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https://pubsonline.informs.org/journal/mnsc

MANAGEMENT SCIENCE
Vol. 71, No. 5, May 2025, pp. 3713–3733
ISSN 0025-1909 (print), ISSN 1526-5501 (online)

Innovation: The Bright Side of Common Ownership?

Miguel Antón,[a] Florian Ederer,[b,c,d,e,*] Mireia Giné,[a,c,d,f] Martin Schmalz[c,d,g,h,i]

[a] IESE Business School, 08034 Barcelona, Spain; [b] Questrom School of Business, Boston University, Boston, Massachusetts 02215; [c] Centre for Economic Policy Research (CEPR), London EC1V 0DX, United Kingdom; [d] European Corporate Governance Institute (ECGI), 1000 Brussels, Belgium; [e] National Bureau of Economic Research (NBER), Cambridge, Massachusetts 02138; [f] WRDS, Philadelphia, Pennsylvania 19104; [g] University of Oxford Saïd Business School, Oxford OX1 1HP, United Kingdom; [h] CESifo, 81679 Munich, Germany; [i] C-SEB, 50923 Cologne, Germany

*Corresponding author

Contact: manton@iese.edu (MA); ederer@bu.edu, https://orcid.org/0000-0002-3018-7908 (FE); mgine@iese.edu (MG); martin.schmalz@sbs.ox.ac.uk (MS)

Received: January 4, 2024
Revised: February 27, 2024
Accepted: April 18, 2024
Published Online in Articles in Advance: August 16, 2024

https://doi.org/10.1287/mnsc.2024.04363

Abstract. Firms have inefficiently low incentives to innovate when other firms benefit from their inventions and the innovating firm therefore does not capture the full surplus of its innovations. We show that, in theory, common ownership of firms mitigates this impediment to corporate innovation. By contrast, without technological spillovers, innovation has the effect of stealing market share from rivals and in that case more common ownership reduces innovation. Empirically, the association between common ownership and innovation inputs and outputs decreases with product market proximity and increases with technology proximity. The sign and magnitude of the overall relationship between common ownership and corporate innovation thus varies considerably across the universe of firms depending on their relative proximity in technology and product market space. Some of these results persist if we use only variation from BlackRock's acquisition of BGI. Our findings inform the debate about the welfare effects of increasing common ownership among U.S. corporations.

History: Accepted by Joshua Gans, business strategy.
Funding: The authors acknowledge grant funding from the Washington Center for Equitable Growth. M. Antón acknowledges the financial support of the Department of Economy and Knowledge of the Generalitat de Catalunya [Ref. 2014 SGR 1496] and the Ministry of Science, Innovation, and Universities [Ref. PGC2018-097335-A-I00]. M. Schmalz acknowledges funding from Deutsche Forschungsgemeinschaft under Germany's Excellence Strategy [EXC 2126/1-390838866].
Supplemental Material: The online appendix and data files are available at https://doi.org/10.1287/mnsc.2024.04363.

Keywords: common ownership • innovation • competition • R&D

1. Introduction

Two secular trends have recently led to a spirited discussion among academics and policy makers regarding the competitiveness of the U.S. economy. First, increasing levels of product market concentration, as measured at the national industry level, have been accompanied by increasing profitability, a decline of the labor share of income, rising inequality, declining business dynamism, and, perhaps most importantly, declining innovation.[1] Second, in addition to rising product market concentration and declining innovation, common ownership has also increased: firms are increasingly commonly owned by a decreasing number of institutional investors.[2] For example, Softbank's Vision Fund attracted the attention of a number of competition authorities by acquiring large stakes in rivals in the ride-hailing industry and exerting its influence to effectuate a lessening of competition in an alleged attempt to "dominate ride-hailing" (The Economist 2018). As a result, competition authorities have begun investigations to study the competitive effects of common ownership of industry competitors by mutual funds, hedge funds, and other types of investment vehicles (e.g., Berkshire Hathaway) that pool resources from a large number of investors but concentrate control over portfolio firms in a few asset management firms.[3] Although much attention has focused on the empirical investigation of anticompetitive effects of common ownership, much less work has been devoted to its procompetitive and potentially welfare-enhancing role.

In this paper we investigate, both theoretically and empirically, how corporate innovation depends on common ownership. In our model, the sign and the magnitude of the common ownership effect on corporate innovation vary with the relative importance of technological spillovers and business stealing repercussions of innovative activity. We show empirically that the sign and magnitude of the relationship between common ownership and innovation varies considerably across the universe of publicly listed U.S. corporations, in line with the theory's predictions. These findings inform a debate about the welfare effects of common ownership.

We begin our analysis by introducing common ownership in a canonical model of (process) innovation and strategic competition with both technology and product market spillovers between firms. Our model allows for product differentiation, technology spillovers, and common ownership to vary across all firm pairs. This permits us to study common ownership links between firms across the entire economy rather than just in a single industry. In the presence of technological spillovers, innovation in one firm not only generates benefits in the firm that produced the innovation but also in technologically related firms. This surplus appropriability problem leads to inefficiently low ex ante incentives to innovate (Bolton and Harris 1999, Jones and Williams 2000, Arora et al. 2021). Common ownership of technologically related firms mitigates this problem to the extent that firms act in the interest of these common owners. Common ownership can even render innovative activity profitable that would be unprofitable if it only benefited the innovating firm itself. Prior literature has suggested such beneficial knowledge transfers predominantly in the context of private firms (Lindsey 2008, Eldar et al. 2020, González-Uribe 2020) or among investors (Stein 2008, Botelho 2018), whereas we focus on the corporate innovation activities of the universe of U.S. public firms.

However, there is a second dimension affecting the firm's innovation decisions: the interaction between innovation and product market competition. Innovations resulting from R&D expenditures naturally lead to the innovator stealing market share and profits from firms competing in the same or related product markets (Bloom et al. 2013). When the competitors are predominantly owned by separate groups of shareholders, this procompetitive effect of innovation is desirable for the innovating company's shareholders. However, when the same shareholders own both the innovator and its product market competitors, such business stealing is less desirable.[4] Hence, common ownership can reduce the incentives to innovate when the business stealing effect is stronger than the aforementioned technological spillover effect.[5] Our theoretical framework combines both of these effects and provides conditions that determine which one of them dominates.

Including both dimensions is of first-order importance for understanding the overall effect of common ownership on innovation not just in the theory but also in our empirical implementation. To illustrate, Table 1 reports the ownership shares of four technology firms (IBM, Intel, Motorola, and Apple) that are technologically related but compete to a varying extent in the same product markets. First, the four companies are closely technologically related over the sample period. The technological proximity, as measured by firms' patent issuances across different patent classes in Bloom et al. (2013), between IBM-Intel, IBM-Motorola, and IBM-Apple are 0.76, 0.46, and 0.64, respectively—which is much larger than the sample average of 0.038. Product market proximity, as measured by firms' sales shares in different industries in Bloom et al. (2013), is more heterogeneous across these firm pairs. Whereas IBM is close to Apple in product market space (product market proximity of 0.65 compared with the sample average of 0.015), IBM is not close to Intel and Motorola (product market proximity of 0.01).

As shown in Table 1, these four firms also have a significant degree of common ownership, particularly toward the end of our sample period in 2015. BlackRock, Vanguard, and State Street are all represented among the top owners of each of the four companies. However, the large concentrated blockholdings by Berkshire Hathaway and ValueAct illustrate that common ownership interests are heterogeneous and asymmetric across firms. Therefore, the degree of common ownership between firms may differentially affect their innovation decisions as a function of the firms' technological and product market proximity. Our central theoretical prediction is that the effect of common ownership on innovation depends on firms' relative proximity in technology and product market space and can vary both in terms of sign and magnitude.

Whether the theoretical predictions about the relationship between common ownership and innovation are helpful in organizing the data is a question that requires more than just anecdotal evidence. We find first suggestive evidence in panel regressions that both effects exist with the predicted sign and that they lead to substantial heterogeneity of the relationship between common ownership and innovation across firms. We also find limited evidence from a quasi-natural experiment that the uncovered correlations may have a causal interpretation. Specifically, we use the methodology pioneered by Bloom et al. (2013), Hoberg and Phillips (2016), and Lucking et al. (2019) to measure technology and product market spillovers. We combine these data with information about the ownership of firms, in particular to which extent the largest owners of one firm also hold shares in other firms using the "kappa" measure advocated by Backus et al. (2021). Using panel regressions, we find an ambiguous relationship *on average* between common ownership and corporate innovation as measured by innovation inputs (scaled research and development (R&D) expenditures) and innovation outputs (citation-weighted number of patents and total stock market value of patents). However, throughout all our specifications, innovation is more positively related to common ownership when technological proximity is higher, whereas more common ownership is associated with less innovation when product market proximity is greater. As a result—and as predicted by our theory—

Table 1. Ownership Holdings and Technology and Product Market Correlations of Four High Technology Firms

IBM	*[%]*	***Intel***	*[%]*
Berkshire Hathaway	8.35	BlackRock	6.14
Vanguard	6.06	Vanguard	6.00
State Street	5.12	Capital Research	5.56
BlackRock	5.06	State Street	3.98
State Farm	1.72	Wellington	2.18
BNY Mellon	1.46	Northern Trust	1.26
Fidelity	1.29	UBS	1.10
Northern Trust	1.14	Harris Associates	1.09
Norges Bank	0.94	BNY Mellon	1.01
Geode Capital	0.75	Norges Bank	0.96

IBM–Intel: **0.76** / 0.01
IBM–Apple: **0.64** / 0.65
Intel–Motorola Solutions: **0.46** / 0.34
IBM–Motorola Solutions: **0.46** / 0.01
Intel–Apple: **0.47** / 0.00

Motorola Solutions	*[%]*	***Apple***	*[%]*
ValueAct	10.11	Vanguard	5.79
BlackRock	8.67	BlackRock	5.65
Capital Research	7.93	State Street	3.90
Orbis	7.61	Fidelity	2.79
Vanguard	5.31	Northern Trust	1.27
Parnassus Investments	4.97	BNY Mellon	1.22
State Street	3.83	T. Rowe Price	0.90
Metropolitan West	2.26	Norges Bank	0.86
Janus Capital	2.09	Invesco	0.85
Neuberger Berman	2.06	J.P. Morgan	0.84

Motorola Solutions–Apple: **0.17** / 0.02

Notes. The table presents the 10 largest owners and their ownership holdings in 2015 of the four technology companies (IBM, Intel, Motorola, and Apple) discussed in the text. The arrows between each of the company pairs depict the technology (black) and product market (red) correlations reported in Bloom et al. (2013).

common ownership and corporate innovation are positively related when technology proximity spillovers are large relative to product market business stealing incentives and are negatively related otherwise. However, the relationship between common ownership and innovation varies considerably across the publicly listed firms depending on the relative strength of product market and technology spillovers. Specifically, a one-standard-deviation increase in common ownership is associated with a *decrease* in innovation for about half the firms (i.e., firms with relatively high product market spillovers to other commonly owned firms). In contrast, for the other half of firms for which technology spillovers to other commonly owned firms are relatively large, the same increase in common ownership is associated with an *increase* in innovation.

Finally, when we shock the interaction between common ownership and technological proximity using the BlackRock-BGI acquisition, we find limited evidence of a causal effect of common ownership on innovation outputs (citation-weighted patents and stock market value of patents) but not on innovation inputs, perhaps consistent with the rationale advanced in Li et al. (2022) who find that common venture capital (VC) owners tend to hold back projects, withhold funding, and redirect innovation at lagging startups. We do not find robust causal evidence of a negative effect of common ownership between product market rivals on innovation. Overall, whether the uncovered empirical relationships have a causal interpretation and thus whether common ownership is indeed a bright side of common ownership remains an open question. We discuss the implications of our results for antitrust and innovation policy.

Given that incentives to compete are tightly linked to incentives to innovate (D'Aspremont and Jacquemin 1988, Hoskisson et al. 2002, Aghion et al. 2005, Bloom et al. 2013), our paper lies at the intersection of corporate innovation, corporate strategy, and corporate governance. The extant literature focuses on the potential benefits of cooperative R&D, on how innovation is affected by mergers, or how it relates to institutional ownership.[6] One of this literature's primary objectives is to examine the underinvestment of R&D and the welfare effects of moving from a noncooperative to a cooperative regime in R&D. For example, Kamien et al. (1992) identify conditions under which a cartelized research joint venture (RJV) is optimal. Leahy and Neary (1997) show that R&D cooperation leads to more output, innovation, and welfare when spillovers are positive. We adopt these canonical models of innovation and product market competition and re-examine their conclusions in light of the fact that firms with different names do not necessarily have disjoint sets of investors.

The most closely related paper to our own analysis is Bloom et al. (2013), who study the effect of product market and technology proximity on innovation and provide economy-wide empirical evidence for the importance of both effects, but without considering the role of common ownership. They estimate the extent of spillovers in a panel of U.S. firms from 1981 to 2001 and find that gross social returns to R&D are at least twice as high as the private returns. Their results imply that the internalization of those technological spillovers is a matter of first-order welfare importance.[7] We demonstrate that common ownership can internalize product market and technology externalities between the firms and thereby significantly affect the level and heterogeneity of corporate innovation. Our paper is also related to López and Vives (2019) who theoretically study the effect of (symmetric and identical) common ownership on innovation of several symmetric industry competitors.[8] In their model, all firms are symmetric, compete in the same industry, and produce undifferentiated products. Technology spillovers and common ownership shares are identical between them. In contrast, our model allows for common ownership of firms in the entire economy, including potentially in separate industries. To reflect that greater scope, we allow for product differentiation, technology spillovers, and common ownership to vary across firms. These generalizations are crucial to predict and understand the variation of the effect of common ownership on innovation found in the data.

Several recent contributions provide distinct empirical investigations of the relationship between various measures of common ownership and innovation. Our analysis differs from all of them in that it uses a theoretical model that guides our empirical design and informs the interpretation of our results. Our analysis may help explain the substantial variation in the sign and magnitude of common ownership effects on innovation across these different papers. Li et al. (2022) study common venture capital ownership of pharmaceutical startups and find evidence suggesting that common ownership improves innovation efficiency. In contrast to their work, we focus on a broad sample of public firms. He and Huang (2017) examine the question of whether common *blockholders* have an effect on corporate innovation on average. In contrast, we study the entire institutional ownership structure of the firm and examine whether the degree of technology proximity and product market proximity differentially affect the relationship between common ownership and innovation. Kostovetsky and Manconi (2020) show that increases in shared institutional ownership caused by index additions are followed by more citations of the patents of the firm that was added to the index. Borochin et al. (2020) provide evidence that the sign of the relationship between patent output, nonself citations, and common ownership depends on the type of institutional owner creating the common ownership link. Chiao et al. (2020) argue that common ownership as measured by the industry-level modified Herfindahl-Hirschman index delta (MHHID) in a sample ending in 2008 is on average negatively related to patent grants, citations, and R&D expenditures. They also find that common ownership is negatively associated with the likelihood that firms are involved in patent litigation and positively related to the speed of the settlement of lawsuits between commonly owned firms. The empirical evidence of Geng et al. (2016) suggests that common ownership can mitigate hold-up problems between firms owning complementary patent portfolios. However, the strength of the effect depends on the type of institutional owner. Finally, using a pan-European sample, Gibbon and Schain (2021) find that common ownership (as measured by MHHID calculated at the three-digit industry and country level) is related to citation-weighted patents in high technology industries, whereas common ownership is related to markups in low technology industries. One limitation of our paper remains that we are unable to address asymmetries in innovation spillovers as in Knott et al. (2009) because our innovation spillover measures are, by construction, symmetric.

The remainder of this paper is organized as follows. Section 2 presents the theoretical framework that guides the empirical analysis. Section 3 describes the data. The empirical results are presented and discussed in Section 4. Section 5 concludes.

2. Theoretical Framework

2.1. Setup

We analyze the role of common ownership and its interplay with product market and technological proximity in the canonical model of innovation and product market competition pioneered by D'Aspremont and Jacquemin (1988). We use the terms proximity and spillover interchangeably but prefer proximity. This is to acknowledge that the proximity measure really proxies for the *potential* for actual spillovers rather than realized spillovers. By doing so, we also extend the model of Bloom et al. (2013), which studies the effect of product market and technology spillovers on innovation, to allow for overlapping ownership between firms. Our theoretical setup is also related to the model of López and Vives (2019) that studies the interplay between innovation and common ownership, but we allow for both product market and technology spillovers, as well as common ownership weights to differ across firms.

Firms' innovation choices, product quantities, prices, and profits are endogenously codetermined by the degree of common ownership and product market and technological spillovers. In line with the existing literature on common ownership, we assume that ownership is exogenous.

2.1.1. Product Market Competition. Consider an economy with n firms that each produce a single differentiated product. There are no industries per se, but all firms compete with each other depending on how closely related their products are. In our model, the welfare-enhancing effects of common ownership are due to economy-wide horizontal and vertical externalities that arise from technology spillovers. Although strictly speaking, we present a partial equilibrium model, all our insights regarding the impact of common ownership under different technology and product market spillovers also hold in a general equilibrium model.[9]

Following Singh and Vives (1984) and Häckner (2000), we derive demand from the behavior of a representative consumer with the following quadratic utility function:

$$U(\mathbf{q}) = A\sum_{i=1}^{n} q_i - \frac{1}{2}\left(a_{ii}\sum_{i=1}^{n} q_i^2 + 2\sum_{i\neq j} a_{ij}q_iq_j\right), \quad (1)$$

where q_i is the quantity of product i, $\mathbf{q} = (q_1, \ldots, q_n)$ is the vector of all quantities, $A > 0$ represents overall product quality, $a_{ii} > 0$ measures the concavity of the utility function, and a_{ij} represents the degree of substitutability between two differentiated products i and j; $a_{ii} > a_{ij} \geq 0$ ensures that the products are (imperfect) substitutes. Without loss of generality and to simplify notation, we set $a_{ii} = 1$. The higher the value of a_{ij}, the more alike the products are. The resulting consumer maximization problem yields linear demand for each product i, such that the firms face symmetric inverse demand functions given by

$$p_i(\mathbf{q}) = A - q_i - \sum_{j\neq i}^{n} a_{ij}q_j, \quad (2)$$

where $i = 1, 2, \ldots, n$. Because $1 > a_{ij} \geq 0$, a firm's quantity q_i has a greater impact on the price p_i for its own product than the quantity of any other firm q_j.[10] The parameter a_{ij} measures product homogeneity or product market spillovers. Given the symmetry of the empirical measure of product market spillovers (Bloom et al. 2013) that we describe in Section 3, we assume that this parameter is symmetric between firm i and j, $a_{ij} = a_{ji}$. If a_{ij} is small, the products of firm i and j are quite distinct and thus expanding output q_i (or lowering price p_i) does not steal much market share from the competing firm j. Conversely, if a_{ij} is large the product varieties produced by the firms are quite similar and thus business stealing is more pronounced.

2.1.2. Innovation. Following the extant theoretical literature on innovation (D'Aspremont and Jacquemin 1988, Kamien et al. 1992, Leahy and Neary 1997, López and Vives 2019), we model corporate innovation as decreasing marginal cost. This particular modeling choice ensures tractability. One could also model innovation as increasing product quality that would yield qualitatively similar results. However, as in much of the existing innovation literature, we only focus on the intensity of innovation but do not consider the direction of innovation, which is the focus of Letina (2016), Bryan and Lemus (2017), and Callander and Matouschek (2021). Common ownership may also influence which innovation projects firms choose to pursue.

Firm i has a marginal cost of c_i given by

$$c_i = \bar{c} - x_i - \sum_{j\neq i}^{n} \beta_{ij}x_j. \quad (3)$$

Firm i can lower its marginal cost from $\bar{c}$ by investing in innovation x_i at a cost $\frac{\gamma}{2}x_i^2$. A firm's marginal costs are also reduced by the innovative investments of other firms x_j, to the extent that these investments benefit firm i because of technological spillovers captured by $0 \leq \beta_{ij} < 1$. This means that a firm i's investment in innovation reduces its own marginal cost c_i and to a lesser extent may also reduce the marginal cost c_j of firm j. Given the construction of the empirical measure of technological spillovers (Bloom et al. 2013), we assume that this parameter is symmetric, $\beta_{ij} = \beta_{ji}$. These technological spillovers are not confined within the same industry or even just to firms that produce relatively similar substitute products. Innovation benefits can spill over to technologically related firms (i.e., $\beta_{ij} > 0$) that produce goods that are entirely unrelated in terms of product market competition (i.e., $a_{ij} = 0$). The example mentioned in the introduction of IBM and its relationship to Intel and Motorola, which are close in technology space but not in product market space, fits this case quite well.

The profits of firm i are given by

$$\pi_i = q_i\left[A - q_i - \sum_{j\neq i}^{n} a_{ij}q_j - \left(\bar{c} - x_i - \sum_{j\neq i}^{n} \beta_{ij}x_j\right)\right] - \frac{\gamma}{2}x_i^2. \quad (4)$$

Firms choose quantities q_i and innovation levels x_i simultaneously. We obtain qualitatively similar results when firms invest in innovation before choosing quantities (or prices).

2.1.3. Owners. There are n owners which share the same index as the n firms. Each owner i owns a stake in firm i as well as shares in other firms denoted by $j \neq i$. We assume firms act in their largest owners' interest.[11] Our model nests the special case in which firms maximize their own profits.[12]

Specifically, we follow the common ownership literature starting with Rotemberg (1984) and assume that firms maximize a weighted average of their shareholders' portfolio profits. Azar (2012) and Backus et al. (2021) show that firm i's maximization problem can be restated as

$$\phi_i = \pi_i + \sum_{j \neq i} \kappa_{ij} \pi_j, \tag{5}$$

where κ_{ij} is the weight that firm i places on the profits π_j of firm j. Its exact value depends on the type of ownership and corresponds to what Edgeworth (1881) termed the coefficient of effective sympathy among firms. In fact, even before the common ownership literature there is a long tradition in economics of weighting shareholder interests in the objective function of the firm, including Drèze (1974) and Grossman and Hart (1979). We assume that the profit weight κ_{ij} is between zero (separate ownership) and one (perfectly common ownership). In contrast to a_{ij} and β_{ij}, we do not assume that κ_{ij} is symmetric between any firm pair i and j, that is $\kappa_{ij} \neq \kappa_{ji}$ in general.

We use the κ notation of Backus et al. (2021), which is equivalent to λ in Azar (2012), López and Vives (2019), and Azar and Vives (2021). Values of κ exceeding one are possible, but they lead to owners placing more weight on their competitors' profits than on their own profits. This would make it possible for common ownership to create incentives for the "tunneling" of profits from one firm to another (Johnson et al. 2000). By maximizing Equation (5), the owner of firm i essentially maximizes a weighted average of the profits of firm i and other firms in the portfolio.

2.2. Analysis and Comparative Statics

We now analyze the differential impact that common ownership has on corporate innovation that depends on both product market and technological spillovers. Firm i's first-order conditions with respect to quantity q_i and innovation x_i can be rearranged to yield the following best-response functions

$$q_i = \frac{1}{2}\left[A - \left(\bar{c} - x_i - \sum_{j \neq i}^{n} \beta_{ij} x_j\right) - \sum_{j \neq i}^{n} a_{ij} q_j - \underbrace{\sum_{j \neq i}^{n} \kappa_{ij} a_{ji} q_j}_{\text{CO} \times \text{product market spillovers}}\right], \tag{6}$$

$$x_i = \frac{1}{\gamma}\left(q_i + \underbrace{\sum_{j \neq i}^{n} \kappa_{ij} \beta_{ji} q_j}_{\text{CO} \times \text{technology spillovers}}\right), \tag{7}$$

where given our symmetry assumptions $a_{ij} = a_{ji}$ and $\beta_{ij} = \beta_{ji}$.

Firm innovation x_i is directly proportional to firm quantity q_i such that any increase in quantity q_i will also increase innovation x_i. These first-order conditions illustrate the driving forces of our model. When common ownership κ_{ij} increases, this has two distinct effects on firm i's first-order conditions.

First, in Equation (6), an increase in κ_{ij} reduces q_i through the interaction of common ownership and product market spillovers (i.e., the term labeled "CO × product market spillovers") and thereby reduces innovation x_i in Equation (7). This is the anticompetitive effect of common ownership arising from product market spillovers. Effectively, increasing innovation x_i causes firm i to steal business from any firm j that is selling a substitute product. This well-known business stealing effect of innovation will be larger the greater the product homogeneity (also known as the degree of product market spillovers) a_{ij}. The more closely related the products are, the larger will be the negative profit impact of an increase in quantity on other firms. Common ownership exacerbates this negative effect of product market similarity a_{ij} on output and innovation, because common ownership weakens the firm's business stealing incentive. The reason is that when a firm's objective function puts positive weight κ_{ij} on other firms' profits π_j, firm i will partly internalize any negative profit repercussions on these other firms by reducing innovation x_i and quantity produced q_i.

Second, in Equation (7), an increase in κ_{ij} directly increases innovation. When firm i innovates, it benefits other firms $j \neq i$ by lowering their marginal costs c_j. This is the procompetitive effect of common ownership arising from technological spillovers (i.e., the term labeled "CO × technology spillovers"). The greater the technological proximity β_{ij} between the two firms, the larger is this technology spillover effect. This is because firm j that is more closely located in technology space to firm i will benefit more from the firm i's innovation. Common ownership strengthens this technology spillover effect because with a positive weight κ_{ij} in its objective function, firm i partly internalizes the positive externality of innovation on other firms $j \neq i$ that it would otherwise ignore. This output-increasing technology spillover effect is still present when the firms have no product market connection ($a_{ij} = 0$). In graphical terms, an increase in κ_{ij} tilts the innovation reaction function of firm i inward due to the product market spillovers operating through a_{ji} but shifts it outward due to the technology spillovers operating through β_{ji}.

It is immediately obvious that the effect of common ownership on innovation has an ambiguous sign: It can be either positive or negative depending on the relative strength of the product market and technology spillovers. If $a_{ij} = 0$ (i.e., product market spillovers are absent) any increase in common ownership κ_{ij} will raise firm innovation x_i due to technological spillovers $\beta_{ij} \geq 0$. Conversely, if $\beta_{ij} = 0$ (i.e., technological spillovers do not exist), any increase in κ_{ij} will decrease firm innovation x_i due to product market spillovers $a_{ij} \geq 0$.

We can rewrite the system of first-order conditions given in Equations (6) and (7) in the following way:

$$(\mathbf{a} + \mathbf{K} \circ \mathbf{a}')\mathbf{q} = (A - \bar{c}) \cdot \mathbf{1} + \mathbf{B}\mathbf{x}$$
$$(\mathbf{K} \circ \mathbf{B}')\mathbf{q} = \gamma \mathbf{x},$$

where $\circ$ is the Hadamard (element-by-element) product, $\mathbf{1}$ is an $n \times 1$ vector of ones, $\mathbf{a}$ is the product similarity matrix, $\mathbf{B}$ is the technology spillover matrix, and $\mathbf{K}$ is the common ownership matrix. The matrices $\mathbf{a}$, $\mathbf{B}$, and $\mathbf{K}$ are defined as follows:

$$\mathbf{a} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} 1 & \beta_{12} & \cdots & \beta_{1n} \\ \beta_{21} & 1 & \cdots & \beta_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \beta_{n1} & \beta_{n2} & \cdots & 1 \end{bmatrix},$$
$$\mathbf{K} = \begin{bmatrix} 1 & \kappa_{12} & \cdots & \kappa_{1n} \\ \kappa_{21} & 1 & \cdots & \kappa_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \kappa_{n1} & \kappa_{n2} & \cdots & 1 \end{bmatrix}.$$

Defining $\mathbf{K_a} = \mathbf{a} + \mathbf{K} \circ \mathbf{a}'$ and $\mathbf{K}_\beta = \mathbf{K} \circ \mathbf{B}'$ and substituting the second system of first-order conditions into the first system yields the vector of equilibrium innovation choices $\mathbf{x}^*$ given by

$$\mathbf{x}^* = \begin{bmatrix} x_1^* \\ x_2^* \\ \vdots \\ x_n^* \end{bmatrix} = (A - \bar{c})[\gamma \mathbf{K_a} \mathbf{K}_\beta{}^{-1} - \mathbf{B}]^{-1} \cdot \mathbf{1}, \qquad (8)$$

where $\mathbf{1}$ is an $n \times 1$ vector of ones.

Proposition 1. *Common ownership κ_{ij} increases equilibrium firm innovation x_i^* if and only if technological spillovers β_{ij} are sufficiently large relative to product market spillovers a_{ij}. The effect of κ_{ij} on x_i^* is decreasing in a_{ij}, $\frac{\partial^2 x_i^*}{\partial \kappa_{ij} \partial a_{ij}} < 0$, and increasing in β_{ij}, $\frac{\partial^2 x_i^*}{\partial \kappa_{ij} \partial \beta_{ij}} > 0$.*

Proposition 1 shows that without knowledge of product differentiation and technological characteristics common ownership has an ambiguous effect on innovation. This insight may help explain some of the variation in empirical findings to date on the relation between common ownership and corporate innovation (Borochin et al. 2020, Kostovetsky and Manconi 2020, Chiao et al. 2021). These empirical designs do not make the distinctions that our theoretical framework predicts to be crucial for determining the sign of the effect of common ownership on innovation. Depending on the relative strengths of (i) the business stealing and (ii) the technology spillover effect, common ownership can either decrease or increase corporate innovation. However, our framework also predicts under what conditions common ownership has a negative or a positive effect on innovation. Common ownership should decrease innovation if a_{ij} is sufficiently large relative to β_{ij}, whereas common ownership should increase innovation if the opposite is the case. In other words, we expect common ownership to decrease (increase) innovation when product market spillovers are sufficiently large (small) and technology spillovers are sufficiently small (large).[13]

In our empirical implementation, we follow Bloom et al. (2013) and construct measures of firm-specific product market spillovers for $\sum_{j \neq i}^{n} a_{ji} q_j$ and of firm-specific technological spillovers for $\sum_{j \neq i}^{n} \beta_{ji} q_j$ which we interact with the firm-specific common ownership measure of κ_{ij} to estimate the pro- and anticompetitive effects of common ownership due to product market and technology spillovers highlighted in the first-order conditions (6) and (7).[14]

Importantly, once we control for the relative strength of product market and technology spillovers, the sign of the effect of common ownership on innovation is unambiguous and does not depend on whether firms compete in strategic substitutes or strategic complements. This is in contrast to the analysis in Bloom et al. (2013), where many of the predictions depend on the form of strategic competition. The reason for this difference is that common ownership has a "direct effect" (i.e., directly affecting the objective function) rather than a "strategic effect" (i.e., indirectly affecting it through the effect on decisions of other firms) as defined by Fudenberg and Tirole (1984). Hence, the sign of the common ownership effect on innovation does not depend on the sign of the strategic response of other firms.

Our predictions provide theoretical guidance for our empirical analysis. Specifically, they allow us to quantify whether and under what conditions common ownership should increase or decrease innovation and how product market and technology spillovers should affect this relationship.

3. Data

In this section, we investigate the empirical relationship between common ownership, product market competition, and innovation. Specifically, we are interested in how innovation inputs (e.g., R&D expenditures) and outputs (e.g., citation-weighted value of patents and stock market value of patents) depend on the extent to which a firm is controlled by shareholders that have significant stakes in related firms and on the extent to which the innovation spills over to neighboring firms in the product market and technology space. As in our theoretical framework, we study the economy-wide implications of common ownership and do not restrict ourselves to the study of any particular single industry. Unless otherwise stated, all the data used for our estimations are from 1985 to 2015. Table 2 provides an overview of our summary statistics for the key variables.

3.1. Measures of Innovation

To proxy for a firm's innovation x_i in our theoretical model, we construct empirical innovation measures, denoted by $INNOVATION_{it}$, based on firm-level patent grants and citations from the database built by Kogan et al. (2017). This database has additions and corrections to the NBER patent data built by Hall et al. (2001) from the official records of the U.S. Patent and Trademark Office (USPTO).[15]

To measure innovation inputs, we use $\ln(1+R_{it}/ASSETS_{it})$ where R_{it} is the level of inflation-adjusted R&D expenditures and $ASSETS_{it}$ are the total assets of firm i in year t as reported in Compustat. Because many firms report zero values for R&D expenditures in most years, we follow the standard in the literature and replaced missing R&D values with zeros, and included a dummy if R&D is zero (in the R&D regression), and a dummy if the stock of R&D is zero (in the *TCW* and *TSM*) regressions following Koh and Reeb (2015).

To measure innovation outputs, we rely on two different measures that capture the scientific and economic value of innovation, respectively. First, we use the number of citation-weighted patents TCW_{it} given by

$$TCW_{it} = \sum_{j \in P_{it}} \left(1 + \frac{C_j}{\overline{C}_j}\right), \tag{9}$$

where P_{it} denotes the set of patents issued to firm i in year t, C_j is the number of forward citations to patent j, and $\overline{C}_j$ is the mean number of citations to patents granted in the same year as patent j. The innovation literature has argued that forward patent citations are a good indicator of the quality of the innovation and its scientific value (Hall et al. 2001).

Second, we measure the private economic value of innovation (Hall et al. 2005, Kogan et al. 2017) as proxied by stock market reactions following a patent issuance. Specifically, we use the measure of Kogan et al. (2017) that estimates a firm i's stock market reaction ξ_j during the three-day announcement window following the issuance of the firm's patent j. Kogan et al. (2017) then sum up all the estimated values ξ_j of patents j that were granted to firm i in year t to construct the total stock market value of innovation TSM_{it} generated by firm i in year t:

$$TSM_{it} = \sum_{j \in P_{it}} \xi_j. \tag{10}$$

These two innovation outputs (forward patent citations and stock market value of patents) likely measure different aspects of quality. Whereas patent citations are more reflective of the scientific value of the innovation, the total stock market value measures the private economic value that is fully appropriated by the firm. For example, a patent may constitute only a minor scientific progress (and therefore generate few patent citations), but it

Table 2. Summary Statistics for Key Variables

Variables	Observations	Mean	Standard deviation	10%	50%	90%
Innovation variables						
R&D Expenditures	32,498	128.96	552.00	0.00	13.33	201.19
ln*(1+R&D/Assets)*	32,498	0.09	0.13	0.00	0.05	0.23
TCW (Citation weighted patents)	32,498	86.12	523.46	0.00	8.18	134.54
TSM (Total stock market value of patents)	32,498	1,001.35	5,346.86	0.00	14.79	1,283.06
Proximity measures						
ln*(SPILLTECH)*	32,498	11.74	0.99	10.65	11.98	12.63
ln*(SPILLHP)*	32,498	9.69	0.77	8.67	9.78	10.60
ln*(COSPILLTECH)*	32,133	9.56	1.94	7.03	9.95	11.51
ln*(COSPILLHP)*	32,142	7.71	1.68	5.57	7.95	9.52
Firm characteristics						
K/L (capital-labor ratio)	32,498	101.88	526.25	12.38	37.69	165.32
ln*(K/L)*	32,498	3.74	1.10	2.52	3.63	5.11
Sales	32,498	3,609.85	13,591.21	10.88	312.13	7,651.04
Institutional Ownership	32,498	0.53	0.28	0.11	0.55	0.88
Common ownership						
EW Kappa	32,498	0.16	0.15	0.02	0.12	0.35
VW Kappa	32,498	0.22	0.20	0.02	0.16	0.49

may be particularly successful at limiting competition thereby generating significant profits for the issuing firm.

3.2. Measures of Common Ownership

To construct the ownership variables, we use two sources of data: Thomson Reuters (institutional ownership in 13F) and Schwartz-Ziv and Volkova (2024) (blockholdings in 13D and 13G). The Thomson Reuters 13Fs are taken from SEC regulatory filings by institutions with at least $100 million total assets under management. We augment this data by scraping SEC 13F filings following Ben-David et al. (2021), which resolves the issues of stale and omitted institutional reports, excluded securities, and missing holdings from 2,000 onward.

We complement these institutional ownership data with blockholdings data from Schwartz-Ziv and Volkova (2024) because there are large, influential blockholders in many publicly listed U.S. firms. The presence of such blockholders might be correlated with ownership by 13F institutional investors in a systematic way and correlate with our outcome measures. For example, some 13F institutions might have a preference for or against firms with family blockholders, which may systematically differ in their approach to governance. Thus, incorporating both institutional and noninstitutional blockholders is important for the measurement of common ownership. We describe the precise construction of the common ownership variables from these data in the following section.

A limitation implied by this data source is that we do not observe the holdings of individual owners unless they are employed as officers of the company or serve on its board, in which case we complement these data with Execucomp. We assume that the remaining individual stakes of outsiders are relatively small and that in most cases they do not directly exert a significant influence on firm management. The arising inaccuracies introduce measurement error and an attenuation bias toward zero in our regressions.

To identify how common ownership influences the relationship between product market competition, technology spillovers, and innovation, we require a measure of common ownership. The existing literature provides several candidate measures of common ownership, the first of which is closely linked to the theoretical literature on common ownership, including our own model.

From Equation (5), recall that the objective function of firm i is given by

$$\phi_i = \pi_i + \sum_{j \neq i} \kappa_{ij} \pi_j,$$

where κ_{ij} is the weight that firm i places on firm j's profits, π_j. The weighted sum of these profit weights κ_{ij} across all the potential product market competitors of firm i is the principal object of interest in the common ownership hypothesis (Backus et al. 2021). Our main measure of common ownership is κ_{ij} between any firm pair i and j across the entire economy. We refer to the equal- or value-weighted average of the weights that the owners of firm i place in year t on the profits of the $n-1$ other firms in the economy as $\overline{\kappa}_{it}$ or simply "kappa." More formally,

$$\overline{\kappa}_{it} = \frac{1}{n-1} \sum_{j \neq i} \kappa_{ij,t} \quad \text{or} \quad \overline{\kappa}_{it} = \frac{1}{\sum_{j \neq i} \omega_{jt}} \sum_{j \neq i} \kappa_{ij,t} \omega_{jt}, \tag{11}$$

where the weighting ω_{jt} is the stock market value of firm j in year t. As in our theoretical model, we exclude from our empirical analysis the small fraction of observations where $\overline{\kappa}_{it}$ exceeds one because these observations are indicative of incorrect or missing ownership data (Backus et al. 2021). Our results are essentially unchanged if we include these observations.

3.3. Measures of Technological and Product Market Proximity

For our analysis, we require two distinct measures of technological proximity and product market proximity between firms. For technological proximity, we follow Bloom et al. (2013) and Lucking et al. (2019) and use the overlap in patents between each pair of firms in particular technology classes denoted by $TECH_{ij}$. $TECH_{ij}$ empirically proxies the degree of technological spillovers β_{ij}. For product market proximity, we rely on the product cosine similarity measure of Hoberg and Phillips (2016), which is based on product descriptions in the Business Description section of 10-K statements. These pairwise cosine similarities which we denote by HP_{ij}, proxy for the degree of product market spillovers a_{ij} between a pair of firms in our model. We briefly explain the specific construction of these measures below. For a thorough discussion including microeconomic foundations, see Bloom et al. (2013) and Hoberg and Phillips (2016). Following Bloom et al. (2013), we construct the $TECH_{ij}$ measure using both the Jaffe and the Mahalanobis proximity. The HP_{ij} measure is only available as a cosine similarity.

Denote the vector of the share of patents of firm i in any given technology class by T_i. $TECH_{ij}$ is the uncentered correlation between all firm i, j pairings and closely corresponds to the β_{ij} parameter in our model. Following Jaffe (1988), this measure is defined as

$$TECH_{ij} = \frac{T_i T_j'}{(T_i T_i')^{1/2} (T_j T_j')^{1/2}}. \tag{12}$$

To avoid a look ahead bias we need to ensure that a patent granted after year t is not used in a regression before t. We therefore compute a $TECH_{ij}$ matrix for each year, using patent data only up to that year. However, our results continue to hold when we compute the $TECH_{ij}$ matrix using patents from all years.

Importantly, we compute each $TECH_{ij}$ measure by allowing patents with multiple classifications. Instead of only using the first classifications, we use all classifications to better reflect the uses of the patents. The data source on patents from Kogan et al. (2017) that classifies them according to the Cooperative Patent Classification (CPC)[16] does not give more weight to one class than another for a given patent. Hence, we use them equally. If patent A is categorized in two classes (e.g., class B1 and B2), we count for that company one patent in class B1 and one patent in class B2. Using multiple classifications in our analysis is important because 50% of the patents have at least three classifications and 25% have more than six.[17]

To build each $TECH_{ij}$ measure we use the section/class/subclass/group, but we do not use information on subgroup. This provides sufficient detail for each patent and avoids having very little overlap between patents of different companies which would result in a $TECH_{ij}$ matrix full of zeros.

Following Bloom et al. (2013) and Lucking et al. (2019), we also construct an alternative version of $TECH_{ij}$ using the Mahalanobis proximity metric that we denote by $TECH_{ij}^M$. This measure allows for spillovers between different technology classes. In contrast, such spillovers across technology classes are ruled out by the Jaffe metric that assumes full spillovers within the same class or industry and no spillovers otherwise. Complete detail on the definition and construction of the Mahalanobis measures is included in the online appendices of Bloom et al. (2013) and Lucking et al. (2019).

The Mahalanobis $TECH_{ij}^M$ measure quantifies spillovers across technology class by using revealed preference. If two technologies are often located together in the same firm (for example, computer input/output and computer processing), then proximity will be greater. The share of times the two technology classes are patented within the same firm proxies for this proximity.

We then construct the pool of technology spillovers for firm i in year t, $SPILLTECH_{it}$ as follows:

$$SPILLTECH_{it} = \sum_{j \neq i} TECH_{ij} G_{jt}, \tag{13}$$

where G_{jt} is the weighted stock of R&D of firm j given by

$$G_{jt} = 0.85 G_{jt-1} + RRD_{jt}, \tag{14}$$

where RRD_{jt} are real $R\&D$ expenditures adjusted for inflation.

The $SPILLHP_{ij}$ measure comes from Hoberg and Phillips (2016) and is the cosine similarity of the words contained in the Business Description section of 10-K statements. Hoberg and Phillips (2016) build a vocabulary of 61,146 words that firms use to describe the characteristics of their products. Based on this vocabulary they produce for each firm i a vector of word frequencies where each entry of the vector corresponds to the number of times a word appears in firm i's product description. $SPILLHP_{ij}$ is the cosine similarity between firm i and j and ranges between zero (no overlap in word frequencies) and one (perfect overlap). Hoberg and Phillips (2016) show that these cosine similarity correctly identify industry groupings and predict competitive relationships between firms much better than other industry classifications. A demand model based on these cosine similarities also generates substitution patterns that closely fit those obtained from industrial organization studies (Pellegrino 2019).

Analogously to our technology spillover measures, we construct the pool of product market spillovers for firm i in year t, $SPILLHP_{it}$ as follows:

$$SPILLHP_{it} = \sum_{j \neq i} HP_{ij} G_{jt}. \tag{15}$$

To measure the interaction of common ownership with technology and product market spillovers we construct two additional measures, $COSPILLTECH_{it}$ and $COSPILLHP_{it}$, which are defined as follows:

$$COSPILLTECH_{it} = \sum_{j \neq i} \kappa_{ij} TECH_{ij} G_j, \tag{16}$$

$$COSPILLHP_{it} = \sum_{j \neq i} \kappa_{ij} HP_{ij} G_j. \tag{17}$$

As is obvious from these definitions, the interaction terms are constructed at the pair level and correspond to the terms $\sum_{j \neq i} \kappa_{ij} \beta_{ij}$ and $\sum_{j \neq i} \kappa_{ij} a_{ij}$ in our theoretical model.

3.4. Other Variables

Throughout our analysis we also use an additional set of control variables. First, $\ln(SALES_{it})$ is the natural logarithm of sales of the company where we adjust for inflation as in Brav et al. (2018). Second, $\ln(K_{it}/L_{it})$ is the capital-labor ratio, computed as the natural logarithm of the ratio of plant property equipment K_{it} and the number of employees L_{it} as in Aghion et al. (2013), Hall et al. (2001), and Gompers and Metrick (2001). Finally, we control for a firm's share of all its institutional ownership as in Aghion et al. (2013) as this could also influence corporate innovation independent of the overlapping shareholdings of institutional investors.

4. Empirical Analysis

We empirically study how corporate innovation depends on the degree to which the firms are commonly owned and how that relationship is affected by the spillovers on other firms in the technology and product market space. The theoretical model presented in Section 2 illustrates that common ownership can have a positive or a negative effect on innovation, depending on parameters. Specifically, the model predicts that the correlation between common ownership and innovation increases with the level of technological spillovers but decreases the closer the firms are in product space.

4.1. Empirical Methodology

In our empirical analysis, we estimate for each of the three outcome variables (scaled R&D, citation-weighted patents, stock market value of patents) how innovation depends on common ownership and the interactions of common ownership with product market spillovers and technology spillovers, controlling for known or suspected codeterminants of innovation such the size of the firm, capital intensity, and institutional ownership (Aghion et al. 2013). Our baseline regression is

$$\begin{aligned} INNOVATION_{it} = {} & \alpha_1 \cdot CO_{it} + \alpha_2 \cdot COSPILLTECH_{it} \\ & + \alpha_3 \cdot COSPILLHP_{it} \\ & + \alpha_4 \cdot SPILLTECH_{it} + \alpha_5 \cdot SPILLHP_{it} \\ & + \alpha_6 \cdot X_{it} + \sum_x \xi_x \cdot \eta_x + \varepsilon_{ijt}, \end{aligned} \tag{18}$$

where firms are indexed by i, and years by t. X_{it} is the vector of control variables $\ln(SALES_{it})$, $\ln(K_{it}/L_{it})$, and institutional ownership. η_x with $x \in \{i, t\}$ are firm i, and year t fixed effects. $CO_{it} = \overline{\kappa}_{it}$ measures to what extent the largest and most powerful shareholders of firm i are also beneficial owners of other firms that are connected to firm i. Standard errors are clustered at the firm level.

We estimate ordinary least squares (OLS) regressions for scaled R&D expenditures and the stock market value of patents and negative binominal count data models for citation-weighted patents. The negative binomial regressions include a firm fixed effect that controls for the firm's average citation-weighted patents in the presample period, as in Blundell et al. (1999), Bloom et al. (2013), and Lucking et al. (2019), where the presample period is defined as the five years before the firm enters the regression sample.

Recall that firms influence each other because they benefit from any innovation activities of firm i (technology spillovers) and/or because they are natural product market competitors of firm i (product market spillovers). The principal coefficients of interest are therefore α_2 and α_3 that measure how the relationship between common ownership and innovation varies with product market and technology spillovers.

4.2. Empirical Results

We begin our analysis by examining the impact of common ownership and technology spillovers on innovation inputs (R&D expenses) as the outcome variable. Table 3 reports the results for estimation of Equation (18) with the R&D to asset ratio as the dependent variable. Across the different specifications we include firm and year fixed effects to difference out any otherwise omitted time trends or levels of common ownership that may correlate with trends or levels of R&D expenditures, leading to biased regression coefficients. Column 1 is similar to Lucking et al. (2019) as our baseline specification using the Jaffe proximity measures. Column 2 adds common ownership and shows that it is negatively correlated with innovation input. In column 3, we include interaction terms between common ownership and our two proximity measures. Columns 4 and 5 are similar to columns 2 and 3 but use the Mahalanobis proximity measures. We find that common ownership is generally associated with lower innovation input, although insignificantly. The coefficient on institutional ownership is generally negative, unlike in Aghion et al. (2013).

Our primary coefficients of interest, however, are those reflecting how the relation between common ownership and innovation varies with technology and product market spillovers. Columns 3 and 5 include interaction terms between common ownership and our two measures of spillovers. The estimated coefficient on the interaction term with technological spillovers *COSPILLTECH* is positive both for the Jaffe and Mahalanobis specification, whereas the interaction between common ownership and product market spillover *COSPILLHP* has a significantly negative coefficient. That is to say, in accordance with our theoretical analysis, the negative relation between common ownership and innovation inputs becomes more negative as the degree of product market spillovers increases. Conversely, the relationship between common ownership and innovation inputs becomes less negative and can even turn positive the larger technology spillovers are. On average, the countervailing forces of technology and product market spillovers that pull the relationship between common ownership and corporate innovation in different directions essentially cancel each other out. However, this masks the significant heterogeneity in implied coefficient estimates of the relationship between common ownership and assets-adjusted R&D expenditure. As we show below, for about half of the firms (i.e., for those with relatively high technology and low product market spillovers), the relationship is positive, whereas for the other half (low technology and high product market spillovers), it is negative.

We now turn to the empirical relation between common ownership and innovation outputs. Table 4 is constructed similarly to the previous table but reports the results for the citation-weighted value of patents held by a firm using a negative binomial count data model.[18] On average, the citation-weighted value of patents shows a statistically insignificant negative correlation with common ownership in all specifications. In other words, on average across our entire sample, common ownership and corporate innovation output as measured by citation-weighted patents are not strongly

Table 3. Asset-Adjusted R&D Expenditure as a Function of Common Ownership, Technology Spillovers, and Product Market Spillovers and Their Interactions with Common Ownership

R&D expenditure $\ln(1+R_{it}/A_{it})$	(1) Jaffe	(2) Jaffe	(3) Jaffe	(4) Mahal.	(5) Mahal.
CO		−0.000210	−0.000527	−0.000209	−0.000451
		(0.000763)	(0.000789)	(0.000763)	(0.000780)
ln(*COSPILLTECH*)			0.00513**		0.00506**
			(0.00226)		(0.00240)
ln(*COSPILLHP*)			−0.00457**		−0.00459**
			(0.00222)		(0.00233)
ln(*SPILLTECH*)	−0.00114	−0.00114	−0.00645**	−0.000709	−0.00616
	(0.00157)	(0.00156)	(0.00300)	(0.00235)	(0.00381)
ln(*SPILLHP*)	0.00179	0.00179	0.00672***	0.00174	0.00674***
	(0.00110)	(0.00109)	(0.00246)	(0.00110)	(0.00260)
Institutional Ownership	−0.0297***	−0.0300***	−0.0310***	−0.0300***	−0.0309***
	(0.00404)	(0.00418)	(0.00413)	(0.00419)	(0.00414)
Observations	31,538	31,538	31,169	31,538	31,186
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes

Notes. The table reports OLS coefficient estimates of Equation (18) with the dependent variable $\ln(1+R\&D_{it}/A_{it})$. Standard errors are clustered at the firm level. Variable definitions are described in Section 3. Untabulated controls include firm sales, industry sales, dummy for R&D is equal zero, and capital-labor ratio in $t-1$.

related. However, as before, this is because the interactions of common ownership with technology and product market spillovers cancel each other out in the aggregate.

In particular, once we include the interaction terms between common ownership and the two spillover measures in columns 3 and 5, as before and in accordance with our theoretical predictions, we find that when the variable that captures the pair level interaction of common ownership and product market spillovers *COSPILLHP* is larger, innovation output becomes more negative. It becomes positive instead when the interaction of common ownership with technology spillovers *COSPILLTECH* is larger. Because there is considerable heterogeneity of these spillovers across industries and firms, this leads to vastly different effects of common ownership on corporate innovation across firms. The coefficient on institutional ownership is weakly positive, qualitatively in line with the results of Aghion et al. (2013).

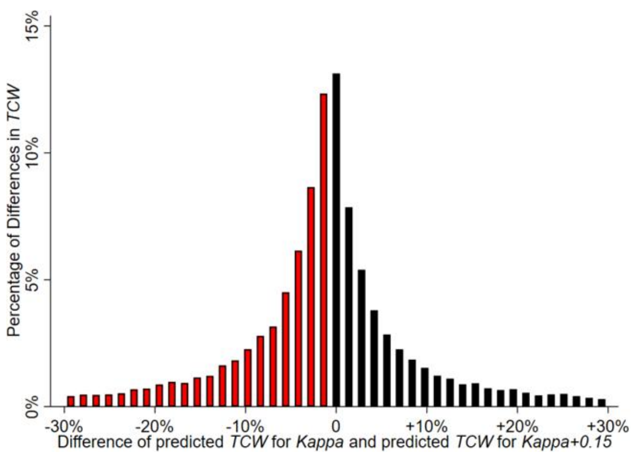
We illustrate the heterogeneity of the relationship between common ownership and corporate innovation in Figure 1. We want to measure how corporate innovation varies with a one-standard-deviation increase in common ownership. This will depend on the level of technology and product market spillovers of each firm

Table 4. Citation-Weighted Measure of Patents as a Function of Common Ownership, Technology Spillovers, and Product Market Spillovers

Citation-weighted patents TCW_{it}	(1) Jaffe	(2) Jaffe	(3) Jaffe	(4) Mahal.	(5) Mahal.
CO		−0.00638	−0.00796	−0.00638	−0.00795
		(0.00642)	(0.00691)	(0.00643)	(0.00691)
ln(*COSPILLTECH*)			0.0717***		0.104***
			(0.0257)		(0.0287)
ln(*COSPILLHP*)			−0.0659**		−0.0978***
			(0.0264)		(0.0295)
ln(*SPILLTECH*)	0.00436	0.00430	−0.0721**	0.00575	−0.104***
	(0.0143)	(0.0143)	(0.0303)	(0.0191)	(0.0354)
ln(*SPILLHP*)	0.0887***	0.0887***	0.154***	0.0888***	0.186***
	(0.0148)	(0.0148)	(0.0297)	(0.0147)	(0.0327)
Institutional Ownership	0.0804**	0.0753**	0.0546	0.0754**	0.0534
	(0.0359)	(0.0364)	(0.0371)	(0.0364)	(0.0371)
Observations	28,401	28,401	28,060	28,401	28,076
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes

Notes. The table reports coefficient estimates as per Equation (18) with the dependent variable TCW_{it} using a negative binominal count data model. Standard errors are clustered at the firm level. Variable definitions are described in Section 3. Untabulated controls include firm sales, capital-labor ratio, and stock of R&D and the log of the dependent variable in $t-1$.

Figure 1. Heterogeneity of the Relationship Between Common Ownership and Citation-Weighted Patents *TCW*



Notes. This figure plots the distribution of how an increase by one standard deviation in common ownership changes citation-weighted patents *TCW* taking into account firm-specific levels of technology and product market spillovers. Negative coefficient estimates are shown in red and positive ones in black.

pair. Given that the variables *COSPILLTECH* and *COSPILLHP* incorporate the interactions of common ownership and the two respective spillovers, we proceed in the following way. We run the baseline regression and compute the predicted *TCW*. For every year t we then replace common ownership κ_{ij} at the pair level with $\kappa_{ij} + 0.15$ (an increase of one standard deviation) and compute the predicted level of corporate innovation. Next, we plot the difference between the predicted innovation with $\kappa_{ij} + 0.15$ and the predicted innovation with κ_{ij}. This difference in predicted innovation varies across firms, depending on their respective technology and product market spillovers. An increase of common ownership has a positive effect for roughly half the firms and a negative effect for the other half.

Similar patterns emerge in Table 5 which reports the coefficient estimates for the relationship between the total stock market value of patents and common ownership. On average, the total stock market value of patents is now significantly negatively correlated with common ownership across all specifications, although at varying levels of significance. As predicted by our theoretical framework, we find that this negative relationship is reversed when technology spillovers *SPILLTECH* are larger. Again, this result is present in both the Jaffee and Mahalanobis specifications. The coefficient estimate for the interaction of common owners and product market spillovers *SPILLHP*, also as above and consistent with this paper's theoretical predictions, is negative and statistically significant. The coefficient on institutional ownership is positive and significant, in line with the results of Aghion et al. (2013). That is to say, as before, depending on the importance of technological spillovers across the universe of firms, common ownership can either be negatively or positively related to corporate innovation.

The relative importance of technology spillovers versus product market spillovers again leads to significant heterogeneity in the relationship between common ownership and innovation as can be seen in Figure 2. Again, about half of the implied common-ownership coefficient estimates at the firm level are positive and the other half is negative.

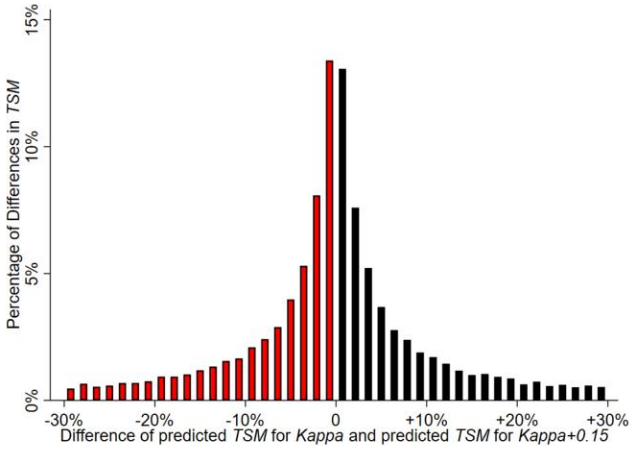
Taken together, we find strong and consistent support for the model's theoretical predictions. First, there

Table 5. Stock Market Value of Patents as a Function of Common Ownership, Technology Spillovers, and Product Market Spillovers

Stock market value of patents (TSM_{it})	(1) Jaffe	(2) Jaffe	(3) Jaffe	(4) Mahal.	(5) Mahal.
CO		−0.0135**	−0.0104*	−0.0136**	−0.0106*
		(0.00572)	(0.00591)	(0.00571)	(0.00587)
ln(*COSPILLTECH*)			0.101***		0.108***
			(0.0298)		(0.0314)
ln(*COSPILLHP*)			−0.102***		−0.110***
			(0.0307)		(0.0322)
ln(*SPILLTECH*)	−0.00217	−0.00240	−0.108***	−0.0157	−0.129***
	(0.0154)	(0.0154)	(0.0344)	(0.0208)	(0.0388)
ln(*SPILLHP*)	0.108***	0.108***	0.212***	0.109***	0.220***
	(0.0154)	(0.0154)	(0.0351)	(0.0154)	(0.0368)
Institutional Ownership	0.434***	0.423***	0.405***	0.424***	0.407***
	(0.0382)	(0.0390)	(0.0393)	(0.0390)	(0.0393)
Observations	28,401	28,401	28,060	28,401	28,076
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes

Notes. The table reports negative binomial regression coefficient estimates of Equation (18) with the dependent variable TSM_{it}. Standard errors are clustered at the firm level. Variable definitions are described in Section 3. Untabulated controls include firm sales, capital over labor, stock of R&D in $t-1$, and the log of the dependent variable in $t-1$ also included as controls.

Figure 2. Heterogeneity of the Relationship Between Common Ownership and the Market Value of Patents *TSM*



Notes. This figure plots the distribution of how an increase by one standard deviation in common ownership changes the market value of patents *TSM* taking into account firm-specific levels of technology and product market spillovers. Negative coefficient estimates are shown in red and positive ones in black.

exists an empirically ambiguous relationship between common ownership and innovation that can be either positive or negative on average. Second, the innovation-reducing effect of common ownership increases with the degree of product market spillovers. Third, technology spillovers increase the innovation-enhancing effect of common ownership. As predicted by the theoretical framework, the overall effect of common ownership on corporate innovation crucially depends on the relative strength of product market business stealing incentives and of technological spillovers between firms and differs markedly across firms. The finding of small effects on R&D inputs but economically large effects (in some firms) on R&D outputs is consistent with the findings of Li et al. (2022) who find that common ownership by venture capitalists in the pharmaceutical industry reduces duplication of R&D and thus increases innovation efficiency.

4.3. Robustness to Alternative Specifications

We review the robustness of our results to alternative specifications. First, we examine different definitions of κ. In the Online Appendix, Table B1 shows the robustness of our main results (Jaffe and Mahalanobis proximity measures and for each of the innovation variables) when the κ measure is aggregated using value weights to account for relative firm size among firm pairs. In the Online Appendix, Table B2 shows robustness to computing kappas using quarterly holdings and averaging pair-wise kappas at the year level. The results are mostly consistent with our baseline specifications. Some companies have $\overline{\kappa}$ greater than one, pointing to *tunneling* incentives (Backus et al. 2021). We show in the Online Appendix, Tables B3 and B4, that our results are not driven by the firms with $\overline{\kappa}$ greater than one. This is true regardless of how we impose the restriction that $\overline{\kappa}$ must be smaller than one, either pairwise before aggregation or at the firm level after aggregation. We also show some robustness to different approaches in computing the technology spillover matrices. As detailed in Section 3.3, we compute the $TECH_{ij}$ allowing patents with multiple classifications. In the Online Appendix, Table B5, we show that using only the first classification leads to consistent results. Furthermore, to avoid look-ahead bias (i.e., ensuring that a patent granted after year t is not used in a regression before t), we compute a $TECH_{ij}$ matrix for each year using patent data only up to that year. We show in the Online Appendix, Table B6, that the results also hold when we only use the first classification of the patent.

Table 2 indicates that this sample includes a wide variety of firms, but their respective innovative activities are quite skewed as evidenced by the fact that the measures of innovation variables have large standard deviations. To show that the results are not driven by firms with low innovation activity or low spillovers, we conduct the same analysis with a subsample of firms with high innovation activity and high spillovers. We average innovation and spillovers across different industries and then rank industries by each of those variables (R&D, *TCW*, *TSM*, *SPILLTECH*, and *SPILLHP*). We take the top five industries in each of those lists and keep the companies that are present in all five groups. This subsample[19] selection procedure reduces our data set to 4,869 observations compared with the 31,169 observations in R&D equations and 28,060 observations in patent equations. In the Online Appendix, Table B7 shows the robustness of our results for this subsample of firms.

To ensure that results are not driven by omitted variables, we further add institutional investor concentration as measured by the investor Herfindahl-Hirschman index (IHHI), which is correlated with institutional ownership and common ownership, as an additional regressor. In the Online Appendix, Table B8 shows that the results remain qualitatively unchanged when including IHHI as a control.

Finally, in the Online Appendix, Table B9, we explore how common ownership affects changes in innovation by conducting regressions using lags of the independent variables. One could expect that R&D spending is adjusted more quickly when common ownership increases whereas the effect on patent grants may take longer to show up that the effect in R&D. We find some empirical support for this hypothesis. The results for R&D are decaying from $t-1$ to $t-3$ in magnitude and significance but with some exceptions. The effect on patent grants takes longer to show up with the coefficients increasing from $t-1$ to $t-3$ in most specifications.

4.4. Addressing Endogeneity Concerns

One limitation of this study is that, in the theoretical model, ownership is taken as an exogenously given parameter whereas in the panel regressions presented above, ownership may be endogenous, thus challenging a causal interpretation.[20] That said, we find it difficult to formulate a simple economic model that would give rise to the two opposing effects we measure but not allow for a causal interpretation.

Assume, for example, a perfectly "passive" investor holding the market portfolio as a benchmark. Some types of active investors might pursue a strategy of underweighting industry competitors while overweighting technologically related firms, and at the same time they might have a preference for more innovation (for reasons unrelated to their portfolio choice). Other types of active investors might deliberately overweight industry competitors and sell other holdings while pushing firms to reduce innovation—again for reasons unrelated to their portfolio choice. We are not aware of an economic rationale that links these portfolio choices with a preference for low or high innovation. Or perhaps firms with high innovation activity attract active shareholders that tend to underweight industry competitors in their investment strategy, whereas firms with low innovation activities attract active investors that specialize in holding industry competitors. Again, we are not aware of an economic rationale that could give rise to such a relationship. The economic model proposed in the present paper provides a simple and economically intuitive explanation for the empirical patterns we observe.

Nonetheless, we take these challenges to the identification of a causal channel between common ownership and innovation seriously. To that effect, we consider two standard shocks to common ownership from the literature. First, we consider using the addition of a competitor to the S&P500 as a shock to the extent to which S&P500 *incumbents'* largest shareholders hold financial interests in competitors, as pioneered by Boller and Scott Morton (2020) and used by Antón et al. (2023b). The challenge is that in the present study, we measure common ownership not within industry but across the economy. As such, there are no index additions to competitors. All S&P500 incumbents would be treated by any entry, and only firms outside the S&P500 would serve as controls. This implementation would seem to make the shock less clean than in the previous use cases.[21]

Instead, we turn to the BlackRock-Barclays Global Investors merger as a second candidate shock.[22] This acquisition in June 2009 serves as a better shock to ownership in our setting, because it affects sample firms regardless of the industry. We modify the approach of Azar et al. (2018) by measuring common ownership with κ instead of MHHID. Furthermore, in contrast to Azar et al. (2018), we are not interested in the effect of a shock to common ownership, but in the effect of a shock to common ownership interacted with the two types of spillovers. We implement this idea in three different ways.

In the first approach, we compare the actual level of common ownership at the end of 2008 with the implied common ownership of companies as if the merger had happened at the end of 2008. We then compute the difference between the implied and actual levels and label it the implied change in common ownership. We sort companies by the implied change and take the top quartile as treated and bottom quartile as controls. We then run the regressions of *R&D*, *TCW*, and *TSM* with the following two triple interaction terms as the primary coefficients of interest: *TREATMENT* × *POST* × *SPILLTECH* and *TREATMENT* × *POST* × *SPILLHP*. We control for the double interactions, dummies, and all controls as of the year before the shock, alone and interacted with the post dummy. The results, reported in Table 6 as Method 1 (columns 1–3), are consistent with the baseline analysis but only significant for *TSM* as the dependent variable. These results suggest that this method does not lend itself to ascertain a causal effect of common ownership, one way or the other, on R&D expenditures or citations, but suggests a likely positive causal effect of common ownership on the market value of patents between firms with high technological spillovers, and a negative causal effect of common ownership on the market value of patents between product market competitors.

The second approach is more granular and computes the implied change of common ownership interacted at the pair level with the measures of product market/technology spillovers (or the implied *COSPILLTECH* and *COSPILLHP*). Compared with the previous approach, this method avoids a combination of high implied changes in common ownership treating pairs of firms for which either form of spillovers is low. We consider firms as treated only if they both are treated with a high implied increase in common ownership and have high levels of spillovers. To do so, we first measure the pairwise actual kappas, and then the pairwise implied kappas. We then multiply the actual kappas with *SPILLTECH* at the pair level. Similarly, we multiply implied kappas with *SPILLTECH* to obtain the corresponding interaction term. We follow the same procedure for *SPILLHP*. We then take the difference between implied and actual measures, and sort based on that difference. Treated companies are now those that are both in the top quartile of the rank of implied *COSPILLTECH* difference and in the top quartile of the rank of implied *COSPILLHP*. Firms in the bottom quartile of both variables are the controls. We conduct again a similar regression as before but with the new treated and control firms. The results are labeled as Method 2 and presented in columns 4–6 of Table 6. The measured causal effects of common ownership on innovation in technologically related firms are similar as in Method 1, but the

Table 6. Difference-in-Difference Analysis for BLK-BGI Shock: Methods 1 and 2

	Method 1			Method 2		
Method	(1) *R&D*	(2) *TCW*	(3) *TSM*	(4) *R&D*	(5) *TCW*	(6) *TSM*
Post × Treat × SPILLTECH	0.00641	0.0555	0.515**	0.0107	0.194	0.620**
	(0.006)	(0.166)	(0.247)	(0.012)	(0.223)	(0.315)
Post × Treat × SPILLHP	−0.0139	0.187	−0.611*	−0.00492	0.0173	−0.0893
	(0.020)	(0.345)	(0.371)	(0.015)	(0.190)	(0.195)
Post × Treat	0.0900	−2.358	−0.403	−0.0582	−2.514	−6.858*
	(0.148)	(3.457)	(5.566)	(0.184)	(2.763)	(4.141)
Post		1.818	−0.453		1.924	6.869*
		(3.440)	(5.577)		(2.132)	(3.703)
Observations	2,837	2,468	2,468	2,533	2,409	2,409
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes. The table reports the difference in difference estimates using the BlackRock acquisition of BGI in 2008. In Method 1 (columns 1–3), treated firms are those in the top quartile of the implied change in common ownership, and control firms those in the bottom quartile. In Method 2 (columns 4–6), treated firms are those that are both in the top quartile of implied change in both *COSPILLTECH* and *COSPILLHP*. Untabulated controls include the double interactions, dummies, and all controls as of the year before the shock, alone and interacted with the post dummy.

negative effect of common ownership on innovation between product market rivals found in Method 1 is no longer statistically significant.

The third approach has some similarity with the second approach. Again, we compute actual and implied kappas and multiply them with *SPILLTECH* and *SPILLHP* at the dyad level. We then average at the firm level and sort them. Treated firms are now those companies above the median in the implied change in *COSPILLTECH* and below the median in the implied change of *COSPILLHP*. Conversely, control firms are those companies below the median in the implied change in *COSPILLTECH* and above the median in the implied change of *COSPILLHP*. Because this selection of treatment and control firms already incorporate the interactions between common ownership and spillovers, we no longer require the triple interactions and instead estimate a standard difference-in-differences model. Treated firms are those likely to affect innovation because they experience an increase in common ownership and have high *SPILLTECH* and low *SPILLHP*. Hence, the theory advanced in this paper predicts that the interaction coefficient should be positive. The results are shown in Table 7. The coefficient is positive and significant for *TCW* and positive but not significant for *TSM*.

The three approaches provide suggestive evidence of causal link between common ownership and innovation for some of the corporate innovation measures. The first approach is the simplest one. The second approach is more refined and demanding than the first, because the interaction of common ownership and spillovers are at the pair level before aggregating. Finally, the third approach is as demanding and valid as the second (due to the granularity) but also helps us link further the test to the theory. Specifically, we are testing Proposition 1 (common ownership κ_{ij} increases equilibrium firm innovation x_i^* if and only if technological spillovers β_{ij} are sufficiently large relative to product market spillovers a_{ij}) as close to the theory as possible. Our preferred approaches are thus the second and the third approach.

Overall, we interpret these results as somewhat consistent with causal effects of common ownership on innovation in the predicted ways, but by no means as conclusive. In particular, we were unable to infer positive casual effects of common ownership on R&D expenditures. Furthermore, we found results suggesting

Table 7. Difference-in-Difference Analysis for BLK-BGI Shock: Method 3

	Method 3		
Method	(1) *R&D*	(2) *TCW*	(3) *TSM*
Post × Treat	−0.000938	0.628**	0.287
	(0.004)	(0.314)	(0.402)
Post		−0.158	1.656*
		(0.736)	(0.910)
Observations	810	628	628
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

Notes. The table reports the difference in difference estimates using the BlackRock acquisition of BGI in 2008, for Method 3. Treated firms are now those companies above the median in the implied change in *COSPILLTECH* and below the median in the implied change of *COSPILLHP*, and conversely control firms are those companies below the median in the implied change in *COSPILLTECH*, and above the median in the implied change of *COSPILLHP*. Untabulated controls include the double interactions, dummies, and all controls as of the year before the shock, alone and interacted with the post dummy.

causal effects of common ownership between technologically related firms on stock market value of patents but not on citation-weighted patents. We conclude that the data and methods available to date do not allow strong conclusions regarding whether innovation is truly a bright side of common ownership, as suggested by some theoretical considerations. Therefore, a limitation of our study remains that we cannot establish with high levels of confidence that the correlations we uncover are likely to have a causal interpretation. However, these results remain economically interesting because a positive effect of common ownership on innovation is, in theoretical treatments such as López and Vives (2019), a necessary condition for positive effects of common ownership on welfare. We discuss this rationale and other conclusions in the next section.

4.5. Mechanism

Our analysis provides theoretical predictions and empirical tests of the relationship between common ownership and corporate innovation. We find that the "quiet life" mechanism detailed in Antón et al. (2023b) is a potential explanation as to why common owners of product market competitors would simply compete less by spending less money on innovation when the innovation would have negative externalities, such as product market stealing, on other portfolio firms. The new Department of Justice (DOJ)/Federal Trade Commission (FTC) Merger Guidelines (U.S. Department of Justice and Federal Trade Commission 2023) reflect this emerging consensus noting that "common ownership can reduce competition by softening firms' incentives to compete, even absent any specific anticompetitive act or intent."[23] Similarly, a potential mechanism for our technology spillover results is that common ownership induces managers not to actively suppress innovation that would spill over to other firms. In particular, enforcing a patent infringement would require resources and effort by the patent owner. Simply not exerting such effort and expending such resources is sufficient to enable a technological spillover. Anticipating such nonenforcement makes innovation in a firm with common owners more attractive ex ante. Relaxing R&D budgets and allowing R&D teams to innovate with less regard to protecting the innovation may also be consistent with top managements' quiet-life preferences. Passivity can also be sufficient to thwart innovation in firms where technological spillovers to commonly owned rivals are not technologically feasible. After all, innovation does require resources; not expending those and related efforts can serve as a mechanism to suppress innovation.

Whereas mere passivity appears sufficient to lead to the results we document in theory, this does not imply the absence of active mechanisms in practice. A recent piece of evidence on how those common owners may actively encourage certain innovation activities is found at the heart of coronavirus pandemic. Mooney and Mancini (2020) document how the largest asset managers were encouraging pharma companies to collaborate (rather than compete) in the development of the vaccine. This is not just an off-hand comment from one asset manager, but part of a more structured approach: "A separate group of more than 50 investors, managing more than $2.5tn in assets, will next week step up the pressure by writing to more than a dozen global pharmaceutical companies. The letter will ask the groups to share any relevant findings on a vaccine and other treatments as well as to drop any enforcement of relevant patents." The fundamental reason behind this pressure drug makers receive from asset managers is to protect and enhance portfolio returns: " … fund returns had been very hard hit by the economic crisis", said Mr Krens. "It is very important for us and for our clients to recover as quickly as possible," he added. "One of the means to that end is to get the health industry and pharma companies in particular to collaborate."

The above example is one of many instances, more systematically documented by Shekita (2022), in which common owners actively engage with the management of the company to either soften incentives to compete or to be more open to share knowledge across portfolio firms. These actions include both informal engagement and formal voting on many different governance decisions, from pricing to production and from M&A decisions to innovation.

The debate is, however, still open, and further research is necessary to better understand and disentangle the set of mechanisms (from passive to more active and from indirect to more direct) that drive the effects of common ownership on innovation, in particular the impact on patent litigation and the decision to patent versus keeping trade secrets within the boundaries of the firm.

5. Conclusion

In this paper, we show that common ownership can increase innovation when technological spillovers are sufficiently large relative to product market spillovers. Conversely, common ownership can also decrease innovation because common owners would like to discourage business stealing between commonly owned companies that compete in product markets against each other. The direction of the theoretical prediction thus depends on parameters that vary across firms and poses an interesting empirical question about the sign and magnitude of the effect of common ownership on innovation. We use our theoretical model's predictions to investigate how the relationship between common ownership and innovation depends on the relative strength of technological and product market spillovers. Consistent with the model's theoretical predictions, we find that common ownership has a positive panel correlation with innovation inputs and outputs whenever innovation spillovers to other firms are relatively large compared with the firms' proximity in the product market space and a negative correlation if the product market spillovers dominate. Whether these correlations have a causal interpretation largely remains an open question: Shocks to the interaction between common ownership and technological spillovers caused by BlackRock's acquisition of Barclays Global Investors are positively associated with the stock market value of patents, which likely reflects a causal effect. However, we do not find a robust negative effect on corporate innovation in response to shocks to the interaction between common ownership and product market rivalry. Whether the lack of significance in this quasi-experimental setting is due to measurement error, a lack of power, or simply because there is no strong causal link between common ownership and innovation remains an open question for future research.

Our findings inform an active debate on whether welfare-enhancing effects of common ownership outweigh the previously empirically documented negative effects of common ownership on firms' incentives to compete. Because a positive effect on innovation—which we model as an efficiency increase in this paper—is a necessary condition for common ownership to positively affect welfare in López and Vives (2019), findings of positive innovation effects are a necessary ingredient in using this argument to warn against regulatory interventions on horizontal common ownership links that have competitive effects. The more nuanced insight, however, is that antitrust and innovation policy should distinguish between common ownership of horizontal competitors and common ownership of technologically and perhaps vertically related firms. Previous literature indicates that the former weakens competition and, as we show, also reduces innovation. Our theoretical analysis and empirical results suggest that the latter promotes innovation and may potentially increase total welfare.

Acknowledgments
The authors thank Daron Acemoglu, Nick Bloom, Harald Hau, Barry Nalebuff, Luke Taylor, Raffaella Sadun, Regina Seibel, Fiona Scott Morton, John Van Reenen, and seminar audiences at Berlin Hertie School of Government, Chicago, Humboldt University, National Bureau of Economic Research, Instituto de Estudios Superiores de la Empresa (IESE), MadBar Workshop, Michigan, and Yale for helpful comments and Nick Bloom, John Van Reenen, and, in particular, Brian Lucking for generously sharing data and Pedro Martínez Bruera for outstanding research assistance. The views presented in the paper represent the views of the author and not of any employer or other associated entity.

Endnotes

[1] White House CEA (2016) provides an early overview of these trends. See Philippon and Gutierrez (2017), Gutiérrez and Philippon (2017), De Loecker et al. (2020), and Akcigit and Ates (2021) for a formal quantification and analysis of their macroeconomic implications.

[2] Backus et al. (2021) and Amel-Zadeh et al. (2022) provide a recent comprehensive analysis of common ownership of the largest U.S. corporations. See Davis (2008), Harford et al. (2011), and Azar (2012) for an earlier documentation of this trend and Schmalz (2018, 2021) for reviews of the theoretical and empirical literature on common ownership.

[3] Mentions of the concerns and investigations by competition authorities and international institutions include, among many others, OECD (2017), European Competition Commission (2017), Federal Trade Commission (2018), Vestager (2018), and PTI (2020).

[4] We abstract away from the potential role of common *debtholders* in inducing reduced competition, which is the focus of empirical work by Saidi and Streitz (2021).

[5] Consistent with this idea, González-Uribe (2020) shows that technological spillovers among companies sharing common VCs are more substantial between portfolio companies that are not in direct competition for the VCs' resources because different funds finance them.

[6] For the interplay between competition and innovation, see for example, Brander and Spencer (1983), Spence (1984), Katz (1986), D'Aspremont and Jacquemin (1988), Grossman and Helpman (1991), Kamien et al. (1992), Suzumura (1992), Aghion and Howitt (1992), and Leahy and Neary (1997). For comprehensive reviews of the literature, see Jones (2005) and Gilbert (2006).

[7] Their approach builds on prior work by Jaffe (1988) who assigns firms to technology and product market space but does not examine the proximity between firms in both these spaces. Similarly, Branstetter and Sakakibara (2002) empirically examine the effects of technology closeness and product market overlap on patenting in Japanese research consortia. Lucking et al. (2019) extend the results of Bloom et al. (2013) to later time periods.

[8] Stenbacka and Van Moer (2020) theoretically study how common ownership affects the product innovation decisions under duopoly and distinguishes between input spillovers and output spillovers.

[9] For example, Pellegrino (2019) and Ederer and Pellegrino (2021) model and estimate a general equilibrium hedonic linear demand system in which all the n firms in the economy compete with each other and the investors (or managers) controlling the firms' operations consume an outside good (e.g., leisure).

[10] In the main part of the paper we focus on the Cournot competition case where quantity choices are strategic substitutes. However, our results for Bertrand competition (see Online Appendix) where prices are strategic complements are essentially identical. Although we assume linear demands, the main results of our model generalize to nonlinear demand functions.

[11] Assuming shareholders agree on own-firm value maximization has no theoretical basis when firms are not price takers and shareholders have interests outside the firm Hart (1979). Furthermore, firms acting in their shareholders' portfolio interest is also a better description of how firms behave and how managers are incentivized (Antón et al. 2023b).

[12] Aside from a literal interpretation, this assumption can be understood as a metaphor for an explicit or implicit coalition of shareholders that jointly hold an effective majority of the voting stocks. Olson and Cook (2017) and Shekita (2022) discuss examples of explicit coalitions. Moskalev (2020) shows conditions under which shareholders with similar portfolios will optimally vote the same way, and therefore will be regarded as an implicit coalition or a single block by managers.

[13] In Section 4.5, we argue that for these effects to be present common owners need not actively engage in corporate governance activities.

[14] Bloom et al. (2013) provide microeconomic foundations for the spillover measures we use. However, neither they nor we address Manski's reflection problem.

[15] The database is available on Noah Stoffman's website (http://kelley.iu.edu/nstoffma). More details on how to match patents and citations to the CRSP database can be found in the Online Appendix of Kogan et al. (2017). We should acknowledge that using these measures have some limitations, as pointed out by Kuhn et al. (2020), who conclude that after 2005, patent attorneys started adding hundreds of citations where they would not have previously.

[16] See https://www.uspto.gov/web/patents/classification/cpc/html/cpc.html for more explanation.

[17] Our results also hold when we only use the first classification of the patent as we show in the Online Appendix, Table B5.

[18] Kogan et al. (2017) argue that these two measures are essentially weighted patent counts. If firm *f* files no patent in year *t*, both variables are equal to zero (see section 3.1 of Kogan et al. 2017). Given that those variables have many zeros, high skewnewss, and excess dispersion, we use a negative binomial regression model with the plain variable on the left-hand side for both *TCW* and *TSM*.

[19] Firms from this subset of industries include pharmaceuticals, electronics, services, communications, retail trade, transportation, finance, insurance, and real estate industry. Table B7 contains more details.

[20] For example, Antón et al. (2023a) find that corporate mergers increasingly occur between firms that are more commonly owned and that are more closely related in product market space.

[21] Although the implementation is less clean, we find results consistent with the panel regressions, which may be indicative of the direction of the results (provided in the Online Appendix).

[22] In response to the 2007 financial crisis, Barclays aimed to bolster its financial standing. It received a $4 billion offer from CVC Capital Partners for its iShares exchange-traded funds on March 16, 2009, with the option to seek higher bids. BlackRock, on June 11, 2009, proposed to buy iShares' parent, Barclays Global Investors (BGI), for $13.5 billion. The deal was completed in December 2009. This history suggests that the divestment and merger decisions were not driven primarily by considerations related to how the iShares portfolio would combine with BlackRock's portfolio in terms of potential product market or technological effects.

[23] This guideline also has important implications for firms with large common owners as shareholders as these need to be particularly careful about how their strategic decisions will be viewed by antitrust authorities.

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