity and size of the holdings of the common investors. Among the top common investors in 2004 are Franklin Templeton (with an average shareholding of 9%), UTI Asset Management (with an average shareholding of 24%), and HSBC Holdings (with an average shareholding of 12%). Thus, in 2004, we find that common investors in generic firms have large shareholdings in a selective set of firms. In 2014, these common investors with large stakes disappear or take a cut in the average size of their shareholding. For example, in 2014, the average shareholding size of Franklin Templeton declines to 5%. Common investors have less coverage of generic firms in comparison to brand firms. In our sample, there are a total of twenty-nine generic firms in 2004 and thirty-five generic firms in 2014. Vanguard and BlackRock—the two largest common investors in generic firms in 2014—have stakes in eleven generic pharmaceutical firms (31% of all generic companies).

Network Analysis

In this section, we provide an analysis of the evolution of the common ownership links in the pharmaceutical industry. We make use of network analysis, which uses graph theory to describe the structure

Table 4. Top Ten Common Investors in Generic Firms.

Investor	No. of Shareholdings >1%	No. of Shareholdings >5%	Average Size of Shareholding	No. of Companies Where Investor Is the Largest
2004				
Franklin Templeton	14	4	9%	2
UTI Asset Management	12	9	24%	6
Fidelity Investments	8	1	3%	1
Vanguard Group	8	0	2%	0
HSBC Holdings	8	5	12%	1
Barclays Global Investors	8	2	5%	0
State Street Global	7	0	2%	0
Invesco	6	0	2%	0
Reliance Capital	6	3	8%	0
J. P. Morgan Chase	6	3	10%	1
2014				
Vanguard Group	11	4	4%	0
BlackRock	11	7	5%	2
Fidelity Investments	9	1	3%	0
State Street Global	7	0	3%	0
Dimensional Fund Advisors	7	0	2%	0
Life Insurance Corporation of India	6	2	4%	0
Franklin Templeton	6	1	5%	0
Norges Bank Investment	6	0	2%	0
HDFC Asset Management	5	1	3%	0
Capital Group	5	2	5%	2

and characteristics of networks of actors by focusing on the links that exist between them. Graphs are made up of "nodes" that are connected by "edges" or "links." In our setup, the nodes represent the firms whereas the edges represent the common ownership links that exist between pairs of firms.

We proceed in three steps. We first provide a graphical analysis of the common ownership links that exist within and between the top brand and top generic firms. Subsequently, we investigate the determinants of such links by analyzing the "investor networks" created by the top three investors in the industry. Finally, we analyze which brand and generic firms are the most influential (i.e., the most "central") in the common ownership networks of the pharmaceutical industry.

Common Ownership Links between Top Firms

We first depict the evolution of the common ownership links among (i) the top twenty brand firms, (ii) the top twenty generic firms, and (iii) between the top twenty brand firms on the one hand and top twenty generic firms on the other hand. In all our graphs, the size of the nodes represents the value of the company, relative to the other companies in the same network, whereas the weight of the edges represents how strong the common ownership connections are. We make use of two common ownership measures, which determine links on the basis of (i) individual levels or (ii) joint levels of ownership.[21]

Common Ownership Networks among Brand Firms. Figure 1 provides a comparison of the network structure of the twenty most valuable ("top twenty") brand firms, which are also the twenty most

21. All network plots are made using "nwcommands" *See* Thomas U. Grund, *nwcommands: Software Tools for the Statistical Modeling of Network Data in Stata* (2014). http://nwcommands.org.

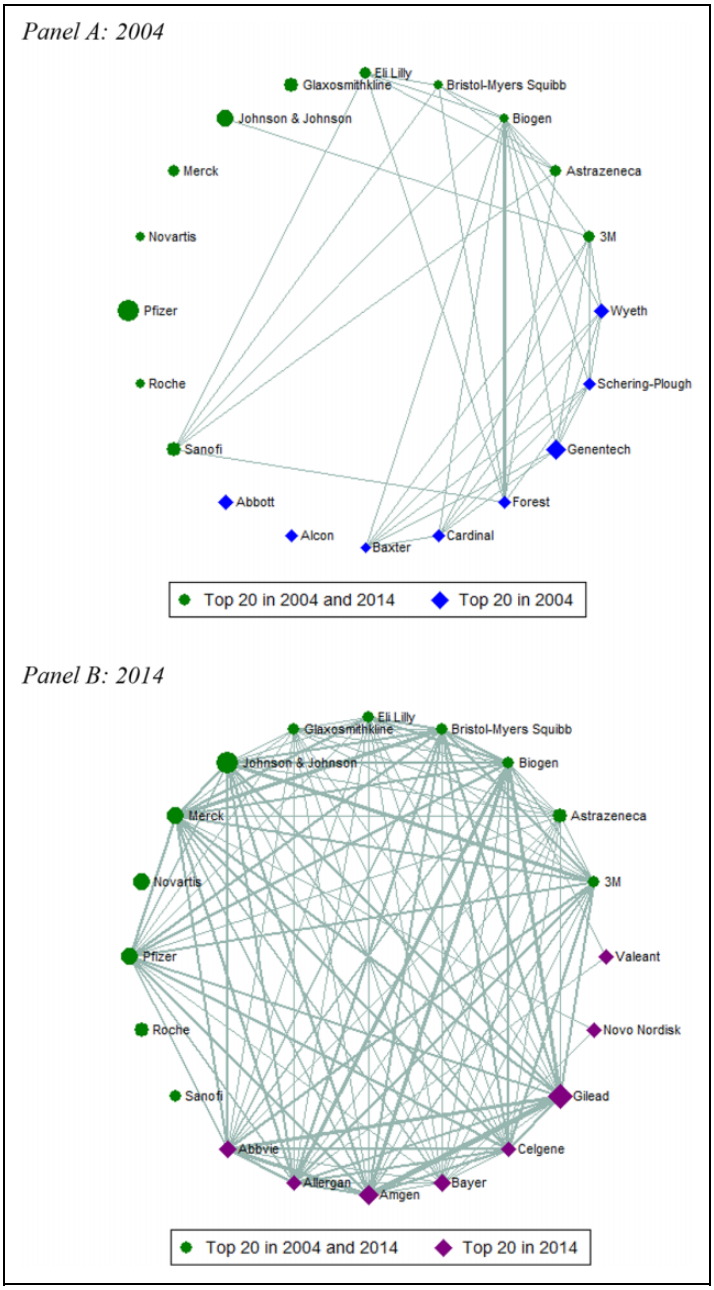

Figure 1. Common ownership network of the top twenty brand firms—individual ownership. *Note:* The size of the nodes indicates the value of the firm. The weight (thickness) of the edges represents the strength of the connections. A link between two firms exists if they have at least one common investor with more than 5% in both firms. The weight of the link between two firms depends on the number of such common investors that the two firms share.

valuable firms overall, at the beginning and end of the sample period, that is, in 2004 and 2014 (Panels A and B, respectively). To ease the comparison, we depict the firms that were in the top twenty in both years in the same position (in green circles). We also include the top twenty companies in 2004 that drop from the top twenty by 2014 (in blue diamonds) and, vice versa, those that appear in the top twenty in 2014 but were not in the top twenty in 2004 (in purple diamonds). As a measure of the common ownership link between two firms, we compute the number of individual investors whose ownership stake is larger than 5% in both firms, that is, the number of common investors with more than 5% in both firms. A link between two firms exists if they have at least one such common investor. The weight of the link between two firms depends on the number of such common investors that the two firms share.[22]

Figure 1 shows that the top brand firms have become more connected over time, according to this measure of common ownership. As shown in Panel A, several pairs of firms already had common investors, that is, with more than 5% in both firms, in 2004. But the links that existed in 2004 had relatively low weight, that is, the firms have few investors in common. Some of the largest firms, such as Pfizer or GlaxoSmithKline, had no connections at all. There are, however, some firms that are highly connected. Perhaps surprisingly, the most connected firms, such as Baxter or Cardinal, or the ones with stronger links, such as Biogen and Forest, are relatively small within the set of top twenty companies. Similarly, if anything, most of the (smaller) firms that drop from the top twenty by 2014 are more connected than those that remain.[23] In sum, the network in 2004 is not only sparser as compared to 2014 but also more asymmetric.

As shown in Panel B, the network becomes almost fully connected by 2014. Some firms, such as Pfizer, go from having no connection in 2004 to being almost fully connected with all the other firms in 2014. The connections between firms also become stronger. For example, in 2014, Johnson & Johnson and 3M have three common investors with more than 5% in both firms. Interestingly though, some firms, such as Sanofi, Novartis, and Roche, remain without any links in 2014. Although to some extent present, the institutional investors in these firms have ownership stakes that do not reach the 5% threshold, in part because of the presence of large noncommon investors such as L'Oreal in Sanofi, the Sandoz Family, and the Novartis foundation in Novartis, and Novartis itself as a shareholder in Roche. In sum, top brand firms become, according to the individual measure of ownership, more connected over time with a few notable exceptions.

Figure 2 shows the network for a measure of joint ownership of the common investors. This measure compares the ownership stakes of all the common investors in relation to the ownership stakes of all the investors in our database. We consider two companies linked if the common investors (>1% in the two firms) own, on average, in the two firms, more shares than the noncommon investors (>1% in just one of the two firms); that is, if the sum of the ownership stakes of all the common investors is greater than 50%. Note that there is no measure of the strength of the links in this network; the link just exists or not (in this sense, it is an example of an "unweighted network"). We make use of the same set of top twenty most valuable brand firms in 2004 and 2014, as in Figure 1.[24]

22. In formal terms, and denoting by $s_{i,j}$ the ownership share of an investor i in firm j, the "weight" of the link between any pair of firms j and j' is given by $\sum_i I(\min\left\{s_{i,j}, s_{i,j'}\right\} > 0.05)$, where $I(x)$ is the indicator function that takes a value of 1 if the condition x is satisfied and a value of 0 if it is not. If the weight is 0, the link between the pair of firms does not exist.
23. The majority of companies that exit the top twenty in 2014 were acquired. Schering Plough was acquired by Merck in 2009. Genentech was acquired by Roche in 2009. Forest was acquired by Actavis (now Allergan) in 2014. Novartis acquired a majority stake in Alcon in 2010. Wyeth was acquired by Pfizer in 2009. Abbott, Cardinal, and Baxter still exist as independent companies.
24. In formal terms, and denoting by $s_{i,j}$ the ownership share of an investor i in firm j, a link between any pair of firms j and j' exists if $[\sum_{i \in C}(s_{i,j} + s_{i,j'})/2] > 0.5$, where C is the set of "common investors" in that pair of firms j and j', that is, those investors i with ownership stakes such that $\min\left\{s_{i,j}, s_{i,j'}\right\} > 0.01$.

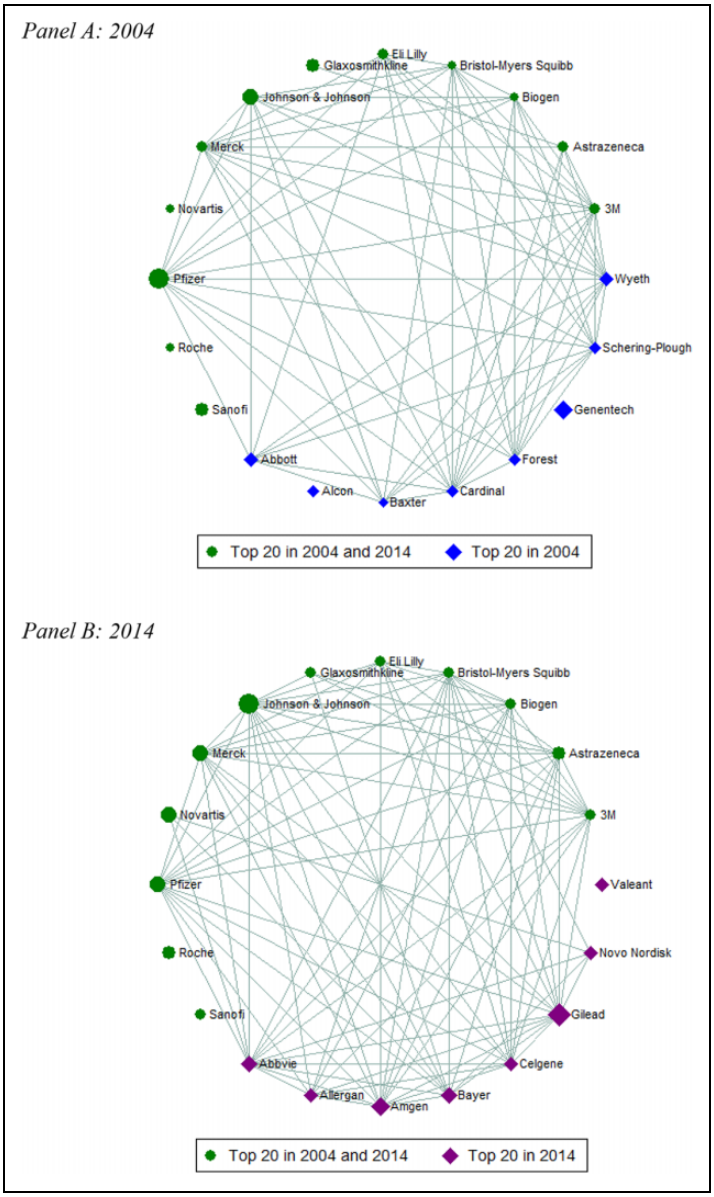

Figure 2. Common ownership network of the top twenty brand firms—joint ownership. *Note:* The size of the nodes indicates the value of the firm. A link between two firms exists if the common investors (>1% in the two firms) own, on average, in the two firms, more shares than the noncommon investors (>1% in just one of the two firms).

Figure 2 shows that the common investors own more than half of all the (large) shareholders in many pairs of firms, both in 2004 (Panel A) and in 2014 (Panel B). The network becomes even more connected over time. Novartis, for instance, had no connections in 2004. But, in 2014, the common investors of Novartis and Bayer, for instance, have more than 50% of the shares in both firms; the two firms become thus connected according to our joint measure. This is true despite the fact that Novartis and Bayer do not share any single individual investor holding more than 5% in both firms (as shown in

Figure 1, Panel B). In general, though, we observe a less dramatic change when using the joint measure of common ownership than the individual one. Thus, the effects of the evolution of common ownership may depend on whether common investors have individual influence or if they do (or can) exert joint influence. For both measures, some firms, such as Sanofi and Roche, remain without any links in 2014.

Common Ownership Networks among Generic Firms. Figure 3 replicates the network analysis of Figure 1 for the twenty most valuable generic firms. First, we again use the number of common investors whose ownership stake is larger than 5% in both firms as our measure of a common ownership link.

Figure 3 shows that the generic firms, contrary to the brand firms in Figure 1, became less connected in 2014 relative to 2004. Sun Pharma, for instance, lost all the connections it had in 2004, despite the fact that it became relatively larger. Overall, the level of connectivity of the generic firms is substantially lower than the brands in both years. Whereas the top brands are almost fully connected in 2014, the network of the generic firms is sparse. Very few firms have connections with other firms, and even fewer have connections with more than one investor. Only Perrigo, Impax, and Endo have relatively strong links with each other.

Figure 4 shows the generic network of common ownership using the joint shareholding measure. We again take into account the ownership stakes of all the common investors in relation to the ownership stakes of all the investors in our database. We consider two companies linked if the sum of the ownership stakes of all the common investors in the two firms is, on average, greater than 50%.

Figure 4 shows that the generic firms became less connected in 2014 relative to 2004, when applying our joint measure of common ownership. This is also what we found when using the individual measure. Sun Pharma lost all of the connections that it had in 2004 despite the fact that it became relatively larger. Overall, the level of connectivity is even lower when using the joint measure as opposed to the individual measure of common ownership. Very few firms have connections in 2004, and even fewer have connections in 2014. The exception is Perrigo, which slightly increased its number of connections.

Common Ownership Networks between Brand and Generic Firms. We now provide an analysis of the bipartite network of brands and generics. Bipartite networks are a particular class of networks, whose nodes are divided into two sets, and only connections between two nodes in different sets are allowed. As in the previous analysis, we use two measures of common ownership: (i) individual ownership, where the links reflect the number of investors whose ownership stake is larger than 5% in both firms, and (ii) joint ownership, where a link exists if the sum of the ownership stakes of all the common investors is greater than 50%. Note again that the size of the nodes represents the value of the firm relative to the firms in the same network.

Figure 5 shows that the brands and the generics became significantly more connected over time when looking at individual levels of ownership. As shown in Panel A, most brand-generic pairs were not connected in 2004, and in case they were, they only had one investor in common. Even the largest brands, such as Pfizer, had zero connections with the generics. Instead, as shown in Panel B, the number and the strength of the connections between brands and generics increased in 2014. Most of the large brands, such as Johnson & Johnson and Pfizer, have a large number of links. Some generics, such as Impax and Perrigo, have a high number of connections too.

Figure 6 shows that, when considering common ownership networks based on the joint measure, the same pattern emerges. Whereas in 2004 there were very few links between brand and generic companies, in 2014, these links were much more numerous (although fewer when compared to the common ownership network based on individual ownership).

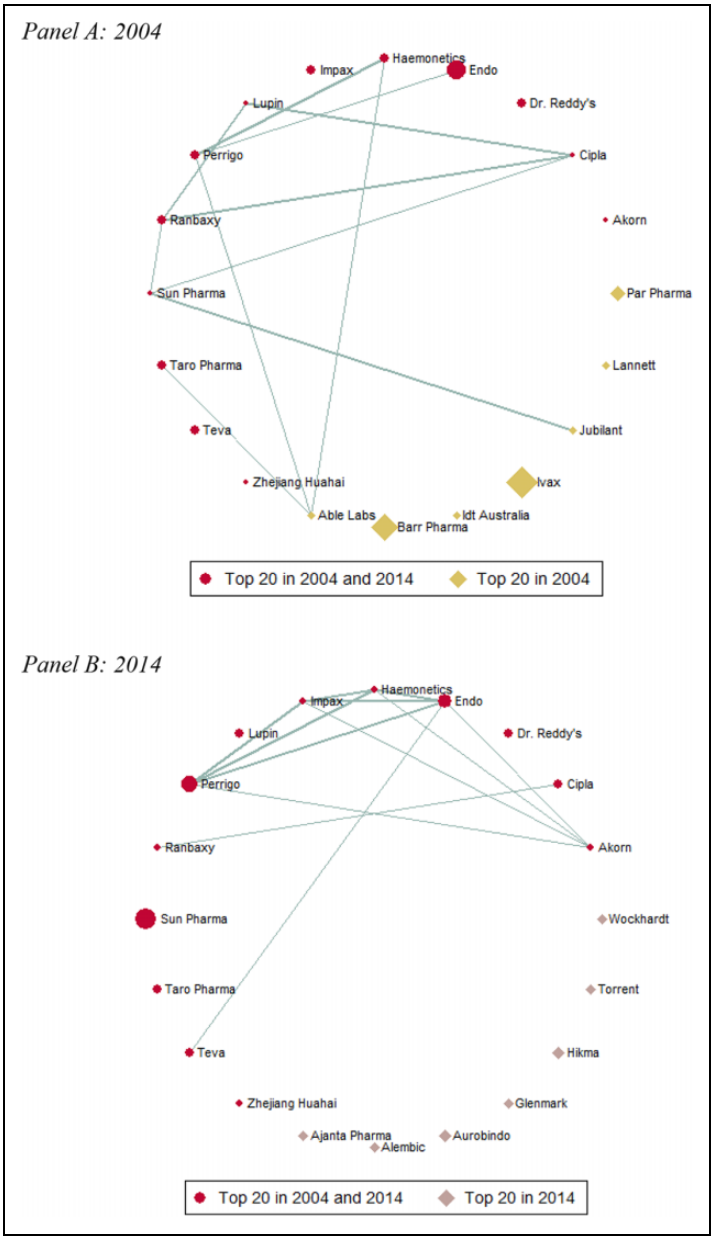

Figure 3. Common ownership network of the top twenty generic firms—individual ownership. *Note:* The size of the nodes indicates the value of the firm. The weight (thickness) of the edges represents the strength of the connections. A link between two firms exists if they have at least one common investor with more than 5% in both firms. The weight of the link between two firms depends on the number of such common investors that the two firms share.

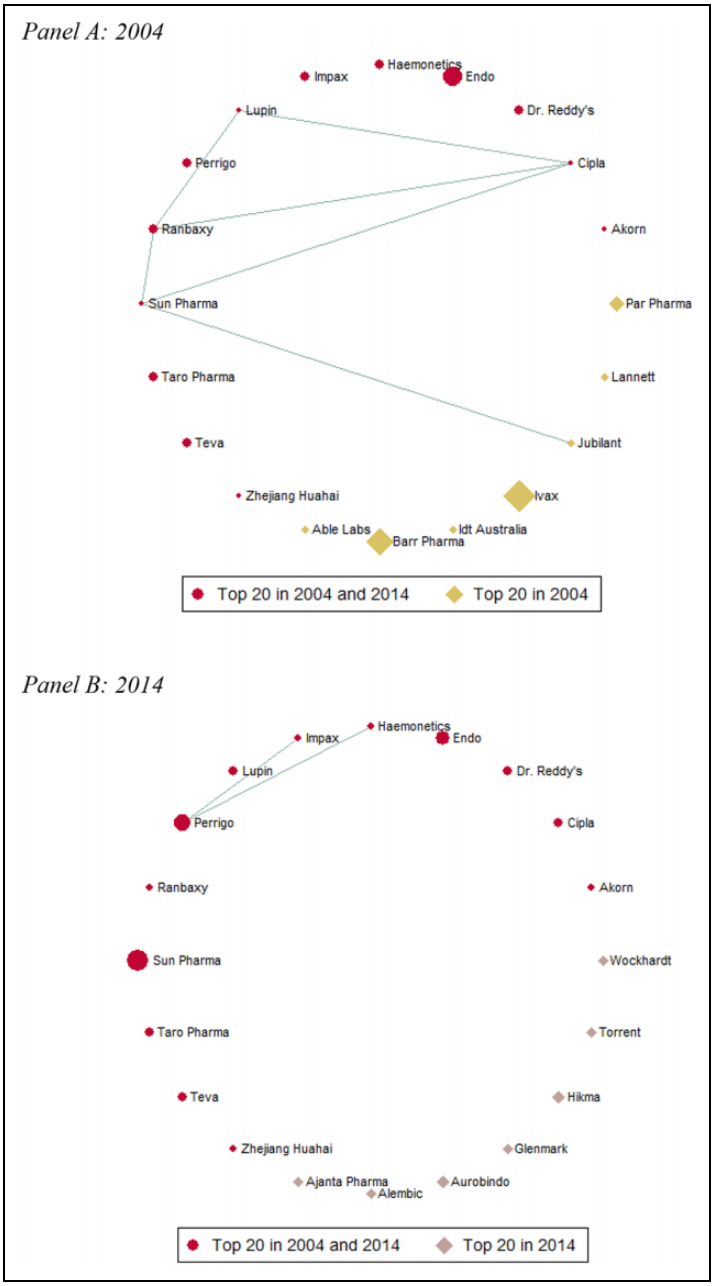

Figure 4. Common ownership network of the top twenty generic firms—joint ownership. *Note:* The size of the nodes indicates the value of the firm. A link between two firms exists if the common investors (>1% in the two firms) own, on average, in the two firms, more shares than the noncommon investors (>1% in just one of the two firms).

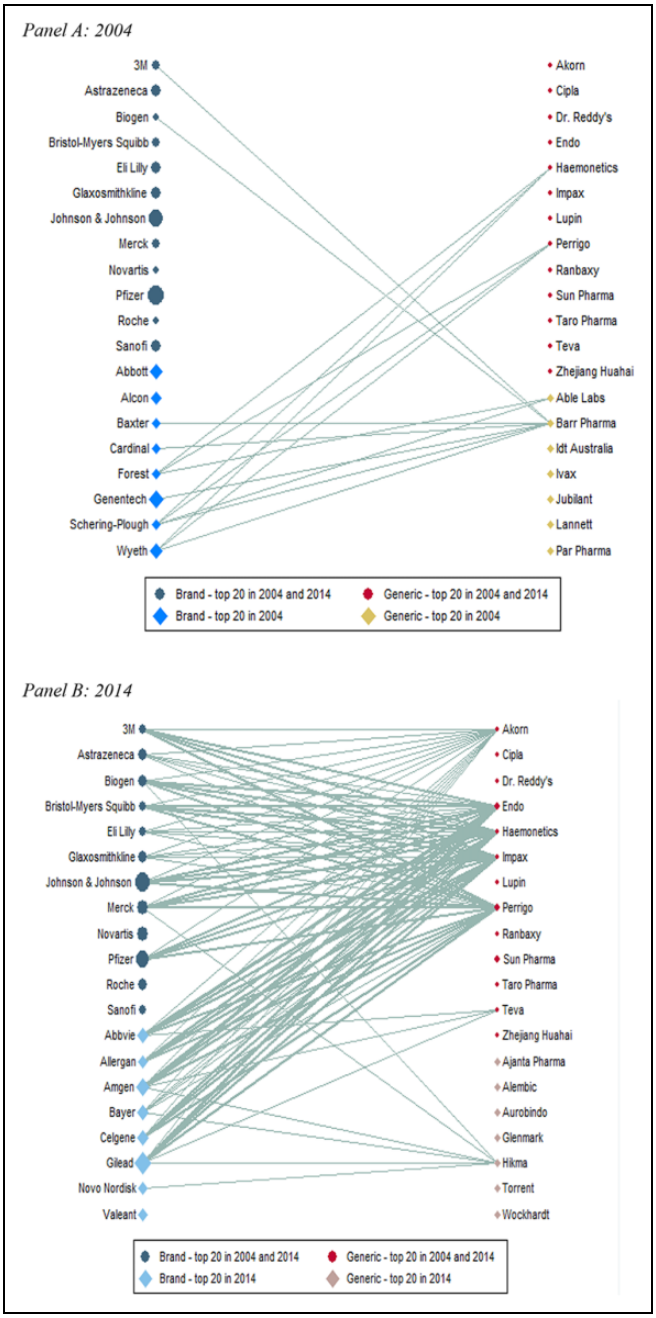

Figure 5. Bipartite network of brands and generics—individual ownership. *Note:* The size of the nodes indicates the value of the firm. The weight (thickness) of the edges represents the strength of the connections. A link between two firms exists if they have at least one common investor with more than 5% in both firms. The weight of the link between two firms depends on the number of such common investors that the two firms share.

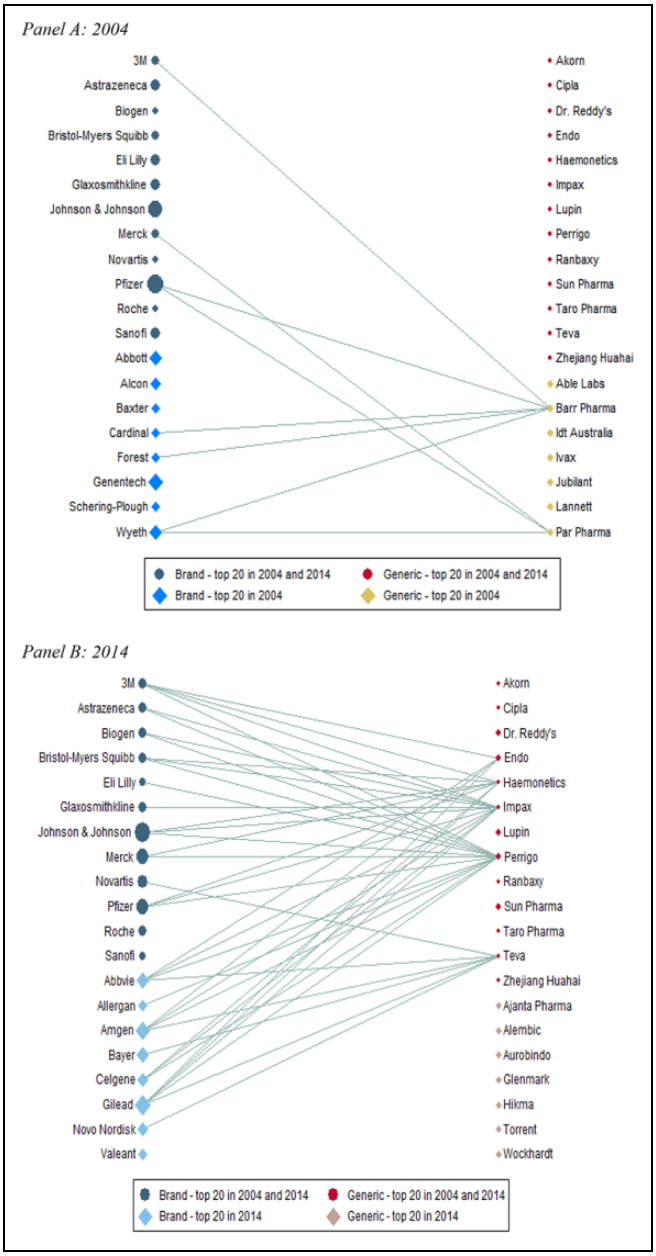

Figure 6. Bipartite network of brands and generics—joint ownership. *Note:* The size of the nodes indicates the value of the firm. A link between two firms exists if the common investors (>1% in the two firms) own, on average, in the two firms, more shares than the noncommon investors (>1% in just one of the two firms).

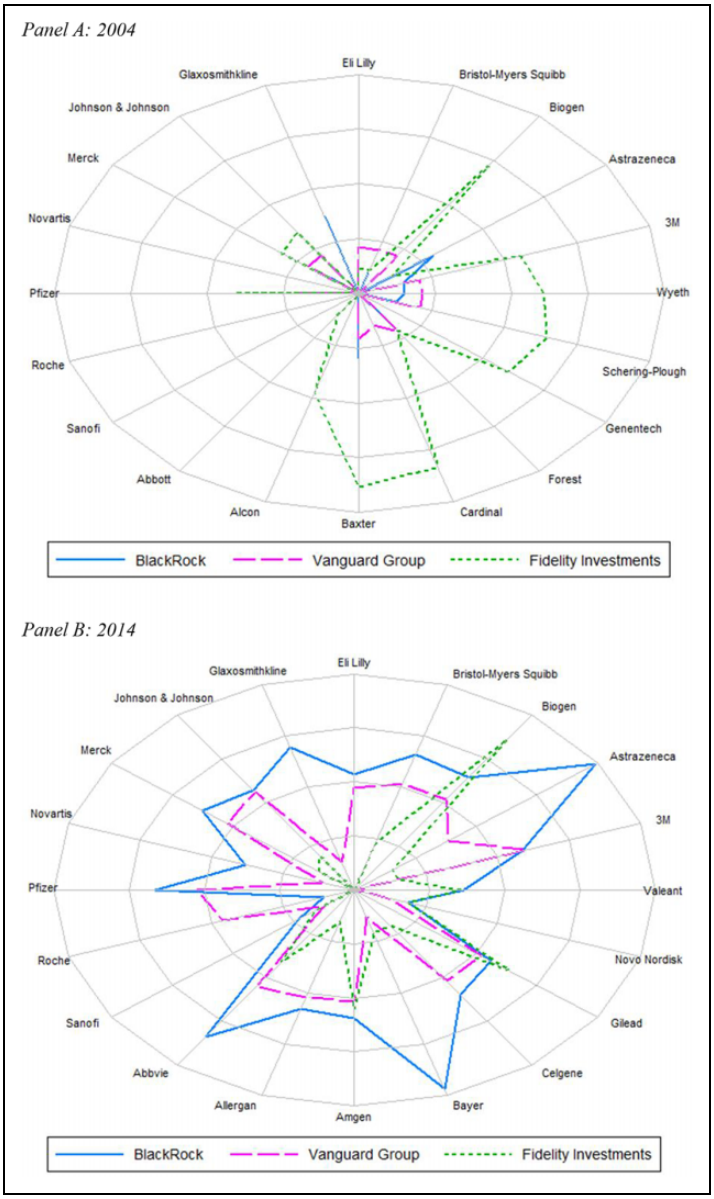

Figure 7. Investor networks in brand firms. *Note:* The axis tick marks for each circle represent shareholding levels of 2.5%, 5%, 7.5%, and 10%.

Investor Networks

This section investigates the determinants of the common ownership links identified in the previous section. We analyze in particular the evolution of the "investor networks" created by the shareholdings of the top three individual institutional investors of 2014 (Blackrock, Vanguard, and Fidelity; see Tables 3 and 4) in both brand and generic firms.

Brand Firms' Investor Network. Figure 7 represents the investor networks of Blackrock, Vanguard, and Fidelity in the top twenty brand firms, in the beginning (2004) and at the end of our sample (2014),

respectively. Each figure shows a "radar plot" of the ownership stakes. The axis tick marks represent the levels of 2.5%, 5%, 7.5%, and 10%.[25]

A comparison of Panel A with Panel B shows the significant growth of Blackrock and Vanguard over time. Blackrock's growth is partly due to the merger with Barclays Global Investors in 2009. In 2004, Blackrock only had ownership stakes below 5%. In 2014, Blackrock owns significant stakes in many of the top pharmaceutical companies, usually in the range of 5–7.5%, but in some cases even close to 10%. In 2004, Vanguard's stakes are all below 2.5%. In 2014, Vanguard's ownership stakes are consistently around 5%.

Fidelity owns a much lower number of blocks than Vanguard and BlackRock, although they tend to be of a larger size in 2004. The holdings of Fidelity appear more stable over time and have not experienced the same growth as Vanguard and BlackRock, which have surpassed Fidelity in both number and average size of holdings.

Generic Firms' Investor Network. Figure 8 represents the investor networks of the top three investors in the top twenty generic firms in 2004 and 2014, respectively.

Comparing Figure 8 with Figure 7 shows much smaller investor networks in the generics than in the brands. While increasing over time, in 2014, Blackrock and Vanguard own significant stakes in just five of the top twenty generic firms. Fidelity owns even fewer and smaller blocks in 2014 than it did in 2004.

Centrality in the Brand and Generic Networks

We now analyze which are the most influential brand and generic firms in their respective common ownership networks. In network analysis, influence is measured by how "central" an individual node's position is in the network, based on the existence and strength of its links with other nodes.[26]

We proceed as follows. We first provide a definition of two standard measures of centrality: degree and closeness centrality. As both of them depend on network size, throughout this section, we consider the network of the eighty-five most valuable brands and the network of the twenty-five most valuable generics in each year. Although the identity of the firms in each network changes over time, the number (and thus the size of the network) remains constant throughout the sample period.

We then provide a description of the centrality measures of the top twenty brand and top twenty generic firms within each of their networks, both at the beginning and end of the sample. Finally, we show the evolution of the mean and dispersion of the measure of degree centrality for the whole set of firms in each of the two networks.

Definitions. We construct two centrality measures based on the concepts of degree and closeness centrality. These concepts capture slightly different aspects of the firms' roles in the common ownership network. We provide a definition of each:

- **Degree centrality** measures the number of relationships an actor in the network has. The more ties, the more opportunities to interact and so the more influential, or central, the actor is. Firms that have ties to many other firms may be in an advantaged position. Since they have many ties, they are less dependent on any other firm for information, for instance. Formally, degree centrality counts the number of unique ties each firm has; that is, the number of unique firms

25. All radar plots are made using "RADAR": Adrian Mander, 2007. "RADAR: Stata module to draw radar (spider) plots," Statistical Software Components S456829, Boston College Department of Economics, revised Sep. 02 2018.

26. *See* Linton C. Freeman, *A Set of Measures of Centrality Based on Betweenness*, Sociometry 35 (1977); Linton C. Freeman, *Centrality in Social Networks Conceptual Clarification*, 1 Soc. Networks 215 (1978).

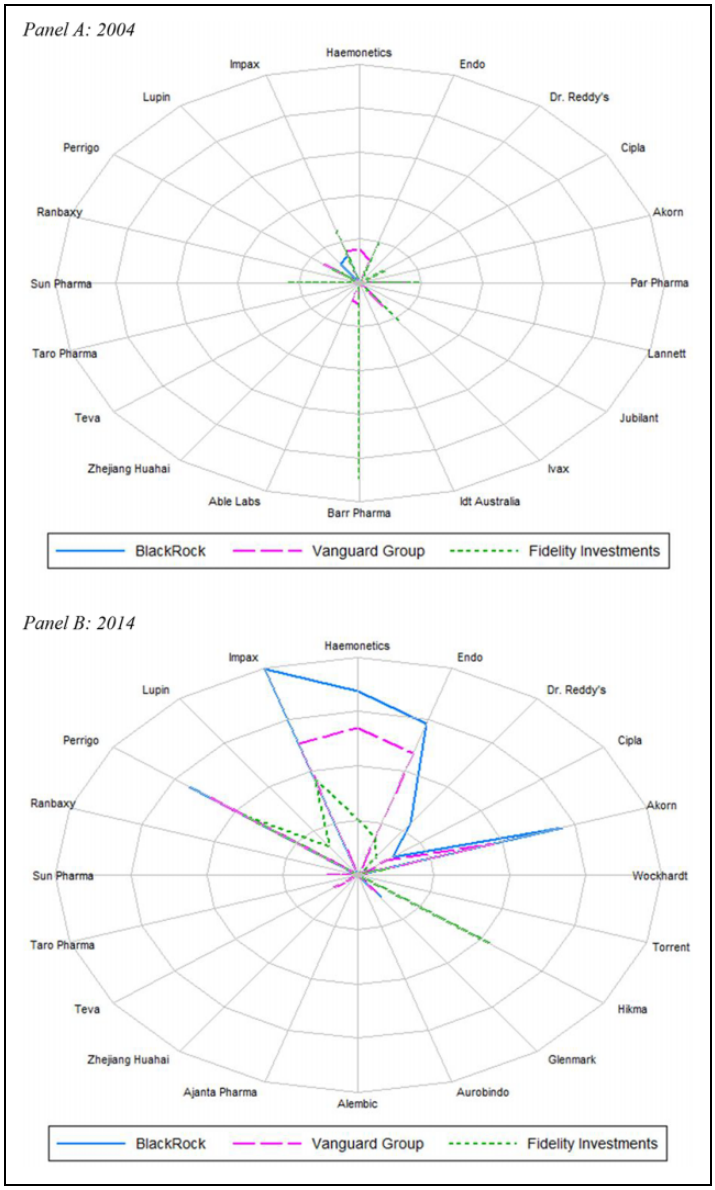

Figure 8. Investor networks in generic firms. *Note:* The axis tick marks for each circle represent shareholding levels of 2.5%, 5%, 7.5%, and 10%.

with which a firm has a link with. Naturally, as networks become more connected, the average degree centrality across firms increases.

- **Closeness centrality** is a measure based on the distance between nodes.[27] Nodes with high closeness centrality are close to all other nodes, that is, they can reach all other nodes in only a

27. For a formal definition see Section 13.2 in Thomas U. Grund (2014). *nwcommands: Software Tools for the Statistical Modeling of Network Data in Stata*.

Table 5. Levels of Centrality for the Twenty Brand Companies.

	Individual Ownership Measure				Joint Ownership Measure			
	Degree Centrality		Closeness		Degree Centrality		Closeness	
Firm	2004	2014	2004	2014	2004	2014	2004	2014
Johnson & Johnson	1	46	0.12	0.22	16	40	.11	.15
Pfizer	0	46	.07	.22	23	31	.11	.15
Merck	0	49	.07	.22	19	30	.11	.15
Gilead	0	49	.07	.22	20	33	.11	.15
Novartis	0	0	.07	.07	0	3	.07	.14
Amgen		49		.22		27		.15
Roche	0	0	.07	.07	0	0	.07	.07
Astrazeneca	10	46	.12	.22	7	21	.11	.15
Biogen	25	51	.13	.22	14	25	.11	.15
Glaxosmithkline	0	45	.07	.22	1	8	.10	.14
Bayer	1	47	.07	.22	0	14	.07	.14
Abbvie		46		.22		31		.15
Bristol-Myers Squibb	10	48	.12	.22	15	33	.11	.15
3M	16	46	.13	.22	21	40	.11	.15
Sanofi	10	0	.12	.07	0	0	.07	.07
Eli Lilly	10	47	.12	.22	10	15	.11	.14
Celgene	15	46	.13	.22	3	33	.10	.15
Valeant	0	4	.07	.19	0	5	.07	.14
Novo Nordisk	11	8	.13	.19	0	0	.07	.07
Allergan	24	48	.13	.22	13	14	.11	.14
Average	7.39	36.05	.10	.19	9.00	20.15	.10	.14

few steps. In contrast, nodes with low closeness centrality are far away from all other nodes. For unconnected nodes, we set the distance to all the other nodes as the maximum distance in the network plus 10.

Firm-Level and Mean Centrality Measures. Table 5 shows the average degree and closeness centrality for each top twenty brand company (calculated within the sample of eighty-five firms in the brand network), as compared to the levels in 2004. The average value at the bottom of the table is the average among the top twenty brand companies. We order firms by their size (market value) in 2014. We again make use of the two measures of common ownership: individual and joint ownership.

As we can see in Table 5, the average degree centrality for both ownership measures has more than doubled between 2004 and 2014. There are differences in which firms are the most central depending on the measure used. If we focus on the individual ownership measure, in 2004, Biogen and Allergan have the highest levels of degree centrality with values of 25 and 24, respectively. These two firms also have high closeness values in 2004 when using the individual ownership measure. In 2014, the most central firm is Biogen with a value of 51 for degree centrality using the individual measure.

When using the joint ownership measure, in 2004, Pfizer and 3M have the highest levels of degree centrality with values of 23 and 21, respectively. In 2014, the most central firm is Johnson & Johnson with a value of 40 for degree centrality using the joint measure. This indicates that how common ownership links are measured plays an important role in determining which actors are the most central.

Table 5 also shows that many of the top twenty brand firms have a similar number of connections in 2014 based on the measure degree centrality for the individual measure, that is, levels of degree

Table 6. Levels of Centrality for the Twenty Generic Companies.

	Individual Ownership Measure				Joint Ownership Measure			
	Degree Centrality		Closeness		Degree Centrality		Closeness	
Firm	2004	2014	2004	2014	2004	2014	2004	2014
Sun Pharma	3	0	.10	.08	4	0	.11	.08
Perrigo	3	6	.08	.11	0	2	.08	.09
Endo	1	7	.08	.11	0	0	.08	.08
Lupin	6	0	.10	.08	5	0	.11	.08
Dr. Reddy's	0	0	.07	.08	0	0	.08	.08
Teva	0	1	.07	.11	0	0	.08	.08
Cipla	6	1	.10	.09	6	0	.11	.08
Hikma		0		.08		0		.08
Taro Pharma	1	0	.08	.08	0	0	.08	.08
Ranbaxy	6	1	.10	.09	6	0	.11	.08
Aurobindo	5	0	.10	.08	4	0	.11	.08
Akorn	0	6	.07	.11	0	0	.08	.08
Glenmark		0		.08		0		.08
Torrent	6	0	.10	.08	6	0	.11	.08
Haemonetics	2	6	.08	.11	0	1	.08	.09
Impax	0	6	.07	.11	0	1	.08	.09
Wockhardt	6	0	.10	.08	5	0	.11	.08
Zhejiang Huahai	0	0	.07	.08	0	0	.08	.08
Alembic		0		.08		0		.08
Ajanta Pharma		0		.08		0		.08
Average	2.81	1.70	.09	.09	2.25	0.20	.09	.08

centrality lie between forty-six and fifty-one. Still, some others, including large firms such as Novartis and Roche, are not connected at all and thus have a level of degree centrality of zero, both in 2004 and in 2014. The levels of degree centrality in 2004 were substantially lower than in 2014: Johnson & Johnson had one connection whereas Pfizer had none.

The differences across firms in terms of closeness centrality for both measures are lower than for degree centrality. In addition, the differences between 2004 and 2014 are smaller in the case of closeness than in the case of degree centrality.

Table 6 shows the degree and closeness centrality of the top twenty generic firms within the twenty-five-generic firm network in 2014, as compared to the levels of 2004. We again order firms by 2014 market value and include the averages at the bottom of the table.

The levels of degree centrality for the generics are substantially lower than for the brand firms. For both measures, many generics have a degree of zero in 2014, including the largest generic firm in our sample, Sun Pharma. The generic firm with most connections in 2014, Endo, has seven when using the individual measure, that is, 29% of the maximum number of connections possible in the generic network (twenty-four). By comparison, fifteen of the top twenty brand firms have more than forty-five connections, that is, 54% of the maximum number of connections possible in the brand network (eighty-four). Moreover, the average degree of centrality of generics is lower in 2014 than it was in 2004.

In sum, the measures of centrality are substantially higher in 2014 as compared to 2004 for the brand firms. For the generic firms, the opposite is true. Degree centrality is not only much lower than for the brand firms in both years, but it is also lower in 2014 than it was in 2004. In the following

subsection, we investigate more systematically the evolution, over time, of average degree centrality for both measures of ownership.

Evolution of the Mean and Dispersion of the Centrality Measures over Time. We now investigate the evolution of the mean and dispersion of centrality over time in the brand and generic networks. We again make use of the two measures of common ownership: individual and joint ownership. For simplicity, we focus on one of the measures of centrality, degree centrality (the pattern is similar for closeness centrality).

Figure 9 shows the average degree centrality for the eighty-five brand and the twenty-five generic companies over the 2004–2014 period (brand on the right axis and generics on the left), for the two measures of common ownership: individual in Panel A and joint in Panel B.

Note that there are important differences between the two sets of firms. Whereas the average degree of the brand firms has increased substantially, the average degree centrality of the generic firms has decreased over time. This is true for the individual measure of ownership, but it is especially the case for the joint measure of ownership.

Figures 10 and 11 display the histograms of the measure of degree centrality in both 2004 and 2014 for the brand firms and generic firms, respectively. Panel A shows the individual ownership measure and Panel B shows the joint ownership measure.

Figure 10 shows that the dispersion of degree centrality across the brand firms has increased in 2014 as compared to 2004, in both measures of ownership. A relatively large number of firms still have zero connections and thus a degree centrality of zero in 2014. But the highest levels of degree centrality become higher by 2014 relative to 2004.

The conclusions that can be drawn about the dispersion of the generic firm network are sensitive to the measure of common ownership used. If we use the individual common ownership measure, it appears that the dispersion of degree centrality across the generic firms has increased slightly in 2014 as compared to 2004. A larger number of firms have zero connections and thus a degree centrality of zero. The most connected generics have a slightly higher number of connections in 2014 as compared to 2004. However, if we use the joint measure, we find that centrality is limited to the range of zero to two in 2014, whereas in 2004 some generics had centrality measures in the range of four to six. These differences are explained by the fact that for generics, in 2004, there are common owners present with large stakes (see Table 4) which create linkages in 2004 when we use the joint ownership measure. With the absence of these investors in 2014, the common ownership network for generic firms on the basis of the joint ownership measure is much sparser (see Figure 4, Panel B).

Antitrust Implications of Common Ownership in the Pharmaceutical Industry

Our empirical analysis shows, generally, that the common ownership network among brand companies has become denser and more complete over time, whereas that of the generics is much sparser and becomes sparser over time. Finally, the bipartite network between brand companies, on the one hand, and generic companies, on the other, has become denser. This section discusses the antitrust implications of these patterns.[28]

We first discuss the implications of the dynamics of the brand firm network for innovation, as brand companies engage in innovation investments with the aim to patent new drugs—and enjoy rents from the resulting temporary monopoly. We then analyze the consequences of the evolution

28. For a full discussion of legal theories to tackle common ownership, *see* Einer Elhauge, *How Horizontal Shareholding Harms Our Economy-And Why Antitrust Law Can Fix It*, 10 Harv. Bus. L. Rev. 207 (2020).

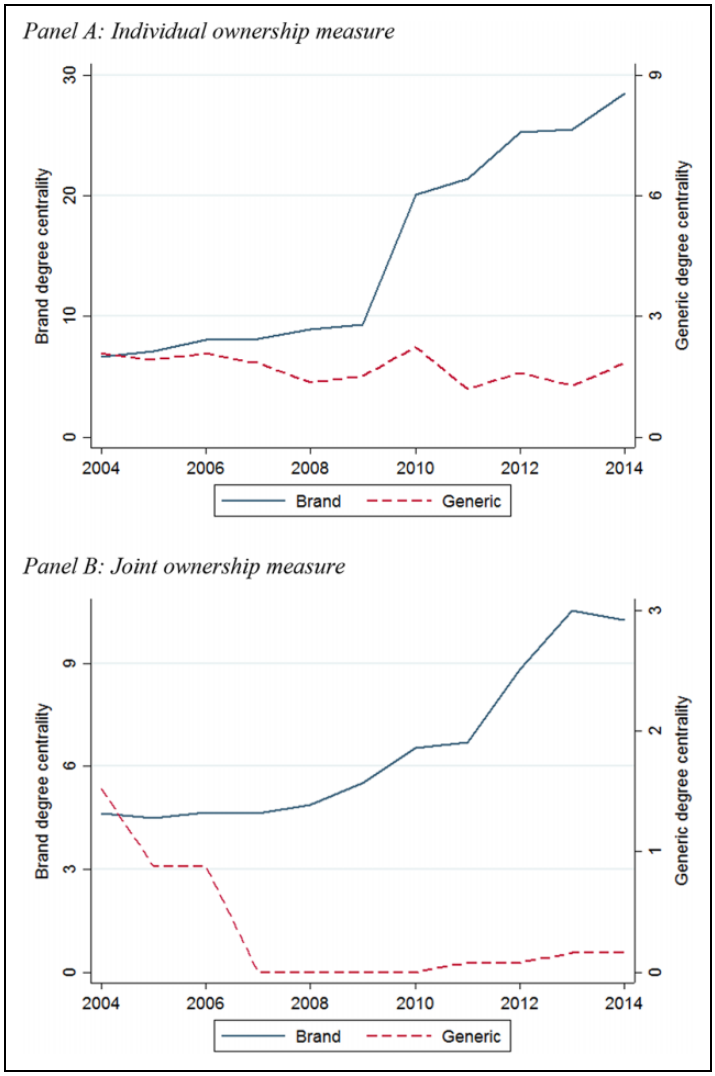

Figure 9. Average degree centrality of brand and generic firms over time (2004–2014). Panel A: Individual ownership measure. Panel B: Joint ownership measure.

of the bipartite network between brand and generic companies on generic entry in markets where the brand no longer enjoys regulatory protection. Thirdly, we discuss the implication of common ownership for prices in the pharmaceutical industry. High drug prices are a major concern for policy makers in the United States: prescription drugs, responsible for 10% of all healthcare costs, represent one of the fastest-growing areas of healthcare spending.[29] Finally, we briefly discuss implications for collusion.

29. *See* Anne B. Martin et al., *National Health Spending: Faster Growth in 2015 as Coverage Expands and Utilization Increases*, 36 Health Aff. 166 (2017).

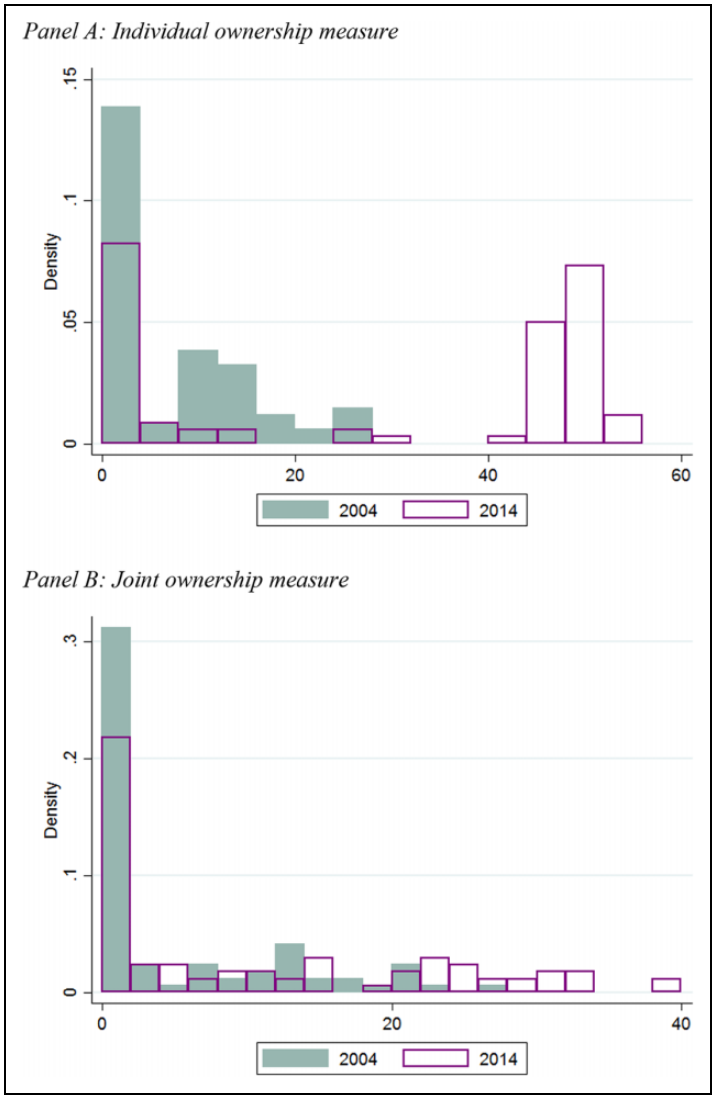

Figure 10. Histogram of degree centrality for brands within the eighty-five brand firm network in 2004 and 2014. Panel A: Individual ownership measure. Panel B: Joint ownership measure.

Innovation

R&D is crucial for bringing new drugs to the market. Thus, whether common ownership positively or negatively affects innovation in the pharmaceutical industry is a key concern for policy makers. Common ownership between brand companies may, on the one hand, enhance information sharing, generate synergies, and increase the incentives to invest in R&D. On the other hand, common ownership may also incentivize firms to innovate in a way that avoids head-on competition between each other in the innovation space. We briefly discuss each of these possibilities in turn.

The increasingly dense common ownership network that we observe among brand companies may be good for innovation for the following reasons. First, the common ownership links may *facilitate information sharing* between connected firms. This can bring in substantial benefits. Indeed, in the

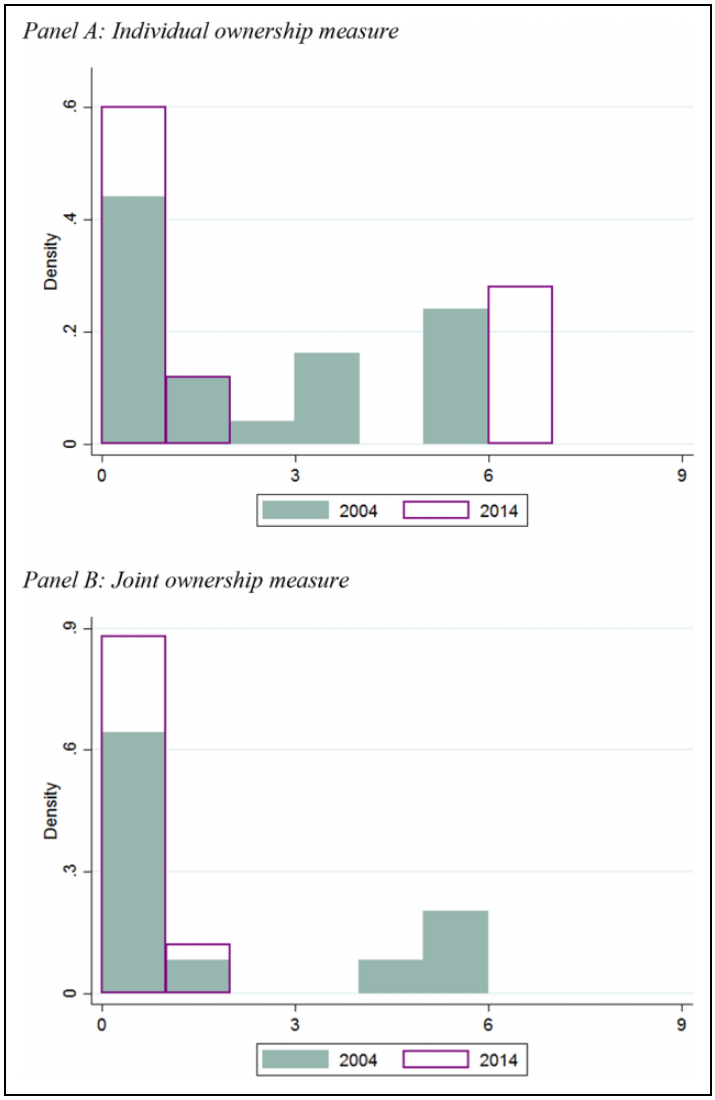

Figure 11. Histogram of degree centrality for generics within the twenty-five generic firm network in 2004 and 2014. Panel A: Individual ownership measure. Panel B: Joint ownership measure.

early stages of development, firms select which R&D projects to bring into their R&D portfolio and test numerous lead molecules. At this stage, connections with other firms may provide an opportunity for brand firms to share each other's knowledge bases. Indeed, Kostovetsky and Manconi find a higher intensity of patent citations among firms that share institutional owners, suggesting that common institutional investors can facilitate the diffusion of information among their portfolio firms.[30] In a similar vein, Ghosh and Morita show that cross-ownership, which has elements in common with

30. *See* Leonard Kostovetsky & Alberto Manconi, *Common Institutional Ownership and Diffusion of Innovation* (Working paper, Apr. 2020), https://ssrn.com/abstract=2896372.

common ownership (see also below in the section on pricing), can induce knowledge transfer between connected firms, thereby increasing consumer surplus and/or total surplus under certain conditions.[31]

Common ownership links may also lead to more *informal or formal innovation collaborations*, with the associated benefits. Indeed, sharing scientific personnel and/or research labs that result in a combination of complementary assets may lead to synergies. Similarly, collaboration may lead to the reduction of wasteful innovation duplication. He and Huang, for instance, find evidence suggesting that institutional cross-ownership facilitates explicit forms of collaboration, such as within-industry joint ventures and strategic alliances, and that this improves innovation productivity.[32] Geng, Hau, and Lai find furthermore that shareholder ownership overlap across firms with patent complementarities correlates significantly with higher investment in innovation and more success with patents.[33]

Further, common ownership links between innovating pharmaceutical companies can increase innovation by *mitigating technology spillover problems*. Indeed, companies often hold back on costly innovation efforts since competitors may be able to imitate and free ride on these efforts. If companies are commonly owned, then innovation spills over to companies within the same network and may thus benefit the same owners. Supporting this line of reasoning, Lopez and Vives show theoretically that horizontal common-ownership links can mitigate firms' well-known disincentives to innovate that can arise because of the technological spillovers.[34] Antón, Ederer, Gine, and Schmalz confirm theoretically and empirically that common ownership may incentivize firms to engage in more R&D. In particular, common ownership increases R&D when technological spillovers are large relative to product market spillovers. If the reverse occurs, that is, when product market spillovers are larger, then common ownership reduces R&D.[35]

Common ownership may also *reduce competition in innovation*. For example, common ownership might negatively affect the number and/or the selection of R&D projects pursued. As drugs pass through clinical trials, firms may reoptimize their portfolio and decide which drugs to submit for FDA approval. Many development projects are terminated, not due to safety or efficacy concerns, but due to commercial considerations. Large pharmaceutical firms often invest in ten to fifteen distinct research programs that run simultaneously. In an effort to reduce competition, firms with common investors may *jointly* pursue a similar line of research or *terminate competing projects*. This is potentially to the detriment of consumers if it means that fewer drug variants are available.

Recent research indicates that one of the motives for pharmaceutical firms to engage in M&As is to neutralize potential competition. The idea is that an incumbent—that is, a company that has already launched a drug—has an incentive to acquire and terminate projects in the development process if these projects have "overlap" with its launched product (where overlap is defined as the same MoA within a therapeutic class). These acquisitions where the incumbent acquires a nascent or potential competitor in order to neutralize the competition have been termed "killer acquisitions." Cunningham,

31. *See* Arghya Ghosh & Hodaka Morita, *Knowledge Transfer and Partial Equity Ownership*. 48 Rand J. Econ. 1044 (2017).
32. *See* Jie Jack He & Jiekun Huang. *Product Market Competition in a World of Cross-Ownership: Evidence from Institutional Blockholdings*, 30 Rev. Fin. Stud. 2674 (2017). Although there is evidence that research joint ventures, in turn, may facilitate collusion in product markets. *See* Tomaso Duso et al., *Collusion through Joint R&D: An Empirical Assessment*, 96 Rev. Econ. Stat. 349 (2014), and *see* Eric Helland & Michelle Sovinsky, *Do Research Joint Ventures Serve a Collusive Function?* (Working paper, 2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3336792.
33. *See* Heng Geng et al., *Patent Success, Patent Holdup, and the Structure of Property Rights* (Working Paper, Sch. Econ. Finance, Vic. Univ. Wellingt. 2017) http://www.haraldhau.com/wp-content/uploads/Patent-Networks-v261_full.pdf.
34. *See* Ángel L. López & Xavier Vives, *Overlapping Ownership, R&D Spillovers, and Antitrust Policy*, 127 J. Pol. Econ. 2402 (2019).
35. *See* Miguel Anton et al., *Innovation: The Bright Side of Common Ownership?* (Working paper, 2018), https://ssrn.com/abstract=3099578.

Ederer, and Ma find that projects acquired by firms that have an overlapping drug are 23.4 % less likely to have continued development activity.[36]

The presence of common ownership between two firms with overlapping drugs may mitigate the need for a merger to achieve a similar effect. A recent paper that looks at common ownership links in pharmaceutical start-ups by venture capital (VC) companies, Li, Liu, and Taylor find precisely this effect.[37] In particular, they examine how a start-up responds after seeing a competitor make progress on a related drug project. If the two start-ups share a common VC, the lagging start-up is less likely to advance its own project, which reduces competition between the start-ups. The authors find that these anticompetitive effects are mostly present for technologically similar projects, early-stage projects, and with VCs involved that have larger equity stakes and less-diversified portfolios.

In sum, high common ownership among brand companies can have both positive and negative effects on innovation in the pharmaceutical sector. Current theoretical and empirical research highlights both sides. Research in this dimension is a promising avenue for future research, especially in terms of identifying whether and under which circumstances common ownership of firms with projects that have overlapping mechanisms of action and similar therapeutic classes leads to better or worse innovation outcomes.

Entry

Patented markets are the main source of revenue for brand companies. When the patent expires—or when it is challenged in court[38]—and generic companies enter, revenues for the brand decline dramatically (by as much as 90%). Therefore, brand companies have a strong incentive to deter generic entry, or at least to delay generic entry as long as possible. Entry induces losses to the brands and gains to the generics that are highly asymmetric: a brand company loses much more after entry than a generic profits after entry. Therefore, the joint payoff for brand and generic in holding off entry is clearly positive.

Scott Morton reviews how direct ownership links between brand and generic firms influences the likelihood of generic entry.[39] She finds that generics owned by the original innovator (i.e., the brand company) are less likely to enter the market. This hints that an investor with shares in both the brand and generic may benefit from steering the generic away from entering. Therefore, entry decisions of generics may crucially depend on the joint ownership of generic and brand firms. Shareholdings in the brand provide common investors with incentives to steer decisions toward joint profits and shareholdings in the generic provide investors with the ability to influence such decisions.[40]

Newham, Seldeslachts, and Banal-Estanol find that this is indeed the case.[41] They analyze generic firms' entry decisions into pharmaceutical markets opened up by the end of regulatory protection. They find that a higher level of common ownership between a brand firm and a potential generic

36. *See* Colleen Cunningham et al., *Killer Acquisitions* (Working paper, 2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3241707.
37. *See* Xuelin Li et al., *Do Venture Capitalists Stifle Competition?* (Jacobs Levy Equity Management Center for Quantitative Financial Research Paper, May 28, 2020), https://ssrn.com/abstract=3479439.
38. A brand's patent validity can be brought to court through a Paragraph IV challenge, which is the section of the Hatch-Waxman act under which generic entrants dispute pharmaceutical patents. *See, e.g.,* Eric Helland & Seth A. Seabury, *Are Settlements in Patent Litigation Collusive? Evidence from Paragraph IV Challenges* (Working paper No. w22194. National Bureau of Economic Research, 2016), https://www.nber.org/papers/w22194.
39. Fiona Scott Morton, *Horizontal Integration between Brand and Generic Firms in the Pharmaceutical Industry*, 11 J. Econ. & Mgmt Strat. 135 (2002).
40. *Also, see* Eric A. Posner et al., *A Proposal to Limit the Anti-Competitive Power of Institutional Investors*, 81 Antitrust L. J. 669 (2017).
41. *See* Newham et al., *supra* note 3.

entrant is robustly linked with a lower probability of generic entry and that this effect is economically significant in the sense that overall common ownership at the market level decreases the total number of generics in that market.[42] This means that the increasingly dense bipartite network between brand companies, identified in the previous section, is likely to lead to less generic entry.[43]

Pricing

Unilateral Effects. Commonly owned brand firms that commercialize drugs that are therapeutically similar might have less incentives to unilaterally compete,[44] due to various mechanisms.[45] Indeed, as O'Brien and Salop note, the anticompetitive effects of common ownership are similar to that of cross ownership in that common ownership can be understood to be ownership in one firm, coupled with cross ownership in the others.[46]

First, firms that are largely owned by shareholders who also have sizable stakes in competitors might just simply act in these shareholders' interest, which leads them—rather than maximizing their own profits—to maximize the return of their shareholders' portfolios, in whose interest it might be to soften price competition.[47] Further, while there is evidence that institutional investors engage in active discussions with companies' management,[48] investors do not need to actively intervene to have an impact on the firms' decisions. They may apply "selective omission" by encouraging actions that increase both firm value and portfolio profits and remaining silent when this is not the case.[49] Further, they may design payment schemes for the top management to shape their incentives in a way that leads to softer product market competition. Antón, Ederer, Giné, and Schmalz find that higher firm-level common ownership is linked to less performance-sensitive incentives for CEOs and other top managers, which in turn may lead to softer competition.[50]

Increases in common ownership links between brand and generic companies, as we show in the bipartite network in the previous section, may also indirectly raise drug prices. Indeed, common

42. Related, Xie and Gerakos find that common ownership between brand and generic is positively associated with the two parties entering into a settlement agreement where the generic manufacturer stays out of the market. *See* Jin Xie & Joseph Gerakos, *Institutional Horizontal Shareholdings and Generic Entry in the Pharmaceutical Industry* (Tuck School of Business Working Paper No. 3285161), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3285161. Hovenkamp & Lemus further confirm that settlements after Paragraph IV challenges cause generics to stay out of the market. *See* Erik Hovenkamp & J. Lemus, *Delayed entry Settlements at the Patent Office*, 54 Int'l Rev. L. & Econ. 30 (2017).
43. There is also evidence from other industries that ownership structures affect entry. Majumdar documents the relationship between horizontal ownership and entry in the local telecommunication exchange segment in the United States and finds that dominant ownership controllers experienced lower entry in their territories. *See* Sumit K. Majumdar, *Consequences of Oligopoly: Horizontal Ownership Concentration and Telecommunications Sector Deterred Entry* (Working paper, 2019).
44. Previous research in the airline and banking industries has pointed toward a positive relationship between common ownership and prices. *See* Jose Azar et al., *Ultimate Ownership and Bank Competition* (Working paper, 2019), https://ssrn.com/abstract=2710252; Jose Azar et al., *Anticompetitive Effects of Common Ownership*, 73 J. Fin. 1513, (2018).
45. For an overview of the mechanisms by which large horizontal shareholdings are likely to influence corporate management, *see* Einer Elhauge, *The Causal Mechanisms of Horizontal Shareholding,* 82 Ohio State L.J. (forthcoming issue 2, 2021), https://ssrn.com/abstract=3370675.
46. Patrick O'Brien & Steven Salop. *Competitive Effects of Partial Ownership: Financial Interest and Corporate Control*, 67 Antitrust L.J. 559 (2000).
47. José Azar, *Portfolio Diversification, Market Power, and the Theory of the Firm* (Working paper, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2811221.
48. S*ee, e.g.,* McCahery et al., *supra* note 10.
49. *See* Scott C. Hemphill & Marcel Kahan, *The Strategies of Anticompetitive Common Ownership*, 129 Yale L.J. 1392 (2020), https://ssrn.com/abstract=3210373.
50. Miguel Antón et al., *Common Ownership, Competition, and Top Management Incentives* (Working paper, 2020), https://florianederer.github.io/common_ownership.pdf.

ownership should reduce generic entry and, as shown by previous research, the reduction of generic companies in the market increases prices.

In sum, both the increasingly linked brand network and brand-generic bipartite graph suggest that price competition might have softened. This is an interesting area for future research to study how the link between common ownership affects prices through the channel of entry; *see*, for example, Grabowski and Vernon for a study that links generic entry to drug prices and Suzuki for a study that looks at the impact of differences in market conditions (regulation) on prices through the channel of entry.[51]

Coordinated Effects. Our empirical results indicate that common networks among generics are sparse and, if anything, have become sparser over time. While managers of commonly owned firms may unilaterally engage in anticompetitive behavior, common ownership might also induce coordinated action. Economic theory predicts that communication can facilitate both coordination and monitoring defection from a common strategy.[52] While many forms of private communication are illegal, public information disclosure could serve as an alternative coordinating and monitoring mechanism to achieve tacit collusion, as suggested by, for example, Organization for Economic Cooperation and Development.[53] Indeed, Pawliczek, Skinner, and Zechman find that higher horizontal shareholding levels increase firm disclosures of information that can help firms to coordinate.[54]

Rock and Rubinfeld provide a summary of how common ownership has an impact on coordinated effects; we provide some elements of that discussion here.[55] A key issue is how ownership structure can affect the likelihood that a coordinated outcome will be achieved, that is, the relevant question is how common shareholders can have an influence in coordinating outcomes. This article discusses a variety of ways in which a common owner will be more conducive to collusion, by being, for example, a better "cartel ringmaster" or "cartel initiator." On the other hand, there are also a variety of ways in which a common owner can be a poorer cartel organizer than a noncommon owner.

Among generics, where we find sparse networks of common ownership, a large cartel operating between the years of 2006 and 2016 is currently being investigated.[56] It may thus be that, in the pharmaceutical industry, common ownership and explicit collusion are substitutes. However, we should be very careful when making this connection: the generic pharmaceutical industry has a number of other characteristics that make cartels more likely: homogenous products and frequent interaction at industry trade fairs.

Conclusion

This article documents the common ownership networks between companies that operate in U.S. pharmaceutical markets during the period 2004–2014. We show that common ownership networks between brand companies are rather dense and complete, especially at the end of our sample.

51. Henry G. Grabowski & John M. Vernon, *Brand Loyalty, Entry, and Price Competition in Pharmaceuticals after the 1984 Drug Act*, 35 J.L. & Econ. (1992); Junichi Suzuki, *Land Use Regulation as a Barrier to Entry: Evidence from the Texas Lodging Industry*, 54 Int'l Econ. Rev. 495 (2013).
52. *See* Margaret C. Levenstein & Valerie Y. Suslow, *What Determines Cartel Success?* 44 J. Econ. Lit. 43 (2006); George J. Stigler, *A Theory of Oligopoly*, 72 J. Pol. Econ. 44 (1964).
53. Organization for Economic Cooperation and Development, 2012. Unilateral disclosure of information with anticompetitive effects, http://www.oecd.org/daf/competition/Unilateraldisclosureofinformation2012.pdf.
54. Andrea A. Pawliczek et al., *Facilitating Tacit Collusion: A New Perspective on Common Ownership and Voluntary Disclosure* (Working paper, 2019), https://ssrn.com/abstract=3382324.
55. Edward B. Rock & Daniel L. Rubinfeld, *Common Ownership and Coordinated Effects* 83 Antitrust L.J. 201 (2020).
56. Christopher Rowland, *Investigation of Generic 'Cartel' Expands to 300 Drugs*, The Washington Post, Dec. 10, 2018, https://www.washingtonpost.com/business/economy/investigation-of-generic-cartel-expands-to-300-drugs/2018/12/09/fb900e80-f708-11e8-863c-9e2f864d47e7_story.html.

Furthermore, the common ownership links between brand and generic companies have become notably stronger.

While there is little direct evidence yet how these common ownership networks might impact competition and innovation in pharmaceutical markets (with the notable exception of the impact on generic entry), the presence of large institutional investors in the industry is so widespread that it would be hard to believe that they have no material impact. The further investigation of their influence in pharmaceutical markets is an exciting topic for future research.

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