COMMON OWNERSHIP ALONG THE SUPPLY CHAIN AND SUPPLIER INNOVATIONS

by

XIAN CHEN

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Student: Xian Chen

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This dissertation has been accepted and approved in partial fulfillment of the requirements for the Doctor of Philosophy degree in the Department of Finance by:

Youchang Wu	Chairperson, Advisor
Brandon Julio	Core Member
Ioannis Branikas	Core Member
Trudy Ann Cameron	Institutional Representative

and

Andrew Karduna	Interim Vice Provost for Graduate Studies

Original approval signatures are on file with the University of Oregon Division of Graduate Studies.

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DISSERTATION ABSTRACT

Xian Chen

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Common owners are the (institutional) investors that hold equities of multiple firms. I examine the impact of common ownership of suppliers and customers on suppliers' innovation activities. I find suppliers' investment in innovation, quantity and quality of innovation output increase when common owners control higher fractions of their and their customers' shares outstanding. The impact of this vertical common ownership on innovation input and quality of innovation output is stronger and more robust than that of the horizontal common ownership. I provide plausible evidence for causality using both a difference-in-differences approach and an instrument variable approach based on a quasi-natural experiment in the form of financial institution mergers and acquisitions. Moreover, I test the potential channels through which the vertical common ownership could influence supplier innovation. My evidence suggests that common ownership increases suppliers' investment in innovation by mitigating hold-up issues between suppliers and customers, and enhances suppliers' innovation output performance by improving technological spillovers between suppliers and customers. However, my results also suggest that for suppliers producing mainly capital goods, these positive effects of common ownership on innovation are offset by a negative effect due to vertical creative destruction. Overall, my evidence suggests that common institutional ownership enhances suppliers' innovation performance by improving relationships between suppliers and their customers.

CURRICULUM VITAE

NAME OF AUTHOR: Xian Chen

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon, Eugene
Swiss Federal Institute of Technology Zurich (ETH Zurich), Zurich, Switzerland
University of Illinois at Urbana-Champaign, Champaign
Sun Yat-sen University, Guangzhou, China

DEGREES AWARDED:

Doctor of Finance, 2021, University of Oregon
Master of Science in Quantitative Finance, 2016, ETH Zurich
Master of Science in Finance and Statistics, 2014, University of Illinois at Urbana-Champaign
Bachelor of Arts in Art and Design, 2009, Sun Yat-sen University

AREAS OF SPECIAL INTEREST:

Empirical Corporate Finance
Financial Institutions

PROFESSIONAL EXPERIENCE:

Auditor, KPMG China, 2009 - 2011

AWARDS:

Paper of the Year, Journal of Operational Risk, 2019

PUBLICATION:

Paul Embrechts, Kamil Mizgier, and Xian Chen. Modeling operational risk depending on covariates: an empirical investigation. *Journal of Operational Risk,* 13.3 2018.

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I dedicate this dissertation to my wife and son, who encouraged me to pursue my dreams and bring joy to my life.

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I. INTRODUCTION

Common ownership describes the situation in which equities of multiple companies are held by the same (institutional) investors. Table 1 demonstrates an example of common ownership of suppliers and customers (i.e., vertical common ownership). Tenneco, a designer and manufacturer of emissions and ride-control products, is selling to multiple automotive companies all over the world. Its customers include U.S. companies such as Caterpillar, Ford Motor, Navistar, Harley Davidson, etc. Table 1 reports the top 10 institutional investors for Tenneco and its four major U.S. customers as of 2010 Q4. Among these institutional investors, Fidelity, Vanguard, and BlackRock hold equities in all five companies; Wellington and State Street hold four out of the five companies. In sum, Tenneco and its major customers all have a similar structure of top institutional investors. It is interesting to assess the impact of common owners on the firms in their holding portfolios.

To the extent that common owners may aim to maximize portfolio value instead of a single firm's value, they could attempt to maximize portfolio value by mitigating the conflicts between the firms in the portfolios. A growing literature has examined the anti-competitive effects of common holdings of competitors (e.g., He and Huang, 2017; Azar et al., 2018). The potential anti-competitive effects have also led to debates among legal scholars and economists concerning anti-trust regulations for institutional investors (e.g., Elhauge, 2015; Bebchuk and Hirst, 2019). Nevertheless, the relationships between the firms in common owners' portfolios are quite complex, including not only competitors but also collaborators. Studies of common owners' influence on other relationships in their portfolios, for example, suppliers and customers, can lead to a new perspective for more comprehensive examinations of common ownership, and may adjust scholars' and regulators' negative opinions about common ownership. However, very few studies have assessed the effects of common ownership of suppliers and customers. Moreover, the existing literature has largely overlooked an important impact of common ownerships: their effects on corporate investment decisions. In this paper, I focus on the impact of supplier-customer common holdings on a special type of corporate investment — technological innovation, which is critical for a firm's long-term competitive advantage and sustainable growth (Porter, 1992).

Table 1. This table reports the top 10 institutional investors for Tenneco and its four major U.S. customers as of 2010 Q4. Tenneco is a designer and manufacturer of emissions and ride-control products. Its major U.S. customers include Caterpillar, Ford Motor, Navistar, and Harley Davidson. Among the institutional investors, Fidelity, Vanguard, and BlackRock are holding all five companies; Wellington and State Street are holding four out of the five companies.

Tenneco		**Caterpillar**	
Institution	Holding%	Institution	Holding%
Fidelity	13.70%	State Street	12.02%
Vanguard	4.97%	Vanguard	4.03%
Blackrock	4.92%	Blackrock	3.82%
Wellington	4.23%	Fidelity	3.28%
Westfield Capital	3.39%	State Farm	3.13%
Columbia Management	3.05%	Capital World	1.86%
Next Centutry	2.85%	Mellon Bank	1.59%
Gamco	2.80%	Bill&Melinda Gates	1.52%
Iridian	2.51%	Northern Trust	1.31%
State Street	2.24%	Primecap	1.30%
Navistar		**Harley Davidson**	
Institution	Holding%	Institution	Holding%
Fidelity	12.52%	David Selected	10.58%
Owl Creek	8.01%	Capital Research	7.63%
Wellington	6.67%	Vanguard	4.98%
Blackrock	4.41%	Wellington	4.64%
Gamco	4.29%	Fidelity	4.50%
Vanguard	4.21%	Blackrock	4.00%
Oppenheimer	3.33%	T Row Price	3.56%
Deutsche Bank	2.36%	State Street	3.54%
Frontier Capital	2.26%	Independent Franchise	1.53%
Columbia Management	2.10%	MFS Investment	1.41%
Ford Motor			
Institution	Holding%		
Evercore	7.25%		
Wellington	4.43%		
Blackrock	3.62%		
Janus Capital	3.44%		
State Street	3.39%		
Vanguard	3.33%		
Axa Financial	2.33%		
Fidelity	1.81%		
Mellon Bank	1.37%		
Capital Growth	1.11%		

Although common ownership may in principle affect the innovation activities of both suppliers and customers, I focus in this paper on the activities of suppliers because suppliers are generally more innovation active than customers reported in commonly available databases. In contrast, a lot of customers, such as firms in the retail industry, are generally dormant in innovation.[1] Furthermore, it is important to study suppliers' innovation activities because upstream innovation is crucial along the supply chain. It has a strong impact on downstream firms and acts as a double-edged sword. On one hand, it can devalue customers' assets-in-place through vertical creative destruction (Gofman et al., 2020), but on the other hand, collaboration with innovative suppliers is an important way to improve customers' own innovation performance (Huston and Sakkab, 2006; Henke and Zhang, 2010).

Common ownership of suppliers and customers could affect suppliers' innovations through a number of plausible channels. The first one is the hold-up mitigation channel. Customized innovations by suppliers lead to products for specific customers. These relationship-specific projects are not easily marketed or used elsewhere. Therefore, concerns over possible opportunism and hold-up behavior of the customer will lead to underinvestment in (relationship-specific) innovation by the supplier (Klein et al., 1978). Some seminal theoretical studies (e.g., Grossman and Hart, 1986; Hart and Moore, 1990) suggest that joint asset ownership attenuates hold-up problems under conditions of asset specificity and ex-ante incomplete contracting. As one type of joint asset ownership, common owners could actually benefit from improved supplier innovation performance resulting from better supplier-customer relationship, because the positive spillovers of supplier innovations towards customers help increase the value of the entire portfolio. Therefore, common owners could be motivated to lower the likelihood for hold-up problems to occur, thereby improving suppliers' innovation performance, especially their investment in (relationship-specific) innovation activities.

The second plausible channel through which vertical common ownership may

[1] In untabulated results, I also test the impact of common ownership on innovation-active customers. The sample size of innovation-active customers is much smaller than that for suppliers because the dataset I use, Compustat Customer Segment, reports only the major customers (the sales value to the customer constitutes at leat 10% of its supplier's total sales) for each supplier. And I find no statistically significant results.

affect supplier innovation is the technological spillover channel. Manso (2011)'s principal-agent model proposes that timely feedback from the principal to the agent enhances the agent's innovation. Consistently, Chu et al. (2019) provide empirical evidence that timely feedback from customers to suppliers is one of the potential channels that improve suppliers' innovation performance. Past empirical studies imply that common ownership facilitates information exchange about technological innovation between the held firms. In particular, common ownerships increase the cross-citations between the patents assigned to different firms in the same portfolio (Freeman, 2021; Kostovetsky and Manconi, 2020). By increasing information exchange between suppliers and customers, common ownership could lead to more technological spillovers between customers and suppliers, and consequently improved innovation performance by suppliers.

The third channel is a vertical creative destruction channel. Vertical creative destruction describes the situation that innovations by suppliers can devalue customers' assets-in-place (Gofman et al., 2020). Common owners tend to internalize all the externalities imposed to firms held in the same portfolio (Hansen and Lott, 1996), so they might also react to the negative impact due to vertical creative destruction by weakening suppliers' innovation activities.

Using the Compustat customer segment dataset, I match each supplier to its principal customers from 1980 to 2010.[2] I examine the impact of institutional common holdings of both suppliers and customers on the suppliers' innovation activities along three dimensions: inputs to innovation (measured by R&D intensity), quantity of innovation ouput (measured by the number of patent applications), and quality of innovation output (measured by the average market value of patents). The baseline regression analyses show that suppliers' innovation input, quantity and quality of innovation output all increase significantly when institutional common owners are holding higher fractions of the equity issued by suppliers and their principal customers. This result is robust to alternative common ownership measures based on different assumptions about institutional investors' attention. The effect of vertical common ownership on innovation activities is different from that of horizontal common ownership. In particular, vertical common ownership has

[2]The innovation variables are constructed based on Kogan et al. (2017)'s innovation dataset, which stops at 2010.

stronger and more robust impact on innovation input and quality of innovation output.

Nevertheless, institutions do not randomly invest in firms. A potential endogeneity concern is that institutions could choose to invest in firms with good innovation prospects. In addition, other omitted variables, such as managerial traits, could drive both common ownership and supplier innovation. To mitigate those potential endogeneity concerns, I exploit a quasi-natural experiment based on financial institution mergers and acquisitions (M&As) with both difference-in-differences (DiD) and instrument variable (IV) approaches following He and Huang (2017) and Azar et al. (2018). M&As of financial institutions lead acquirers to hold more firms in their portfolios. As a result, potentially more suppliers and customers will be commonly held by the acquirers. M&As of financial institutions thus cause mechanical increments of vertical common ownership. Meanwhile, M&As of financial institutions are not likely to be driven mainly by an intent to affect corporate innovation. Therefore, such M&As can be used as a plausibly exogenous reason for changes of common ownership. The DiD analysis shows that the treated firms, relative to control firms, experience about 2% higher increase in R&D intensity, 9% higher increase in patent applications, and 9% higher increase in average patent value after the financial institution mergers. The analysis using the instrumental variable approach leads to a similar result.

All these findings suggest that there exist positive, and plausibly causal, effects of supplier vertical common ownership on supplier innovation activities. Next, I examine potential channels through which vertical common ownership could affect supplier's innovations. First, I test the hold-up channel. If common ownership actually affects suppliers' innovation activities by mitigating the hold-up issues, I expect to find that the impact is less pronounced for firms with fewer hold-up problems in the first place. I construct three proxies for hold-up issues: (1) the supplier's vertical integration with its operating segments, (2) the supplier's bargaining power relative to its customers, and (3) the asset specificity of the supplier's input to customers. Consistent with the prediction, I find that the impact of common ownership on innovation activities is weaker for suppliers that (1) are more vertically integrated, (2) have stronger bargaining power relative to their customers, and (3) supply to customers using assets that are more easily redeployed.

Second, I test the technological spillover channel. If technological spillover is the underlying force for common ownership to improve supplier innovation activities, I expect that the impact is stronger for suppliers with higher technology proximity to their customers. I find results consistent with this prediction.

Third, I test the vertical creative destruction channel. The vertical creative destruction effect should be the strongest if the suppliers are capital-goods producers. Consistently, I find that vertical common ownership can potentially weaken innovation output for suppliers in capital-producing industries and the positive association between vertical common ownership and innovation output exists only for intermediate-goods producers.

Interestingly, I find that common ownership mainly influences innovation input (i.e. investment in innovation) through the hold-up mitigation channel, and affects innovation output (both quantity and quality) through the technological spillover and vertical creative destruction channels. The findings suggest that these three channels work on different aspects of innovation activities. Mitigation of hold-up issues increases the incentive to invest, but does not necessarily increase innovation efficiency. In contrast, improved technological spillovers as well as vertical creative destruction work mainly on increasing innovation efficiency, but have little influence on investment in innovation.

In addition, I also test the relation between common ownership and patent cross-citations at supplier-customer level. I find that common ownership at the firm-pair level mainly increases the citations from suppliers to their customers. This finding is potentially consistent with both channels. On one hand, citations from suppliers towards customers could imply technological information spreading from customers to suppliers, which suggests that common ownership improves technological spillovers between suppliers and customers. On the other hand, it could imply suppliers' customized innovation towards customers, suggesting common ownership improves relationship-specific innovation. Furthermore, I find that the citations from suppliers to their customers are more likely to be a proxy for relationship-specific innovation, because common ownership has a significantly weaker impact on citations when the intensity of hold-up issues is lower. This finding provides additional evidence that common ownership could mitigate hold-up issues, thereby leading to more relationship-specific innovation.

This study contributes to four strands of the literature. First, this study contributes to the emerging literature on common ownership. The literature on common ownership focuses mainly on its anti-competitive effects on corporate policies and product markets (e.g., Antón et al., 2018; Azar et al., 2018), but ignores its potential positive effects. Freeman (2021) shows that common ownership can improve cooperation between suppliers and customers, and my paper provides evidence for a bright side of common ownership through its impact on supplier innovation.

Second, this study contributes to the literature on hold-up problems. While theoretical analysis on this topic is extensive (e.g., Grossman and Hart, 1986; Hart and Moore, 1990), empirical evidence is scarce, and focuses mainly on vertical integration as one potential solution to mitigate hold-up problems (e.g., Lafontaine and Slade, 2007). In the absence of vertical integration, partial equity holdings can also improve relationships along the supply chain. For example, Fee et al. (2006) show that when the customer owns an equity stake in its supplier, the relationship lasts longer. This study investigates an alternative method to mitigate hold-up problems based on integration through a third party, i.e., institutional investors.

Third, this study contributes to the literature on the impacts of supply-chain relationships on corporate decisions. The past literature has assessed how supplier-customer relationships affect corporate financing decisions, such as capital structure (Kale and Shahrur, 2007; Banerjee et al., 2008; Chu, 2012) and the cost of debt (Cen et al., 2016a). Chu et al. (2019) show the geographic proximity between a customer and its suppliers can enhance firm innovation. This study examines how improved supplier-customer relationships, on the basis of vertical common ownership, could influence corporate innovation activities.

Lastly, this study contributes to the literature on corporate innovation by finding another potential determinant for corporate innovation. One of the drivers of corporate innovation is variation in ownership structure, such as the formation of strategic alliances (Chemmanur et al., 2016) and hedge fund activism (Brav et al., 2018). This paper examines a more general form of ownership structure (institutional common ownership of suppliers and customers) that takes into account all types of institutions.

A significant body of academic work has expressed serious concern about the potential anti-competitive effects of common ownership. Some legal scholars propose strong anti-trust measures on institutional investors, such as limiting investment managers' holdings in each economic sector, and having regulators scrutinize the behavior of common owners (e.g., Posner et al., 2017; Scott Morton and Hovenkamp, 2017). The findings of this paper shed a light upon the brighter side of common ownership. Regulators may motivate institutional investors to hold firms in different sectors along the supply chain, thereby mitigating the anti-competitive effects, and obtaining extra benefit by improving collaboration between upstream and downstream firms.

The rest of the paper is organized as follows. Section 2 discusses the antecedent literature. Section 3 describes sample construction and reports summary statistics. Section 4 presents the analyses and results covering the relationship between common ownership and suppliers' innovations, including baseline regressions, identification, and additional tests. Section 5 presents the analyses and the results of the potential channels through which vertical common ownership could influence suppliers' innovations. Section 6 concludes.

II. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Related Literature

Common Ownership One basic assumption in financial economics is that the ultimate goal of firm management is to maximize shareholders' value. When shareholders are holding multiple firms in their portfolios, value optimization is no longer focused on a single firm, but the entire portfolio. The past literature has suggested that shareholder diversification can induce managers to internalize all types of externalities (including technological innovation, legal litigation, etc.) imposed on commonly owned firms (e.g., Hansen and Lott, 1996; Gordon, 2003).

However, there are concerns about the mechanisms whereby common owners coordinate the firms in portfolio, especially when the shareholder is a passive investment fund that holds massive numbers of firms in its portfolio. The emerging empirical literature has provided support for multiple potential channels, including voice, vote, and incentives. Azar et al. (2018) discuss anecdotal evidence for a voice channel, including engagement meetings between "passive" funds and portfolio firm managers. He et al. (2019) show that common owners (including both passive and active funds) are more likely to vote against management on shareholder-sponsored governance proposals. Regarding incentives, Antón et al. (2018) show that common owners have rendered the compensation of top managers less sensitive to firm performance.

Based on the plausible mechanisms discussed above, past studies have documented the impacts of common ownership on various aspects of corporate policies, such as mergers and acquisitions (Matvos and Ostrovsky, 2008), product market competition (Azar et al., 2018; Azar et al., 2019), technological spillover (Kostovetsky and Manconi, 2020), and financing friction (Cici et al., 2015; Ojeda, 2018). Among all these studies, my paper is most closely related to research about the impact of common ownership on vertically related firms. For example, Freeman (2021) shows that vertical common ownership can improve duration of relationships between suppliers and customers and tests innovative collaborations as a potential channel. My study differs from prior studies in this area by (a) examining the impact of vertical common ownership on different aspects of corporate innovation activities and (b) exploring potential channels for the results.

Among all the studies in this area, my paper is most relevant to Geng et al. (2017)'s work. They define companies with cited patents as upstream firms and define companies with patents citing the upstream firms as downstream firms. They then examine how the joint ownership of upstream and downstream firms mitigates patent hold-up problems. In contrast, my paper studies the joint ownership of suppliers and their customers along the supply chain.

Hold-up Problem The hold-up problem as first described by Williamson (1975) and Klein et al. (1978) has been accepted by economists as a determinant of corporate underinvestment (e.g., Ellingsen and Johannesson, 2004). A hold-up problem occurs to the party in a transaction with two factors: (1) relation-specific investments and (2) an incomplete contract (Rogerson, 1992). Factor (1) implies that the investment produces (employs) customized products for specific customers (from specific suppliers). The customized products largely increase the bargaining power of the counterparty in the transaction, because if the counterparty ends the transaction, the customized products and the related investment will devalue substantially as it is difficult to use these products elsewhere. Ideally a complete contract will preclude the potential counterparty opportunism.[3] However, in reality, because of bounded rationality and economic uncertainty, it is never possible to write a complete contract ex-ante.[4] Together with factor (1), factor (2) implies that, under an incomplete contract, there could be chances for a contractual party to act opportunistically, thereby leading to significant losses for the counterparty with relation-specific investment for this transaction. Such a situation will

[3]Williamson (1975) defines opportunism as an effort to realize individual gains with guile in transactions. It can have two types. The first type happens at the initial negotiation stage. One party can strategically disclose incomplete or distorted information to write the contract to her own advantage. The second type manifests itself during contract execution and renewal. The contractual parties may behave irresponsibly when lack of monitoring, or may pose problems at the contract renewal interval due to first-mover advantage. In particular, the first-mover advantage here means that winners of original bids acquire firm-specific experience which places them at a cost advantage in relation to non-winners on subsequent rounds of negotiation (Williamson, 1971).

[4]Bounded rationality refers to limited capacities of individuals to receive, store, retrieve, and process information without error. With cognitive limits, the economic actors cannot write contracts of unlimited complexity that would specify all possible contingencies in an economic exchange.

definitely deter relation-specific investment.

A well-known example of the hold-up problem for the customer side is between General Motors (GM) and Fisher Body (Hart, 1995). Fisher Body was the only company to deliver the components according to GM's specification. In 1920, a sharp increase in demand occurred that was above the contractual expectation. It is claimed that Fisher Body held up GM by increasing the price for additional parts produced. My study is related more to the hold-up problem for the supplier side. A good example is that ship-leasing firms (threaten to) cancel (already established) shipbuilding contracts with shipyards because of "non-permissible" delay on production due to COVID-19.[5]

Since it is costly to write a comprehensive contract listing all specific rights over assets in the contract, Grossman and Hart (1986) suggest, in their seminal theoretical work, that it may be optimal to let one contractual party purchase all residual rights in the form of ownership. Therefore, ownership integration is a way to reduce opportunistic behavior and hold-up problems under the condition of ex-ante incomplete contracting (Hart and Moore, 1990). Lafontaine and Slade (2007) review the studies on the effects of vertical integration. In the absence of vertical integration, Fee et al. (2006) show that partial equity holdings can also improve relationships along the supply chain. My paper differs from other studies in this area by assessing a different type of integration in the form of common ownership.

It is empirically challenging to test the hold-up problem since it occurs under unobservable conditions. Martin and Otto (2017) is one of the very few studies to empirically test the effect of a hold-up problem. In particular, they use tariff changes in suppliers' industries as a shock for customers' hold-up issues, and study how customers respond in terms of investment. In contrast, my research examines suppliers' responses to various levels of hold-up problems, and focuses on a special type of investment: investment in innovation activities.

[5]Pandemic, such as COVID-19, is not specifically defined as a permissible situation for production delay in shipbuilding contracts, especially under English law. More details can be found in BIMCO's explanations on its website. BIMCO is the largest of the international shipping associations representing shipowners.

Supply Chain Similar to studies on the hold-up problem, studies on the role of supply-chain relationships in corporate finance also stem from the seminal theoretical studies on transaction costs between upstream and downstream firms (e.g., Williamson, 1975; Hart and Moore, 1990). The literature in this area extends the empirical analysis to more specific determinants of supply-chain relationships besides corporate integration, such as mergers and acquisitions (Fee and Thomas, 2004; Shahrur, 2005), partial integration (Fee et al., 2006), financial distress (Hertzel et al., 2008), anti-takeover measures (Cen et al., 2016b), and CEO turnovers (Intintoli et al., 2017). Another stream of this literature examines how supply-chain relationships may influence corporate financial decisions, such as capital structure (Kale and Shahrur, 2007; Banerjee et al., 2008; Chu, 2012) and the cost of debt (Cen et al., 2016a).

The literature on the impacts of supply-chain relationships on corporate financial decisions is relatively scarce, especially concerning their impacts on real investment activities. Among all the studies in this area, my paper is most closely related to Chu et al. (2019)'s work. They demonstrate that geographic proximity between suppliers and customers can improve corporate innovation. My research differs from their work by studying how improved supplier-customer relationships, due to common ownership, can influence innovation.

Corporate Innovation Manso (2011)'s theoretical study suggests that corporate innovation can be facilitated by (1) tolerance of failures and (2) timely feedback on performance. The empirical literature has widely studied how variations in ownership structure could affect corporate innovation through several potential channels: mergers and acquisitions (Bena and Li, 2014; Seru, 2014), formation of strategic alliances (Chemmanur et al., 2016), venture capital (Tian and Wang, 2014; Chemmanur et al., 2014), and hedge fund activism (Brav et al., 2018). My paper examines the impact on corporate innovation of a new form of ownership structure, common ownership, and tests feedback between suppliers and customers as a potential channel. The work is most closely related to Anton et al. (2018)'s work. They theoretically analyze the impact of horizontal common ownership on corporate innovation. In contrast, this paper is the first one to empirically test the impact of vertical common ownership on innovation.

Regulation Implications The potential anti-competitive effects of common ownership have led to controversies over proposals for related regulations. Empirical studies have documented increases in product prices or decreased market entry due to common ownership in different sectors, such as airlines (Azar et al., 2018), banking (Azar et al., 2019), and pharmaceuticals (Newham et al., 2018). Some legal scholars claim that common ownership may disincentivize output and employment and increase economic inequality, so they propose strong anti-trust scrutiny for common owners (Elhauge, 2015; Posner et al., 2017; Scott Morton and Hovenkamp, 2017).

On the contrary, some scholars suggest that the common ownership scrutiny should not be implemented for all investors, especially index funds (Bebchuk and Hirst, 2019). Index fund managers have weak incentives to engage in stewardship because their contributions to improve held firms' performances will invite free-riding by other investors. In addition, index fund managers have incentives to defer to the preferences of corporate managers because of potential business ties with corporate managers of the firms in portfolios (e.g., having the index funds included in the menu of investment options for 401(k) plans).

My paper reports a bright side of common ownership, which implies potentially helpful regulatory measures: regulators may wish to encourage institutional investors to hold equities in different sectors along the supply chain.

Development of Hypotheses

The main hypothesis is that vertical common ownership can enhance suppliers' innovation performance by improving the relationship between suppliers and their customers. In particular, I hypothesize that vertical common ownership can influence suppliers' innovation through three potential channels.

The first channel is hold-up mitigation channel. In my analytical framework, hold-up problems happen when suppliers invest in production of relation-specific products. This situation can potentially decrease the bargaining power of suppliers because it is hard to sell these specialized products to other customers.[6] Therefore, customers may act opportunistically in their relationship with suppliers. For example, they may attempt to push down the prices of specialized inputs or (threaten to) cancel the order during a negative demand shock. These potential hold-up issues will lead to underinvestment in relation-specific investments/innovations. However, theoretical studies (e.g., Grossman and Hart, 1986; Hart and Moore, 1990) suggest that joint asset ownership, such as common ownership, can mitigate the hold-up issues. Therefore, I hypothesize that vertical common ownership can improve suppliers' innovation performance by mitigating hold-up issues between suppliers and their customers.

The second channel is a technological spillover channel. Both theoretical and empirical studies (e.g., Manso, 2011; Chu et al., 2019) suggest that the exchange of information about innovation activities can improve corporate innovation performance. Past studies also suggest that common ownership can improve rates of information exchange about corporate innovation activities. For example, Kostovetsky and Manconi (2020) show that common ownership can increase cross-citations between patents assigned to firms held in the same portfolio. Therefore, I hypothesize that vertical common ownership can improve suppliers' innovation performance by improving technological spillovers between suppliers and their customers.

The third channel is a vertical creative destruction channel. Vertical creative destruction describes a situation where innovations by suppliers can devalue customers' assets-in-place (Gofman et al., 2020). For example, Nvidia supplies Graphics Processing Units (GPUs) to Amazon for its Amazon Web Services (AWS). AWS then uses Nvidia's GPUs to accelerate artificial intelligence and high performance computing workloads. An updated version of these GPUs, due to technological improvements by Nvidia, can devalue the existing old versions of GPUs used by Amazon. Theoretically, common owners tend to internalize all types of externalities imposed on the firms held in the same portfolio (Hansen and Lott, 1996), so they might also react to the negative effect due to vertical creative destruction.

[6] These relation-specific products can also cause hold-up issues for customers. In my data sample, however, a lot of the customers are retailers without investment in relation-specific inputs. It is thus easier for customers to get rid of the customized products because they do not have to suffer from a loss of sunk costs due to any relation-specific investments.

The impact of vertical creative destruction is strongest for capital-goods producers, so I hypothesize that vertical common ownership can weaken innovation activities, especially for suppliers in capital-producing industries.

III. DATA AND VARIABLE CONSTRUCTION

Sample Construction

The data sample is constructed from variables in four databases: Compustat Segment Customer, Thomson Reuters 13F, Stoffman et al. (2019)'s patent dataset, and Kogan et al. (2017)'s patent dataset. Supplier-customer relationships are identified from the Compustat Segment Customer database. According to the FASB 14 (1976) and 131 (1997), public firms are required to disclose customers who account for at least 10% of their total sales. Some firms may opt to report significant customers below this threshold as well. The Segment database includes the names of corporate customers, as well as the supplier's sales to each of its customers.

Data on institutional ownership are drawn from the Thomson Reuters 13F database. This database includes institutional investors with over $100 milllion in assets under management. These institutions include pension funds, endowments, insurance companies, bank trusts, mutual funds, hedge funds and independent advisors. These data go back to 1980, and report holding fractions for each firm at fund family level at the end of each quarter. For a given firm, if its fiscal year end is not at quarter end, I use institutional holdings at the nearest quarter end prior to its fiscal year end to construct variables developed from information in this database.

Data on patents are drawn from the datasets constructed by Stoffman et al. (2019) and Kogan et al. (2017). Stoffman et al. (2019)'s dataset matches patent numbers to firm identifier variables (CRSP "permco") from 1926 to 2017. This resource provides patent application dates and estimated market values of patents. Kogan et al. (2017)'s dataset provides information on patent cross-citations. In particular, this dataset matches the citing patent numbers with the cited patent numbers from 1926 to 2010.

I generate supplier-level common ownership measures on the basis of the Segment and 13F datasets, and merge them with firm-level innovation variables generated from the datasets provided by Stoffman et al. (2019) and Kogan et al. (2017). Then I merge the resulting data, by firm, with fundamental accounting variables from Compustat. I exclude utility firms (SIC code from 4900 to 4999) and financial firms (SIC code from 6000 to 6999) from the estimating sample because these two industries are highly regulated. I delete all the innovation-inactive firms that have no R&D expenditure or patent applications throughout the sample period. All variables in the form of ratios are winsorized at the 1st and 99th percentiles to minimize distortions due to outliers. This variable construction procedure results in an estimating sample consisting of 17,063 firm-year observations from 1980 to 2010.

Variable Construction

Common Ownership Measures

Following the recent literature on common ownership (e.g. He and Huang, 2017; Lewellen and Lowry, 2020), I first construct my firm-pair level measure of common ownership along a supply chain (i.e., vertical common ownership), called *pairwise VCO*, as:

$$pairwise\ VCO_{sct} = \sum_{f=1}^{F} \beta_{fst} \cdot \beta_{fct},$$

where there are F institutions holding both supplier s and its customer c. $\beta_{fs(c)t}$ denotes institution f's holding fraction of supplier s (customer c) in year t. The value of *pairwise VCO* is higher when there are more common owners and/or when these common owners hold higher fractions of suppliers and/or customers.

Then, I aggregate *pairwise VCO* to the level of supplier s to construct VCO as:

$$VCO_{st} = \sum_{c=1}^{C} w_{ct} \cdot pairwise\ VCO_{sct},$$

where there are C customers for supplier s. The weight w_{ct} denotes customer c's relative share among all the supplier's customers in year t. I employ both equal weights and value weights on the basis of sales value between the supplier and each customer.

Figure 1 displays the time series for the average number of institutions that are commonly holding each supplier-customer pair in the data sample from 1980 to 2010. Figure 2 displays the time series of average common owners' holding fractions of suppliers and customers from 1980 to 2010. Figure 3 displays the time series of average vertical common ownership from 1980 to 2010. The market-level vertical common ownership in the graph is the average VCO weighted by firm market value. There are clear increasing trends in the number of common owners and holding fractions of both suppliers and customers. Consistently, the value of average VCO also exhibits an increasing trend over the sample period.

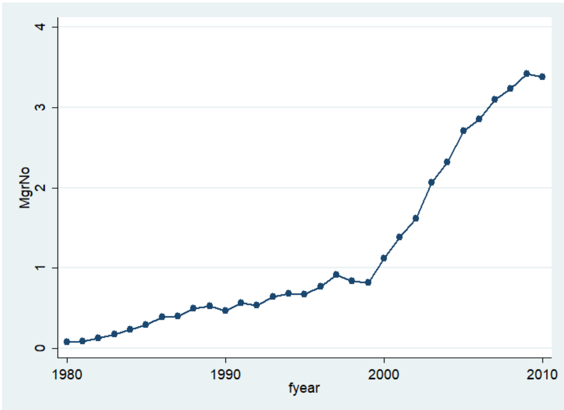

Figure 1. Average number of institutions holding each supplier-customer pair from 1980 to 2010.

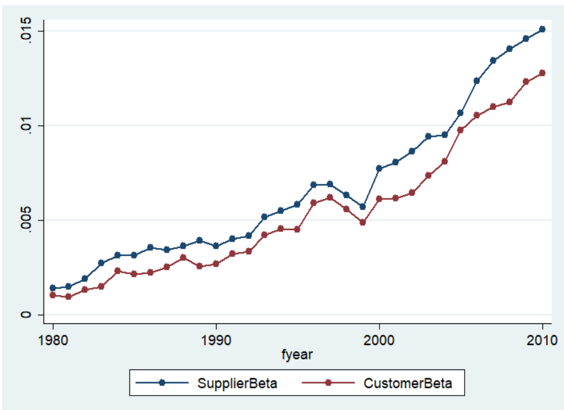

Figure 2. Average common owners' holding fractions of suppliers and customers from 1980 to 2010.

Innovation Measures

As mentioned earlier in Introduction, corporate innovation activities are typically measured along three dimensions: innovation input, quantity of innovation output,

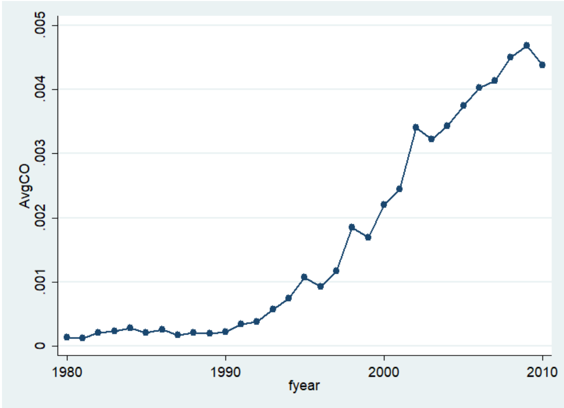

Figure 3. Average vertical common ownership (weighted by firm size) from 1980 to 2010.

and quality of innovation output. Innovation input is measured by R&D Intensity, which is R&D expenditures per unit of sales.

The quantity of innovation output is measured by the number of patent applications submitted (and eventually granted) at the firm-year level. On average, there is more than a two-year lag between applications and grant years. The recorded application year thus better captures the actual time of innovation than the eventual grant year.

Many innovation studies use a patent's subsequent lifetime citations as the proxy for quality of innovation output. By that measure, however, the number of citations for patents filed near the end of sample period is highly truncated. Hall et al. (2001) therefore attempt to mitigate the truncation problem by adjusting subsequent citations based on structural models. However, the current literature empirically demonstrates that this adjustment method does not work particular well (Dass et al., 2017). Kogan et al. (2017) provide another proxy for the quality of innovation output by measuring the market response to patent grants. In this study, the quality of innovation output is measured by the average market value of patents at the firm-year level. Kogan et al. (2017) and Stoffman et al. (2019) estimate these patent market values and provide the data used in this analysis.

Control Variables

To net out any potential confounding effects from other institutional ownership measures, I control for the percentage of total institutional holdings (IO) and the concentration of institutional holdings (IO HHI) at the firm level. Following other studies in the innovation literature (e.g., Atanassov and Liu, 2019), I control for other firm-level variables including Q, firm size measured by sales, as well as leverage, profitability, and capital intensity. More details about control variable construction are in Appendix VI..

Summary Statistics

Table 2 reports summary statistics for the main variables used in this paper. An average supplier has R&D intensity of 0.42 and 14.29 patent applications each year, and each patent's inferred market value averages $8.16 million. Given that the innovation measures are skewed, I use shifted natural logarithms of these measures in my analyses. The average value of vertical common ownership (VCO) is 0.0019. On average, 27% of a supplier's equity is held by institutional investors, and the concentration of institutional holdings (i.e., HHI of institutional holding) is 0.14.[7]

[7]The market-level institutional holding percentage (market-cap weighted average) increases from around 30% to around 60% from 1980 to 2010. However, the institutional holding percentages are higher for large market-cap firms, and the supplier firms in my sample in general are small in size. Therefore, the average firm-level institutional ownership percentage in the sample period is relatively small.

Table 2. This table reports summary statistics for the main variables used in this paper. *R&D Intensity* is R&D expenditure scaled by sales. *#pat* is the number of patent applications (for patents eventually granted) at the firm-year level. *Avg.xi* is the average market value of patents at the firm-year level. *VCO* is the supplier-level vertical common ownership, which is calculated as the weighted average of supplier-customer-pair-level common ownership for each supplier. I use both equal weights (EW) and value weights (VW) on the basis of sales from a supplier to each of its customers. *IO* is the percentage of total institutional holdings. *IO HHI* is the proxy for institutional ownership concentration, which is calculated as the Herfindahl–Hirschman Index of institutional holdings. *Q* is market value of total assets divided by book value of total assets. *Capital Intensity* is net PPE divided by total assets. *Profitability* is EBITDA divided by total assets. *Leverage* is total debt divided by total assets.

	count	mean	s.d.	min	p50	max
Innovation						
$ln(1 + R\&D\ Intensity)$	17,045	0.210	0.409	0	0.066	2.432
R&D Intensity	17,045	0.421	1.345	0	0.068	10.38
$ln(1 + \#pat)$	17,063	1.022	1.346	0	0.693	8.175
#pat	17,063	14.29	90.69	0	1	3549
$ln(1 + Avg.xi)$	17,063	0.953	1.269	0	0.254	6.484
Avg.xi ($mil)	17,063	8.160	31.78	0	0.289	653.4
Common Ownership						
VCO (EW)	17,063	0.002	0.003	0	0.001	0.015
VCO (VW)	17,063	0.002	0.003	0	0.001	0.016
Controls						
IO HHI	17,063	0.141	0.207	0	0.064	1
IO	17,063	0.270	0.292	0	0.167	1.000
Q	15,770	2.405	2.241	0.585	1.628	14.18
$ln(Sales)$	17,043	4.452	2.248	-4.135	4.321	11.63
Capital Intensity	17,057	0.219	0.162	0.009	0.182	0.719
Profitability	17,019	0.011	0.285	-1.359	0.096	0.426
Leverage	17,000	0.196	0.234	0	0.128	1.288

IV. THE RELATIONSHIP BETWEEN COMMON OWNERSHIP AND SUPPLIERS' INNOVATION ACTIVITIES

Baseline Regressions and Results

To assess the relationship between vertical common ownership and suppliers' innovation activities, I estimate the baseline regression:

$$Innovation_{it} = \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it},$$

where $Innovation$ is one of the innovation activity measures (i.e., $ln(1+R\&D\ Intensity)$, $ln(1 + \#pat)$, and $ln(1 + Avg.xi)$), VCO is the supplier-level proxy for vertical common ownership on the basis of both equal weights and sales-value weights, and X is a vector of control variables that could systematically affect corporate innovation activities.[8] All explanatory variables are lagged one year to mitigate simultaneity. The α_i captures firm-level fixed effects which control for any observable or unobservable heterogeneity across firms that affect innovation activities (e.g. corporate culture that encourages innovation). The α_t capture year fixed effects which rule out spurious associations between vertical common ownership and innovation activities due to their aggregate time trends. Standard errors are clustered at the industry level in case variations of firm-level innovation activities are correlated within industries because of industry-level technological innovation shocks or technological collaboration among peer firms in the industry.

Table 3 reports the results of baseline regressions. Columns (1) and (2) show the results when the dependent variable is innovation input, $ln(1+R\&D\ Intensity)$, with equally weighted and value-weighted VCO. The coefficient estimates on the two types of VCO are both positive and statistically significant at the 5% level, suggesting a positive association between a supplier's vertical common ownership and the supplier's innovation input. The economic effect is sizeable: a one standard deviation increase in equally (value-) weighted VCO is associated with a

[8] The data on patent market values are estimated and provided by Kogan et al. (2017). They denote patent market value as xi.

2.32% (1.57%) increase in R&D intensity.

Columns (3) and (4) show the results when the dependent variable is the quantity of innovation output measured by $ln(1+\#pat)$. The coefficient estimates on the two types of VCO are again positive and statistically significant at the 1% level, suggesting a positive association between a supplier's vertical common ownership and the supplier's quantity of innovation output. The effect is also economically large: a one standard deviation increase in equally (value-) weighted VCO is associated with a 9.35% (9.21%) increase in the number of successful patent applications.

Lastly, columns (5) and (6) show the results when the dependent variable is the quality of innovation output measured by $ln(1 + Avg.xi)$. The coefficient estimates on the two types of VCO are still positive and statistically significant at the 1% level, suggesting a positive association between a supplier's vertical common ownership and the supplier's quality of innovation output. The economic effect is large: a one standard deviation increase of equally (value-) weighted VCO is associated with a 5.14% (5.10%) increase in average patent market value, which corresponds to a $0.42 million increase in value.

Overall, the baseline results in Table 3 show that, on average, a supplier's vertical common ownership has a significant effect on the supplier's innovation activities. Suppliers' innovation input, quantity and quality of innovation output all rise significantly when the value of suppliers' vertical common ownership increases. Based on the construction of VCO, a higher value of vertical common ownership implies that more institutions hold higher fractions of equities in both the supplier and its customers.

Identification using Mergers of Financial Institutions

The baseline regression results provide evidence concerning significant associations between vertical common ownership and supplier innovation activities. However, there are still several qualifications with respect to these findings. First, these specifications cannot exclude other unobservable confounding factors that covary with common ownership. Second, they cannot exclude the possibility of reverse causality. It is possible that common owners intentionally search for, and invest

Table 3. This table reports the baseline regression results for the model:

$$Innovation_{it} = \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it}.$$

The dependent variables are $ln(1 + R\&D\ Intensity)$ in columns (1) and (2), $ln(1 + \#pat)$ in columns (3) and (4), and $ln(1 + Avg.xi)$ in columns (5) and (6). The supplier-level variable VCO is the equally weighted average of supplier-customer-pair-level vertical common ownership in columns (1), (3) and (5); and the sales-value weighted average in columns (2), (4) and (6). Details about the control variables are in Appendix VI.. Both firm and year fixed effects are included in all regressions. Standard errors are clustered at the industry level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

	$ln(1 + R\&D\ Intensity)$		$ln(1 + \#pat)$		$ln(1 + Avg.xi)$	
	EW	VW	EW	VW	EW	VW
	(1)	(2)	(3)	(4)	(5)	(6)
VCO	2.290**	1.496**	29.114***	27.771***	15.271***	14.645***
	(2.458)	(2.576)	(3.453)	(3.319)	(3.064)	(2.861)
$IO\ HHI$	-0.031	-0.030	-0.009	-0.009	0.067	0.066
	(-1.358)	(-1.358)	(-0.192)	(-0.195)	(1.515)	(1.513)
IO	0.081*	0.084*	0.051	0.057	0.236**	0.239**
	(1.750)	(1.727)	(0.428)	(0.480)	(2.173)	(2.166)
Q	-0.008*	-0.008*	0.017**	0.017**	0.039***	0.039***
	(-1.728)	(-1.728)	(2.108)	(2.101)	(6.159)	(6.165)
$ln(Sales)$	-0.067**	-0.066**	0.270***	0.270***	0.172***	0.172***
	(-2.054)	(-2.059)	(4.070)	(4.061)	(10.841)	(10.686)
$Capital\ Intensity$	0.020	0.020	0.030	0.032	0.053	0.054
	(0.647)	(0.642)	(0.242)	(0.256)	(0.399)	(0.406)
$Profitability$	-0.079***	-0.079***	-0.268***	-0.268***	-0.061	-0.061
	(-2.664)	(-2.662)	(-4.244)	(-4.239)	(-1.178)	(-1.178)
$Leverage$	-0.074**	-0.074**	-0.360***	-0.359***	-0.177***	-0.177***
	(-2.440)	(-2.450)	(-5.701)	(-5.711)	(-3.355)	(-3.334)
Constant	0.496***	0.495***	-0.156	-0.157	0.077	0.076
	(3.292)	(3.299)	(-0.470)	(-0.472)	(1.055)	(1.033)
Observations	11,857	11,857	11,866	11,866	11,866	11,866
R-squared	0.832	0.832	0.815	0.814	0.774	0.774
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

in, firms with better innovation performances. Therefore, I follow the current literature (e.g., He and Huang, 2017; Azar et al., 2018) to implement an event study based on financial institution mergers and acquisitions (M&As) to more rigorously assess the causality between variations in common ownership and changes in supplier innovation activities.

Quasi-Experimental Design

M&As among financial institutions are plausibly exogenous shocks relative to common ownership. M&As allow the acquirers to hold more firms, or higher fractions of firms, in their portfolios, thereby leading to mechanical increments in common ownership for the firms in the merged portfolios. This quasi-experimental design satisfies the exclusion condition. For financial institutions, the reasons for M&As are complex, but are not likely to be driven mainly by these firms' intentions to affect corporate innovation activities. In addition, I consider multiple events to permit tests of the average effects of these shocks. Even if some of the M&As could be driven mainly by a desire to affect the corporate innovation of firms in their portfolios, such idiosyncratic cases are unlikely to have significant impacts on the overall average result. Thus, concerns about endogeneity when using financial institutions M&As to study corporate innovation are likely to be minimized.

I follow He and Huang (2017) to identify instances of M&As in financial institutions, in the 30 years from 1980 to 2010, from the Capital IQ dataset. The sample inclusion criteria are:

1. The merger is between two 13F institutions (or their parent firms) in the financial sector (with primary SIC codes in the 6000 to 6999 range) and announced during the period between 1980 and 2010;

2. The merger is completed within one year after the initial announcement;

3. The target institution stops filing 13F forms within one year after the completion of the deal.

Altogether, I collect 51 such events between 1980 and 2010. The names of acquirers and targets, the announcement dates, and the effective dates are listed in Appendix VI..

I follow Azar et al. (2018)'s method to identify the treated group by checking the implied changes of common ownership for each firm. First, I calculate counterfactual VCO in the year before the announcement year of M&As as if the M&As had already happened at that time. Then, the differences between the counterfactual VCO and real VCO are defined as "implied changes in VCO" (ΔVCO). Firms are categorized on the basis of ΔVCO: the firms in the top tercile of ΔVCO are considered to be treated firms, and the firms in the bottom tercile of ΔVCO are considered to be control firms. I calculate ΔVCO on the basis of pre-merger hypothetical VCO, rather than post-merger actual VCO, because this method constructs an ex-ante measure of mechanical changes of VCO due to institutional mergers. The hypothetical pre-merger VCO is less endogenous than the actual post-merger VCO because it is less likely to be influenced by the investors' reaction to the merger during the event year.

Appendix VI. shows that there are M&A events in consecutive years, and the treatment effects could last for multiple years. Therefore, the observations in a given event can be affected by (lagged) treatment effects of other events. In particular, the distortions due to treatment effects of other events would be potentially reflected from three perspectives. First, in the pre-event window of a given event, some firms in the treatment or control group could be in the treatment groups in other events. As a result, for this specific event, the parallel trends between treatment and control groups in the pre-event window will no longer hold. Second, in the post-event window of a given event, some firms in the control group could be in the treatment groups in other events. As a result, for this specific event, the difference between control and treatment groups in the post-event window will be biased downward. Third, in the post-event window of a given event, some firms in the treatment group could be in the treatment groups in other events. As a result, for this specific event, the difference between control and treatment groups in the post-event window will be biased upward.

To mitigate the distortions due to other events, I follow Gormley and Matsa (2011)'s method to stack the data sample of multiple events. First, a 5-year pre-event and 5-year post-event window is set around each merger. For a specific merger, any firms that are treated by other mergers within the 11-year window are dropped. Thereby a data sample for the specific merger is constructed. Then, I stack the constructed data samples for all the mergers into one dataset.

DiD Regressions and Results

The treated firms are exposed to higher common ownership increments due to the financial institutions M&As, so I expect that these events will lead the treated firms to have a larger increase in innovation input and output. I run the following difference-in-differences (DiD) regression to test the hypothesis:

$$Innovation_{ijt} = \beta_0 + \beta_1 \cdot Treatment_{ij} \times Post_{jt} + \beta_2 \cdot X_{ij,t} + \alpha_{ij} + \alpha_{tj} + \varepsilon_{ijt},$$

where $Treatment_{ij}$ is a dummy variable that equals one if firm i is the treated firm in merger j. $Post_{jt}$ is a dummy variable that equals one if year t is in the post-event period for merger j. X is the vector of control variables. The institutional ownership concentration ($IO\ HHI$) and the percentage of total institutional holdings (IO) are excluded from the vector of control variables because they are directly affected by the treatment. Both firm-merger and time-merger fixed effects are controlled.[9] Standard errors are clustered at the merger level to mitigate the concern that innovations by firms in the same institutional merger might be correlated.

Table 4 reports the results of these DiD regressions. The treated firms are identified based on both equally weighted and value-weighted ΔVCOs. The results for both models with and without control variables are reported and they are largely similar to each other. For all innovation measures, the estimated coefficients on $Treatment_{ij} \times Post_{jt}$ are positive and significant. This result suggests that treated firms (i.e., those whose common ownership increases due to financial institution mergers) exhibit a greater increase in innovation input and output than control firms. In terms of economic significance, the estimated coefficients on $Treatment_{ij} \times Post_{jt}$ in columns (1) and (3) indicate that treated firms, relative to control firms, experience about 2% higher increase in R&D intensity, 9% higher

[9]The construction of stacked dataset discussed above will lead to duplicate firm-year observations, because the same firm-year observations can serve as treated/control observations in data samples for different mergers. Therefore, it is necessary to control firm/year-merger fixed effects.

increase in patent applications, and 9% higher increase in average patent value during the five years after the financial institution mergers, compared to the five years before the merger.

Table 4. This table reports the DiD regression results for the model:

$$Innovation_{ijt} = \beta_0 + \beta_1 \cdot (Treatment_{ij} \times Post_{jt}) + \beta_2 \cdot X_{ijt} + \alpha_{ij} + \alpha_{tj} + \varepsilon_{ijt}.$$

The dependent variables are $ln(1 + R\&D\ Intensity)$ in Panel A, $ln(1 + \#pat)$ in Panel B, and $ln(1 + Avg.xi)$ in Panel C. $Treatment_{ij}$ is a dummy variable that equals one if firm i is a treated firm in merger j. $Post_{jt}$ is a dummy variable that equals one if year t is in post-event period for merger j. The treated firms are those in the top tercile of ΔVCO, while the control firms are those in the bottom tercile of ΔVCO. ΔVCO is the difference between (1) the hypothetical VCO assuming the merger had already happened in the year before annoucement and (2) the actual VCO in the year before the announcement. The treated firms are identified based on eqaully weighted ΔVCO in columns (1) and (2), and on sales-value-weighted ΔVCO in columns (3) and (4). X is a vector of control variables. Results of DiD regressions without control variables are reported in columns (1) and (3). Both firm-merger and time-merger fixed effects are employed. Standard errors are clustered at the merger level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

	(1)	(2)	(3)	(4)
	EW	EW	VW	VW
Panel A	$ln(1 + R\&D\ Intensity)$			
$Treatment \times Post$	0.015**	0.027***	0.018**	0.028***
	(2.172)	(7.702)	(2.505)	(8.029)
Q		-0.005***		-0.005***
		(-3.500)		(-3.511)
$ln(Sales)$		-0.177***		-0.177***
		(-17.478)		(-17.509)
$Capital\ Intensity$		0.241***		0.241***
		(7.771)		(7.776)
$Profitability$		-0.367***		-0.367***
		(-14.961)		(-14.981)
$Leverage$		-0.152***		-0.152***
		(-10.681)		(-10.679)
Observations	49,244	43,478	49,244	43,478
R-squared	0.757	0.818	0.757	0.818
Firm-merger FE	Yes	Yes	Yes	Yes
Year-merger FE	Yes	Yes	Yes	Yes

Table 4. (continued).

	(1)	(2)	(3)	(4)
	EW	EW	VW	VW
Panel B		$ln(1 + \#pat)$		
$Treatment \times Post$	0.098***	0.059***	0.089***	0.058***
	(5.234)	(3.706)	(4.512)	(3.618)
Q		-0.001		-0.001
		(-0.450)		(-0.462)
$ln(Sales)$		0.243***		0.243***
		(22.956)		(23.045)
$Capital\ Intensity$		0.244***		0.244***
		(4.759)		(4.746)
$Profitability$		-0.226***		-0.226***
		(-10.681)		(-10.654)
$Leverage$		-0.195***		-0.195***
		(-9.088)		(-9.077)
Observations	49,330	43,478	49,330	43,478
R-squared	0.762	0.832	0.762	0.832
Firm-merger FE	Yes	Yes	Yes	Yes
Year-merger FE	Yes	Yes	Yes	Yes
Panel C		$ln(1 + Avg.xi)$		
$Treatment \times Post$	0.089***	0.078***	0.086***	0.081***
	(3.022)	(3.556)	(2.892)	(3.679)
Q		0.024***		0.024***
		(7.206)		(7.229)
$ln(Sales)$		0.144***		0.144***
		(8.548)		(8.538)
$Capital\ Intensity$		-0.094**		-0.094**
		(-2.241)		(-2.225)
$Profitability$		-0.028		-0.028
		(-1.541)		(-1.527)
$Leverage$		-0.159***		-0.159***
		(-6.211)		(-6.200)
Observations	49,330	43,478	49,330	43,478
R-squared	0.731	0.788	0.731	0.788
Firm-merger FE	Yes	Yes	Yes	Yes
Year-merger FE	Yes	Yes	Yes	Yes

IV Regressions and Results

In this subsection, I complement the DiD analysis above with an instrument variable (IV) strategy to obtain a quantitative estimate of the effect of the VCO on suppliers' innovation activities from the variation generated by the financial institutional mergers. I run specifications with the difference between average log innovation variables in the periods before and after the mergers as the dependent variable, and the difference between average VCO in percentage in the periods before and after the mergers as the main explanatory variable. I control merger fixed effects and all control variables in the baseline regression. All the control variables are evaluated in the year prior to the mergers. I instrument the main explanatory variable with the treatment dummy constructed using the top and bottom terciles of the implied change in VCO, as in the DiD analysis above.[10] In particular, the first-stage regression is as follow:

$$\Delta_{post-pre}VCO_{ij} = \delta_1 \cdot Treatment_{ij} + X_{ij,-1} + \alpha_j + \varepsilon_{ij},$$

where $\Delta_{post-pre}VCO$ denotes the difference between the average VCO in the five years after the mergers and the average VCO in the five years before the mergers:

$$\Delta_{post-pre}VCO_{ij} = \frac{\sum_{t_{post}=1}^{5} VCO_{ij,t_{post}} \times 100}{5} - \frac{\sum_{t_{pre}=1}^{5} VCO_{ij,t_{pre}} \times 100}{5}.$$

And the second-stage regression is

$$\Delta_{post-pre}innovation_{ij} = \delta_2 \cdot \widehat{\Delta_{post-pre}VCO_{ij}} + X_{ij,-1} + \alpha_j + \varepsilon_{ij},$$

where $\Delta_{post-pre}innovation_{ij}$ denotes the difference between the average log innovation variables in the five years after the mergers and the average log innovation

[10]The raw implied change in VCO could also be used as the instrument. The benefit of using implied change in VCO as the instrument is that it makes use of more variation. But it potentially has more measurement error.

variables in the five years before the mergers:

$$\Delta_{post-pre}innovation_{ij} = \frac{\sum_{t_{post}=1}^{5} ln(1 + innovation_{ij,t_{post}})}{5} - \frac{\sum_{t_{pre}=1}^{5} ln(1 + innovation_{ij,t_{pre}}}{5}.$$

Panel A of Table 5 reports the result of first-stage regression. The treatment dummy works as a strong instrument for the difference between average VCOs before and after the mergers. Specifically, the p-values from underidentification tests are smaller than 1%, and the F-statistics from weak identification tests are around 75. The coefficient estimates for the instrument variable suggest that, compared with the control firms, the increase in the average VCO of the treated firms in the five years after the mergers is around 0.07 percentage point higher. Panel B of Table 5 presents the results of second-stage regressions. These results show positive and significant effects of the instrumented change in the VCO on the change in innovation. Multiplying the coefficients on $\Delta_{post-\widehat{pre}}VCO$ by the coefficient on $Treatment$ in the first-stage regression, the results suggest that compared with the control firms, the increase in R&D intensity of the treated firms after the mergers is about 4% higher, the increase in the number of applied patents is around 9% higher, and the increase in the average patent value is around 12% higher. These estimates are consistent with the results from the DiD analysis.

Testing the Parallel Trends Assumption

One crucial condition for the DiD approach to be appropriate is the assumption of parallel trends between the treatment and control groups in the pre-event period. I verify this assumption by comparing the average growth of the innovation measures for treated versus control firms during the five years prior to the institutional mergers. Table 6 reports the results of t-tests for differences between the average changes in innovation variables between treatment and control groups in pre-event period. The treated firms are identified using both equally weighted and value-weighted ΔVCOs. The p-values associated with the test statistics for these t-tests suggest that there are no significant differences of average changes in the innovation variable between treatment and control groups in pre-event period.

Table 5. Panel A of this table reports the first-stage IV regression results for the model:

$$\Delta_{post-pre}VCO_{ij} = \delta_1 \cdot Treatment_{ij} + X_{ij,-1} + \alpha_j + \varepsilon_{ij}.$$

$\Delta_{post-pre}VCO$ measures the difference between average VCO in the periods before and after the mergers. The instrument variable is the treatment dummy constructed using the top and bottom terciles of the implied change in VCO, as in the DiD analysis. Panel B of this table reports the second-stage regression results for the model:

$$\Delta_{post-pre}innovation_{ij} = \delta_2 \cdot \widehat{\Delta_{post-pre}VCO_{ij}} + X_{ij,-1} + \alpha_j + \varepsilon_{ij}.$$

$\Delta_{post-pre}innovation$ measures the difference between average log innovation variables in the periods before and after the mergers. In Panel B, the log innovation variables are $ln(1 + R\&D\ Intensity)$ columns (1) and (2), $ln(1 + \#pat)$ in columns (3) and (4), and $ln(1 + Avg.xi)$ in columns (5) and (6). X is a vector of all control variables used in baseline regression evaluated in the year before the mergers. $\Delta_{post-pre}VCO$ and $Treatment$ are constructed based on both equally weighted and sale-value-weighted VCO. Merger fixed effects are employed. Standard errors are clustered at the merger level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

Panel A	$\Delta_{post-pre}VCO$	
	EW	VW
	(1)	(2)
$Treatment$	0.071***	0.067***
	(8.727)	(7.702)
IO_{-1}	0.001	0.002
	(0.076)	(0.085)
$IO\ HHI_{-1}$	-0.007	-0.009
	(-1.214)	(-1.317)
Q_{-1}	0.006***	0.007***
	(5.413)	(5.642)
$ln(Sales)_{-1}$	0.011***	0.012***
	(3.436)	(3.866)
$Capital\ Intensity_{-1}$	-0.072***	-0.058**
	(-2.880)	(-2.524)
$Profitability_{-1}$	0.010	0.012
	(0.906)	(1.132)
$Leverage_{-1}$	-0.016	-0.018
	(-0.674)	(-0.764)
Observations	4,200	4,200
Merger FE	Yes	Yes
P-val. (Underidentification Test)	0.0000	0.0000
Kleibergen-Paap Wald rk F-stat. (Weak Identification Test)	76.16	74.61

Table 5. (continued).

Panel B	$\Delta ln(1 + R\&D\ Intensity)$		$\Delta ln(1 + \#pat)$		$\Delta ln(1 + Avg.xi)$	
	EW	VW	EW	VW	EW	VW
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta_{post-pre}\widehat{VCO}$	0.626**	0.703***	1.329***	1.256***	1.698***	1.701***
	(2.485)	(2.769)	(3.412)	(3.052)	(4.190)	(3.965)
IO_{-1}	-0.242***	-0.243***	0.072	0.069	0.134**	0.132**
	(-4.053)	(-4.141)	(1.470)	(1.387)	(2.312)	(2.193)
$IO\ HHI_{-1}$	-0.260**	-0.259**	-0.123***	-0.122***	-0.045	-0.044
	(-2.319)	(-2.298)	(-3.049)	(-3.039)	(-0.995)	(-0.980)
Q_{-1}	-0.004	-0.005	0.023***	0.023***	0.008	0.008
	(-0.353)	(-0.432)	(3.853)	(3.839)	(1.388)	(1.250)
$ln(Sales)_{-1}$	0.017*	0.016	-0.015	-0.015	-0.007	-0.009
	(1.905)	(1.679)	(-0.964)	(-0.964)	(-0.787)	(-0.956)
$Capital\ Intensity_{-1}$	-0.631***	-0.634***	0.086	0.060	0.171*	0.159*
	(-4.690)	(-4.666)	(0.688)	(0.463)	(1.930)	(1.706)
$Profitability_{-1}$	0.831***	0.829***	0.370***	0.370***	0.133***	0.132***
	(8.975)	(8.961)	(8.137)	(8.168)	(3.695)	(3.762)
$Leverage_{-1}$	-0.118**	-0.115**	-0.137***	-0.133***	-0.081	-0.075
	(-2.154)	(-2.081)	(-2.919)	(-2.894)	(-1.276)	(-1.205)
Observations	4,200	4,200	5,026	5,026	5,026	5,026
R-squared	0.067	0.060	0.044	0.039	0.173	0.193
Merger FE	Yes	Yes	Yes	Yes	Yes	Yes

Therefore, the parallel trends assumption is likely to hold in my setting.

Table 6. This table presents the test to verify the parallel trend assumption. Columns (1) and (2) report the average changes in the innovation measures for treated firms during the five years before financial institution mergers, while columns (3) and (4) report the average changes in innovation measures for control firms during the five years before the mergers. The treated and control firms are identified based on equally weighted ΔVCO in columns (1) and (3), and based on sales-value-weighted ΔVCO in columns (2) and (4). Columns (5) and (6) report the differences in means of innovation measures between treatment and control groups. Columns (7) and (8) report p-vlaues associated with test statistics of t-tests for differences in means.

	Changes in Pre-event Period				Difference		t-test	
	Treatment Mean		Control Mean		(1)-(3)	(2)-(4)	P-value	P-value
	EW	VW	EW	VW	EW	VW	EW	VW
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$ln(1 + R\&D\ Intensity)$	-.001	-.001	-.016	-.017	.015	.016	.132	.123
$ln(1 + \#pat)$	.199	.195	.245	.253	-.046	-.058	.291	.187
$ln(1 + Avg.xi)$	.242	.241	.291	.297	-.049	-.057	.282	.211

Overall, the DiD and the IV analyses suggest that an exogenous increase in a supplier's vertical common ownership leads, on average, to greater amounts of supplier innovation input and output. The findings provide plausible evidence for a causal interpretation of the positive relation between vertical common ownership and supplier innovation activities.

Additional Tests

Vertical vs. Horizontal Common Ownership

To assess whether there are different effects between vertical and horizontal common ownerships, I include a proxy for common ownership of competitors (i.e., horizontal common ownership) in the baseline regressions. Similar to the construction of vertical common ownership, I first construct a firm-pair-level measure of horizontal common ownership, called *pairwise HCO*, as:

$$pairwise\ HCO_{ijt} = \sum_{f=1}^{F} \beta_{fit} \cdot \beta_{fjt},$$

where there are F institutions holding both firm i and its competitor j. $\beta_{fi(j)t}$ denotes institution f's holding fraction of firm i (competitor j) in year t. The value of *pairwise VCO* is higher when there are more common owners and/or when these common owners are holding higher fractions of firms and/or their competitors. I use FIC500 code developed by Hoberg and Phillips (2016) to identify competitors.[11]

Next, I aggregate *pairwise HCO* at the level of firm i to construct *HCO* as:

$$HCO_{it} = \sum_{j=1}^{J} w_{jt} \cdot pairwise\ HCO_{ijt},$$

where there are J competitors for firm i. The weight w_{jt} denotes competitor j's

[11] I do not use SIC codes because industry identification on the basis of SIC codes has multiple issues. First, the industry of a conglomerate cannot be described by a single SIC. Second, firms with the same SIC code are not necessarily competitors, but could be upstream and downstream firms in the same industry. FIC codes mitigate these issues by introducing text-based industry categorization. In particular, FIC codes group the firms into different industries based on the similarity of their product descriptions in 10-K files. FIC500 categorizes firms in the market into 500 industry groups. In untabulated results, I also use FIC300 and FIC400, and get similar results.

relative share among all the competitors in year t. I employ both equal weights and weights on the basis of market value of each competitor.

Table 7 reports the results for models that also control for horizontal common ownership. Given that the needed FIC code is available only for 1996 and later, the sample period for these models is from 1996 to 2010, and sample sizes are smaller than baseline regressions. Panel A compares the effects of vertical versus horizontal common ownership on innovation input as measured by R&D Intensity. Columns (1) and (2) show that equally weighted and value-weighted vertical common ownerships are positively associated with R&D Intensity at the 10% and 5% significance levels respectively. Columns (3) and (4) show that only value-weighted horizontal common ownership is positively associated with R&D Intensity, at the 1% significance level, if VCO is excluded from the model. It implies that the impact of horizontal common ownership on R&D Intensity works mainly through the common holdings of the large firms. When both vertical and horizontal common ownership are included in the regressions, as in columns (5) and (6), horizontal common ownership loses statistical significance, while equally weighted and value-weighted vertical common ownerships still keep statistical significance at 10% and 5% levels respectively. The coefficient magnitudes of vertical common ownership are larger than those of horizontal common ownership in all six columns. The vertical common ownership effect clearly dominates.

Panel B compares the effects between vertical and horizontal common ownership on suppliers' quantity of innovation output as measured by $ln(1 + \#pat)$. Columns (1) and (2) show that both equally weighted and value-weighted vertical common ownerships are positively associated with $ln(1 + \#pat)$ at the 1% significance level. Columns (3) and (4) show that both equally weighted and value-weighted horizontal common ownerships are positively related to $ln(1 + \#pat)$ at the 1% significance level as well, and the coefficient magnitudes of horizontal common ownership are larger than those of vertical common ownership. When both vertical and horizontal common ownerships are included in the regressions in columns (5) and (6), both vertical and horizontal common ownerships retain their statistical significances.

Lastly, Panel C compares the effects of vertical and horizontal common ownership on the quality of innovation output as measured by $ln(1 + Avgxi)$. Columns (1) and (2) show that equally weighted and value-weighted vertical common ownership are positively associated with $ln(1 + Avgxi)$ at the 1% and 5% significance levels respectively. Columns (3) and (4) show that both equally weighted and value-weighted horizontal common ownership are also positively associated with $ln(1 + Avgxi)$ at the 10% significance level. When both vertical and horizontal common ownerships are included in the regressions in columns (5) and (6), horizontal common ownership loses statistical significance, while vertical common ownership retains statistical significance at the 10% level, suggesting that the effect of VCO again dominates.

Table 7. This table reports the results for models that regress the innovation activity measure on vertical common ownership, horizontal common ownership, and both. The dependent variables are $ln(1 + R\&D\ Intensity)$ in Panel A, $ln(1 + \#pat)$ in Panel B, and $ln(1 + Avg.xi)$ in Panel C. The results for vertical common ownership are in columns (1) and (2), those for horizontal common ownership are in columns (3) and (4), and those for both are in columns (5) and (6). Columns (1), (3), and (5) show the results with equally weighted common ownership measures, and columns (2), (4), and (6) show the results with value-weighted measures. All control variables, firm and year fixed effects are included in all regressions. Standard errors are clustered at the industry level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

	(1) EW	(2) VW	(3) EW	(4) VW	(5) EW	(6) VW
Panel A	$ln(1 + R\&D\ Intensity)$					
VCO	2.818*	1.851**			2.996*	1.588**
	(1.896)	(2.500)			(1.756)	(2.066)
HCO			0.942	1.606***	-0.860	0.814
			(1.054)	(2.833)	(-0.563)	(1.649)
Observations	6,237	6,237	6,237	6,237	6,237	6,237
R-squared	0.847	0.847	0.847	0.847	0.847	0.847
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 7. (continued).

	(1) EW	(2) VW	(3) EW	(4) VW	(5) EW	(6) VW
Panel B			$ln(1 + \#pat)$			
VCO	24.890***	22.687***			19.644**	13.346*
	(3.495)	(3.154)			(2.605)	(1.768)
HCO			34.036***	30.346***	19.318*	22.507***
			(3.222)	(4.834)	(1.699)	(3.611)
Observations	6,671	6,671	6,671	6,671	6,671	6,671
R-squared	0.837	0.837	0.837	0.837	0.837	0.837
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Panel C			$ln(1 + Avg.xi)$			
VCO	11.107***	9.995**			9.033*	7.286*
	(2.817)	(2.548)			(1.967)	(1.752)
HCO			14.441*	10.681*	7.461	6.283
			(1.710)	(1.841)	(0.773)	(0.991)
Observations	6,673	6,673	6,673	6,673	6,673	6,673
R-squared	0.779	0.779	0.779	0.779	0.779	0.779
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Overall, Table 7 shows that vertical common ownership has a more robust effect on innovation input and quality of innovation output than does horizontal common ownership. The magnitude of vertical common ownership's impact on input to innovation is consistently larger than that of horizontal common ownership. The reason might be that there are two countervailing effects of horizontal common ownership on corporate innovation: a positive effect from technology spillovers and a negative business-stealing effect from competitors (Bloom et al., 2013; Anton et al., 2018). In contrast, the impact of vertical common ownership on corporate innovation has two positive effects: a positive technology-spillover effect, and a positive effect from hold-up mitigation along the supply chain.

Different Assumptions Concerning Shareholder Attention

Gilje, Gormley, and Levit (2019) construct their common ownership measure by taking into account heterogeneous institutional attention to different firms in a portfolio. In particular, a shareholder's attention to a specific firm in her portfolio is positively related to the "importance" of this firm, which is measured by the weight of this firm in the shareholder's portfolio. Gilje et al. (2019), hereafter GGL, provide three different firm-pair measures of common ownership on the basis of three different assumptions about shareholders' attention:

(1) Linear attention: The shareholder's attention is proportional to the weight of a specific firm in her portfolio,

(2) Convex attention: The shareholder allocates more attention to the firm with higher weight in her portfolio,

(3) Concave attention: The shareholder devotes less attention to the firm with higher weight in her portfolio.

I further aggregate the firm-pair-level measures at the supplier level as:

$$GGLVCO_{st} = \sum_{c=1}^{C} w_{ct} \cdot GGL_{sct},$$

where there are C customers for supplier s in year t. GGL_{sct} is the common ownership measure for the pair consisting of supplier s and customer c in year t. GGL can be constructed under three different assumptions of investors' attention as discussed above. More details about the construction of the GGL measures are provided in Appendix VI.. The term w_{ct} denotes the weight of customer c. Both equal weights and sales-value weights are employed. Following Gilje et al. (2019), I also rescale the common ownership measures by the sample mean.

Table 8 reports the baseline regression results for alternative vertical common ownership measures on the basis of different assumptions about shareholder attention. Panel A shows positive and statistically significant relationships between innovation input measured by $ln(1 + R\&D\ Intensity)$ and vertical common ownership measures under assumptions of linear attention and concave attention in columns (1), (2), (5) and (6). Panel B demonstrates positive and statistically significant associations between the quantity of innovation output measured by $ln(1+\#pat)$ and vertical common ownership measures, differentiated by the three different assumptions about shareholder attention. Lastly, Panel C also displays positive and statistically significant associations between the quality of innovation output measured by $ln(1 + Avg.xi)$ and the vertical common ownership measures under assumptions of linear attention and concave attention in columns (1), (2), (5) and (6).

Overall, the positive and statistically significant relationships between innovation activities and supplier vertical common ownership are robust across models that use alternative measures of common ownership and different assumptions about the allocation of shareholder attention.

Table 8. This table reports the regression results with alternative vertical common ownership measures differentiated on the basis of shareholder attention assumptions. The shareholder attention models and firm-pair level common ownership measures are developed and provided by Gilje et al. (2019). $GGLVCO_{st} = \sum_{c=1}^{C} w_{ct} \cdot GGL_{sct}$, where there are C customers for supplier s in year t. GGL_{sct} is the common ownership measure for the pair of supplier s and customer c in year t. GGL can be constructed under three different assumptions about investors' attention: linear attention, concave attention, and convex attention. More details about the construction of the GGL measures are provided in Appendix VI.. w_{ct} denotes the weight of customer c. Both equal weights and sales-value weights are employed. Following Gilje et al. (2019), I also rescale the common ownership measures by the sample mean. The dependent variables are $ln(1 + R\&D\ Intensity)$ in Panel A, $ln(1 + \#pat)$ in Panel B, and $ln(1 + Avg.xi)$ in Panel C. The estimated effects of vertical common ownership in the case of linear shareholder attention are in columns (1) and (2), those with convex shareholder attention are in columns (3) and (4), and those with concave shareholder attention are in columns (5) and (6). Columns (1), (3), and (5) show the results with equally weighted common ownership measures, and columns (2), (4), and (6) show the results with value-weighted measures. All control variables, firm and year fixed effects are included in all regressions. Standard errors are clustered at the industry level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

	(1) EW	(2) VW	(3) EW	(4) VW	(5) EW	(6) VW
Panel A	$ln(1 + R\&D\ Intensity)$					
	Linear		Convex		Concave	
$GGLVCO$	0.001*	0.001*	0.000	0.000	0.003***	0.002**
	(1.777)	(1.685)	(1.102)	(1.114)	(2.637)	(2.232)
Observations	11,857	11,857	11,857	11,857	11,857	11,857
R-squared	0.827	0.827	0.827	0.827	0.827	0.827
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 8. (continued).

	(1) EW	(2) VW	(3) EW	(4) VW	(5) EW	(6) VW
Panel B	$ln(1+\#pat)$					
	Linear		Convex		Concave	
GGLVCO	0.023***	0.021***	0.007***	0.006*	0.047***	0.043***
	(3.272)	(2.976)	(2.005)	(1.700)	(3.529)	(3.114)
Observations	11,866	11,866	11,866	11,866	11,866	11,866
R-squared	0.814	0.814	0.814	0.814	0.815	0.815
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Panel C	$ln(1+Avg.xi)$					
	Linear		Convex		Concave	
GGLVCO	0.011**	0.010**	0.002	0.002	0.024***	0.021**
	(2.057)	(1.998)	(0.925)	(0.941)	(2.815)	(2.609)
Observations	11,866	11,866	11,866	11,866	11,866	11,866
R-squared	0.774	0.774	0.774	0.774	0.775	0.775
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

V. VERTICAL COMMON OWNERSHIP AND SUPPLIERS' INNOVATION ACTIVITIES: POTENTIAL CHANNELS

Baseline regressions and DiD analyses suggest that vertical common ownership leads suppliers to improve their innovation input and output. This section explores potential reasons why vertical common ownership may affect supplier innovation activities: (1) a hold-up mitigation channel, (2) a technological spillover channel, and (3) a vertical creative destruction channel.

Hold-up Mitigation Channel

The hold-up problem could emerge for a supplier when its customers act opportunistically towards the supplier's relationship-specific innovation/products. The customer opportunism could reduce the supplier's incentives to invest in, and thus generate, innovations. The hold-up problems are unobservable, therefore I construct proxies for the scenarios that are related to the severities of potential hold-up problems. In particular, a hold-up channel is examined from three perspectives: (1) a supplier's vertical integration with its operating segments, (2) a supplier's bargaining power relative to its customers, and (3) the asset specificity of inputs to a supplier's customers.[12]

Vertically integrated firms are those for whom at least one of their operating segments is in the downstream industry. When the customers of vertically integrated firms act or tend to act opportunistically, the segments in downstream industries can at least temporarily function as "internal customers." Therefore, customer opportunism has less impact on vertically integrated suppliers.

When the market power of a supplier in its own industry is relatively stronger than that of its customer in that customer's industry, the bargaining power of the

[12] According to FASB 131, an operating segment is a component of an entity that (1) engages in business activities from which it may earn revenues and incur expenses and (2) has discrete financial information available. An operating segment's operating results are reviewed regularly by the entity's chief operating decision maker to make decisions about resources to be allocated to the segment and assess its performance. An operating segment could be a division, unit, or department of a firm. Public firms are required to disclose information about their operating segments.

supplier is stronger vis-à-vis the customer. Strong market power of a supplier in its industry implies that the supplier has relatively better production capability than peer firms. Its products thus have relatively larger market share and more stable quality control. If a customer switches to other less competitive suppliers, the marginal cost for purchasing the input could be larger due to less accessibility or potentially worse quality. From the customer side, weak market power in its industry implies that the customer has relatively smaller market share than peer firms, and therefore there will be less opportunity cost for its supplier to break the relationship and transfer to other customers. In sum, it is less likely for the customer to act opportunistically by threatening to transfer to other suppliers that provide similar products. Suppliers with stronger bargaining power relative to their customers therefore have fewer hold-up problems.

Customer opportunism arises mainly towards relationship-specific products because these customized products are hard to market or difficult to use for other customers. When the input to customers can be more easily used in other industries (i.e., these assets have less asset specificity), it is less likely for the suppliers to produce relationship-specific products, thereby leading to fewer hold-up problems for the suppliers.

Theoretical studies (e.g., Grossman and Hart, 1986) suggest that joint ownership could mitigate the severities of hold-up problems. Common owners have the incentive to mitigate the severities of hold-up problems because they could actually benefit from better (relationship-specific) innovation performance of the suppliers that could result from improved supplier-customer relationships. For example, relationship-specific products can lower the cost of inputs for the customers, thereby leading to higher profits and thus potentially higher values of the customers as well as the entire portfolio. If vertical common ownership really improve suppliers' innovation performance by mitigating the hold-up problems between suppliers and customers in the same portfolio, I expect to see that the impact of vertical common ownership is less pronounced for the suppliers with fewer hold-up problems in the first place.

The following subsections report the construction of proxies for hold-up issues, and results of the tests for the conjectures above.

Vertical Integration

As discussed above, if vertical common ownership really affects suppliers' innovation activities by lessening opportunities for hold-up problems between the supplier and its customers, the impact of vertical common ownership on innovation activities should be less pronounced for vertically integrated suppliers. I test this conjecture by running the following regression:

$$\begin{aligned} Innovation_{it} =& \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot PVI_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot PVI_{i,t-1}) \\ &+ \beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it}, \end{aligned} \tag{1}$$

where PVI_{it} is the percentage of sales from operating segments in downstream industries out of the total sales from all its segments.[13] I expect to see a negative and statistically significant estimate for the coefficient μ on the interaction term in equation (1) if the conjecture holds.

Table 9 reports the results for tests of this conjecture. The estimated coefficients on the interaction terms between vertical common ownership and the weight of segments in downstream industries measured by PVI are negative and significant when the dependent variables are the innovation input and the quality of innovation output. This finding suggests that the effects of vertical common ownership on the outcome variables, (1) investment in innovation and (2) quality of innovation output, are weaker for more vertically integrated suppliers. This finding is consistent with the argument that vertical common ownership improves the innovation input and the quality of innovation output by reducing the likelihood of hold-up problems.

Supplier Bargaining Power

If a supplier has stronger bargaining power, relative to its customers, then these customers are less likely to act opportunistically against the supplier. I construct the variable Size Rank Ratio (SRR) as a proxy for a supplier's bargaining power

[13] I follow Martin and Otto (2017)'s procedures to identify operating segments in the downstream industries of a firm. More details about the method are in Appendix VI..

Table 9. This table reports regression results for the model:

$$Innovation_{it} = \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot PVI_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot PVI_{i,t-1}) + \beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it},$$

where PVI is the percentage of sales from segments in downstream industries out of the total sales from all segments. The dependent variables are $ln(1 + R\&D\ Intensity)$ in columns (1) and (2), $ln(1 + \#pat)$ in columns (3) and (4), and $ln(1 + Avg.xi)$ in columns (5) and (6). The supplier-level variable VCO is an equally weighted average of supplier-customer-pair-level vertical common ownership in columns (1), (3) and (5); and a sales-value-weighted average in columns (2), (4) and (6). Firm and year fixed effects are employed in all regressions. Standard errors are clustered at the industry level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

	$ln(1 + R\&D\ Intensity)$		$ln(1 + \#pat)$		$ln(1 + Avg.xi)$	
	EW	VW	EW	VW	EW	VW
	(1)	(2)	(3)	(4)	(5)	(6)
VCO	3.057**	3.310**	27.549***	27.048***	32.983***	31.691***
	(2.515)	(2.323)	(2.958)	(3.171)	(3.537)	(3.400)
PVI	-0.003	0.002	-0.011	-0.011	-0.058	-0.063
	(-0.165)	(0.105)	(-0.101)	(-0.103)	(-0.557)	(-0.602)
$VCO \cdot PVI$	-5.780**	-7.210**	-9.275	-9.282	-30.959***	-29.179***
	(-2.269)	(-2.045)	(-0.605)	(-0.627)	(-2.938)	(-2.750)
$IO\ HHI$	0.003	0.003	0.090*	0.090*	0.104**	0.104**
	(0.203)	(0.218)	(1.816)	(1.819)	(2.438)	(2.444)
IO	-0.003	0.000	-0.193	-0.192	0.143	0.143
	(-0.175)	(0.011)	(-1.613)	(-1.586)	(1.301)	(1.279)
Q	-0.003	-0.003	0.036***	0.036***	0.047***	0.047***
	(-0.839)	(-0.842)	(5.199)	(5.196)	(7.101)	(7.111)
$ln(Sales)$	0.018***	0.018***	0.397***	0.397***	0.207***	0.207***
	(3.795)	(3.650)	(8.604)	(8.601)	(10.781)	(10.659)
$Capital\ Intensity$	-0.032	-0.032	0.319**	0.321**	0.243	0.245
	(-1.478)	(-1.477)	(2.305)	(2.326)	(1.562)	(1.577)
$Profitability$	-0.189**	-0.189**	-0.165***	-0.165***	0.039	0.039
	(-2.189)	(-2.195)	(-2.856)	(-2.843)	(0.977)	(0.971)
$Leverage$	-0.103**	-0.103**	-0.330***	-0.329***	-0.146***	-0.146***
	(-2.155)	(-2.157)	(-4.951)	(-4.963)	(-2.793)	(-2.778)
Observations	11,859	11,859	11,868	11,868	11,868	11,868
R-squared	0.824	0.824	0.821	0.821	0.775	0.775
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

relative to its customers:

$$SRR_{it} = \sum_{c=1}^{C} w_{ct} \frac{SR_{it}}{SR_{ct}},$$

where supplier i in year t has C customers. $SR_{i(c)t}$ denotes supplier i (customer c)'s size rank in year t. Size rank of a firm is measured as the decile of its accumulated sales, across the current year and the past two years, in its market as identified by its three-digit SIC code. The weight w_{ct} applies to customer c in year t. I use both (1) equal weights, and (2) value weights based on the sales value between supplier and its customers.

I use accumulated sales because the market power of a firm is the consequence of persistent market performance in multiple years. Short-term sales in a single year may not correctly reflect the true market power of a firm. Size rank reflects the relative market performance of a firm compared with its peers in the same industry. It is more comparable across different industries than sales value or market share. Sales value ignores different sizes across industries. Market share takes industry size into consideration, but ignores the relation between the firm and its peers in the same industry. For example, Firm A has 30% market share in an industry with only two firms and the other firm has 70% market share, while Firm B also has 30% market share, but in an industry with many firms and each of these other firms has less than 5% market share. Firm A and B have the same market share, but the market power is unlikely to be the same.

If vertical common ownership really affects suppliers' innovation activities by mitigating the hold-up issues between a supplier and its customers, the impact of vertical common ownership on innovation activities should be less pronounced for suppliers with higher SRR. I test this conjecture using the following regression:

$$\begin{aligned} Innovation_{it} = & \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot SRR_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot SRR_{i,t-1}) \\ & + \beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it}. \end{aligned} \tag{2}$$

If the conjecture holds, I expect to see a negative and statistically significant estimate for the coefficient μ on the interaction term in equation (2).

Table 10 reports the results for tests of this conjecture. The estimating sample retains only those suppliers having all their customers with available sales data, so the sample size for these regressions is smaller. The estimate for the coefficent on interaction term between vertical common ownership and the size-rank ratio is negative and significant in the model to explain innovation input. The result suggests that the effect of vertical common ownership on investment in innovation is weaker for a supplier with stronger bargaining power relative to its customers. This finding is consistent with the argument that vertical common ownership improves innovation input by minimizing the potential for hold-up problems.

Customer Input Redeployability

If customers are using an input that can be redeployed more easily to other industries, so that their suppliers' products and related innovation are less relationship-specific, these suppliers are less likely to be held up by their customers. Kim and Kung (2017) develop proxies for asset redeployability according to the BEA I/O table. Based on their measures, I construct the variable Input Redeployability (IR) as proxy for the asset specificity of customer inputs:

$$IR_{it} = \sum_{c=1}^{C} w_{ct} \cdot Redeployability_{ct},$$

where supplier i in year t has C customers. $Redeployability_{ct}$ is the firm-level redeployability score developed by Kim and Kung (2017) for customer c in year t. Higher $Redeployability_{ct}$ implies that customer c is using a more redeployable (i.e. less relationship-specific) input from her suppliers. Kim and Kung (2017) also provide their dataset of redeployability scores. The factor w_{ct} denotes the weight of customer c in year t. I use both equal weights and value weights based on the value of sales between the supplier and its customers.

If vertical common ownership really affects suppliers' innovation activities by mitigating the hold-up issues between suppliers and their customers, the impact of vertical common ownership on innovation activities should be less pronounced for

Table 10. This table reports regression results for the model:

$$Innovation_{it} = \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot SRR_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot SRR_{i,t-1}) + \beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it},$$

where $SRR_{it} = \sum_{c=1}^{C} w_{ct} SR_{it}/SR_{ct}$. $SR_{i(c)t}$ denotes supplier i (customer c)'s size rank in year t. Size rank of a firm is measured as the decile of its accumulated sales in the current year and the past two years in its market, as identified by three-digit SIC codes. w_{ct} denotes the weight of customer c in year t. The dependent variables are $ln(1 + R\&D\ Intensity)$ in columns (1) and (2), $ln(1 + \#pat)$ in columns (3) and (4), and $ln(1 + Avg.xi)$ in columns (5) and (6). VCO and SRR are equally weighted in columns (1), (3) and (5); and sales-value weighted in columns (2), (4) and (6). Firm and year fixed effects are employed in all regressions. Standard errors are clustered at the industry level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

	$ln(1 + R\&D\ Intensity)$		$ln(1 + \#pat)$		$ln(1 + Avg.xi)$	
	EW	VW	EW	VW	EW	VW
	(1)	(2)	(3)	(4)	(5)	(6)
VCO	6.630**	5.883***	10.927	12.855	14.413	14.432*
	(2.560)	(2.815)	(0.667)	(0.850)	(1.464)	(1.746)
SRR	0.025***	0.025***	-0.102	-0.109	-0.104***	-0.105***
	(2.676)	(2.635)	(-1.402)	(-1.520)	(-3.426)	(-3.115)
$VCO \cdot SRR$	-5.595**	-5.106**	19.703	16.771	5.602	4.362
	(-2.548)	(-2.604)	(0.930)	(0.854)	(0.657)	(0.578)
$IO\ HHI$	-0.030	-0.030	0.011	0.012	0.097*	0.098*
	(-1.338)	(-1.341)	(0.166)	(0.188)	(1.660)	(1.688)
IO	0.031	0.033	-0.043	-0.039	0.269*	0.275**
	(1.565)	(1.544)	(-0.260)	(-0.230)	(1.956)	(1.998)
Q	-0.005	-0.005	0.023**	0.023**	0.036***	0.036***
	(-0.973)	(-0.972)	(2.252)	(2.257)	(4.022)	(4.038)
$ln(Sales)$	-0.059	-0.059	0.326***	0.328***	0.201***	0.202***
	(-1.644)	(-1.646)	(3.693)	(3.704)	(6.961)	(6.929)
$Capital\ Intensity$	-0.084	-0.083	0.079	0.080	-0.117	-0.115
	(-1.440)	(-1.432)	(0.398)	(0.401)	(-0.790)	(-0.775)
$Profitability$	-0.038*	-0.038*	-0.290***	-0.290***	-0.035	-0.035
	(-1.713)	(-1.727)	(-4.506)	(-4.500)	(-0.515)	(-0.516)
$Leverage$	-0.056***	-0.056***	-0.272***	-0.272***	-0.049	-0.050
	(-2.770)	(-2.782)	(-3.067)	(-3.050)	(-0.669)	(-0.669)
Observations	7,763	7,763	7,763	7,763	7,763	7,763
R-squared	0.866	0.866	0.829	0.829	0.799	0.799
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

suppliers with higher IR. I test this conjecture by running the following regression:

$$\begin{aligned} Innovation_{it} =&\beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot IR_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot IR_{i,t-1}) \\ &+\beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it}. \end{aligned} \tag{3}$$

I expect to see a negative and statistically significant estimate for the coefficient μ on the interaction term in equation (3), if the conjecture holds.

Table 11 reports the results for tests of this conjecture. Kim and Kung (2017)'s dataset starts only in 1985, so the sample size for these regressions is smaller. The estimates for the coefficient on the interaction term between vertical common ownership and customer input redeployability are negative and significant when the dependent variable is innovation input. This result suggests that the effect of vertical common ownership on investment in innovation is weaker for the suppliers with customers that are using more redeployable inputs from these suppliers. This finding is consistent with the argument that vertical common ownership improves innovation input by reducing the potential for hold-up problems with specific consumers.

Overall, the three tests with diffrent proxies for intensity of hold-up issues consistently suggest that vertical common ownership influences suppliers' innovation through a hold-up channel. Investment in innovation is the only robust measure of innovation performance for the three tests. It suggests that this hold-up channel works mainly for innovation input, and has little influence on innovation output.

Technological Spillover Channel

Another potential channel whereby vertical common ownership may impact a supplier's innovation activities is through technological spillover. Technological spillover has been shown to improve corporate innovation performance (e.g., Chu et al., 2019). Empirical evidence (e.g., Kostovetsky and Manconi, 2020) also demonstrates that common ownership is associated with more information exchange concerning innovation, such as patent citations between firms. It is empirically challenging to test unobservable technological spillover. In this paper, I use a proxy for conditions that can facilitate technological spillover, in particular, the "technology proximities" between suppliers and their customers.

Table 11. This table reports regression results for the model:

$$Innovation_{it} = \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot IR_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot IR_{i,t-1}) + \beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it},$$

where $IR_{it} = \sum_{c=1}^{C} w_{ct} \cdot Redeployability_{ct}$. $Redeployability_{ct}$ is the firm-level redeployability score developed by Kim and Kung (2017) for customer c in year t. The term w_{ct} denotes the weight of customer c in year t. The dependent variables are $ln(1 + R\&D\ Intensity)$ in columns (1) and (2), $ln(1 + \#pat)$ in columns (3) and (4), and $ln(1 + Avg.xi)$ in columns (5) and (6). VCO and IR are equally weighted in columns (1), (3) and (5); and sales-value weighted in columns (2), (4) and (6). Firm and year fixed effects are employed in all regressions. Standard errors are clustered at the industry level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

	$ln(1 + R\&D\ Intensity)$		$ln(1 + \#pat)$		$ln(1 + Avg.xi)$	
	EW	VW	EW	VW	EW	VW
	(1)	(2)	(3)	(4)	(5)	(6)
VCO	11.946*	12.881**	26.124	32.594	13.766	8.662
	(1.833)	(2.165)	(0.687)	(0.863)	(0.424)	(0.282)
IR	-0.086	-0.062	0.062	0.048	0.012	0.008
	(-0.929)	(-0.712)	(0.188)	(0.158)	(0.038)	(0.028)
$VCO \cdot IR$	-23.407*	-27.383**	-3.687	-20.231	-1.877	6.825
	(-1.733)	(-2.036)	(-0.040)	(-0.220)	(-0.023)	(0.088)
$IO\ HHI$	-0.040	-0.040	-0.051	-0.051	0.059	0.059
	(-1.279)	(-1.276)	(-0.991)	(-0.997)	(0.869)	(0.865)
IO	0.077*	0.081*	0.091	0.094	0.296***	0.303***
	(1.795)	(1.754)	(0.709)	(0.723)	(2.818)	(2.862)
Q	-0.008	-0.008	0.016*	0.016*	0.038***	0.038***
	(-1.420)	(-1.423)	(1.922)	(1.915)	(5.287)	(5.272)
$ln(Sales)$	-0.070**	-0.070**	0.248***	0.249***	0.155***	0.155***
	(-2.013)	(-2.020)	(3.618)	(3.613)	(8.227)	(8.191)
$Capital\ Intensity$	-0.009	-0.009	0.057	0.058	0.056	0.056
	(-0.351)	(-0.354)	(0.409)	(0.421)	(0.357)	(0.355)
$Profitability$	-0.058***	-0.059***	-0.218***	-0.219***	0.038	0.037
	(-4.521)	(-4.581)	(-2.763)	(-2.782)	(0.685)	(0.674)
$Leverage$	-0.035*	-0.035*	-0.309***	-0.309***	-0.118*	-0.118*
	(-1.952)	(-1.961)	(-4.400)	(-4.403)	(-1.882)	(-1.871)
Observations	8,914	8,914	8,920	8,920	8,920	8,920
R-squared	0.842	0.842	0.836	0.836	0.787	0.787
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Jaffe (1986) suggests that technologicial spillover is related to the technological nature of firms' past research, and presents evidence that closer technological positions of firms' research programs lead to stronger spillover effects between them. The similarity between firms' research programs facilitates the information spillover because it is easier for researchers in similar fields to communicate with and learn from each other. If vertical common ownership really enhances suppliers' innovation performance by improving technological spillovers between suppliers and customers in the same portfolio, I expect to observe that the impact of vertical common ownership on innovation activities is stronger for suppliers having closer technology proximity with their customers.

Following Jaffe (1986), I construct the variable called Technology Proximity (TP) as a proxy for the degree of similarity in the technoloigcal spaces of suppliers and customers:

$$TP_{it} = \sum_{c=1}^{C} w_{ct} \frac{(S'_{it} C_{ct})^2}{(S'_{it} S_{it})(C'_{ct} C_{ct})},$$

where supplier i in year t has C customers. S_{it} (C_{ct}) is a column vector, and each element of S_{it} (C_{ct}) is the ratio of the number of supplier i (customer c)'s patents in the last three years (i.e., from year $t-2$ to year t), in a given patent class, to the total number of supplier i (customer c)'s patents in the last three years.[14] The factor w_{ct} denotes the weight of customer c in year t. I use both equal weights and value weights based on the sales value between a supplier and its customers.

The impact of vertical common ownership on a supplier's innovation activities should be stronger for suppliers with higher technology proximity with its customers if a technological spillover channel exists. I test this conjecture by running the following regression:

$$\begin{aligned} Innovation_{it} = & \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot TP_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot TP_{i,t-1}) \\ & + \beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it}. \end{aligned} \tag{4}$$

I expect to see a positive and statistically significant estimate for the coefficient μ

[14]Before 2013, the United States Patent and Trademark Office (USPTO) used the United States Patent Classification (USPC) system to categorize patents based on the technical features. It has 420 unique classification codes.

on the interaction term in equation (4), if the conjecture holds.

Table 12 reports the results for tests of this conjecture. The estimates for the coefficients on the interaction term between vertical common ownership and technology proximity are positive and significant for both the quantity and the quality of innovation output, but insignificant for the innovation input. These results suggest that the effect of vertical common ownership on innovation output is stronger for firms with greater technology proximity to their customers. This finding is consistent with the argument that vertical common ownership improves innovation output by improving technological spillovers between suppliers and their customers.

Vertical Creative Destruction Channel

Vertical creative destruction describes the situation that innovations by suppliers can devalue customers' assets-in-place (Gofman et al., 2020). Common owners tend to internalize all the externalities imposed on firms held in the same portfolio (Hansen and Lott, 1996), so they might also react to the negative impact caused by vertical creative destruction.

The vertical creative destruction effect should be the strongest if the suppliers are capital-goods producers. In my empirical test, I identify suppliers in capital-producing industries based on BEA I/O tables. In particular, I construct a variable called capital-to-total-use ratio (CTUR) based on the USE table:

$$CTUR_{jt} = Capital\ Good_{jt}/Total\ Use_{jt},$$

where the use of a commodity by industry j as *Capital Good* is the sum of non-residential fixed investment in equipment, intellectual property, and structures, and residential fixed investment in the USE table. Furthermore, $Total\ Use$ of the commodity by industry j includes the intermediate use, consumption, government use, and all other types of investment in the USE table. Then I identify the capital-producing industries as those industries with CTUR larger than 0.5.

The impact of vertical common ownership on a supplier's innovation activities should be weaker for a supplier in a capital-producing industry if a vertical creative

Table 12. This table reports regression results for the model:

$$Innovation_{it} = \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot TP_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot TP_{i,t-1}) + \beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it},$$

where $TP_{it} = \sum_{c=1}^{C} w_{ct}(S'_{it}C_{ct})^2/[(S'_{it}S_{it})(C'_{ct}C_{ct})]$. S_{it} (C_{ct}) is a column vector, and each element of S_{it} (C_{ct}) is the ratio of (a) the number of supplier i (customer c)'s patents in the last three years (i.e., from year $t-2$ to year t) in a patent class to (b) the total number of supplier i (customer c)'s patents in the last three years. The term w_{ct} denotes the weight of customer c in year t. The dependent variables are $ln(1 + R\&D\ Intensity)$ in columns (1) and (2), $ln(1 + \#pat)$ in columns (3) and (4), and $ln(1 + Avg.xi)$ in columns (5) and (6). VCO and TP are equally weighted in columns (1), (3) and (5); and sales-value weighted in columns (2), (4) and (6). Firm and year fixed effects are employed in all regressions. Standard errors are clustered at the industry level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

	$ln(1 + R\&D\ Intensity)$		$ln(1 + \#pat)$		$ln(1 + Avg.xi)$	
	EW	VW	EW	VW	EW	VW
	(1)	(2)	(3)	(4)	(5)	(6)
VCO	1.511**	1.027	25.917***	24.972***	12.070*	11.682*
	(2.319)	(1.575)	(3.471)	(3.451)	(1.909)	(1.919)
TP	0.021	0.018	0.312**	0.294**	0.215*	0.175
	(1.007)	(0.850)	(2.339)	(2.435)	(1.699)	(1.380)
$VCO \cdot TP$	14.159	8.853	54.750*	50.141*	51.126*	47.971*
	(1.511)	(1.471)	(1.919)	(1.772)	(1.776)	(1.716)
$IO\ HHI$	-0.030	-0.030	-0.006	-0.006	0.061	0.060
	(-1.366)	(-1.365)	(-0.125)	(-0.120)	(1.393)	(1.391)
IO	0.079*	0.083*	0.042	0.049	0.227**	0.231**
	(1.763)	(1.732)	(0.324)	(0.371)	(2.071)	(2.096)
Q	-0.008*	-0.008*	0.018***	0.017***	0.036***	0.036***
	(-1.730)	(-1.729)	(2.657)	(2.630)	(5.678)	(5.644)
$ln(Sales)$	-0.067**	-0.066**	0.268***	0.269***	0.163***	0.163***
	(-2.074)	(-2.073)	(4.961)	(4.955)	(5.459)	(5.445)
$Capital\ Intensity$	0.018	0.019	0.013	0.018	0.024	0.028
	(0.610)	(0.616)	(0.102)	(0.134)	(0.190)	(0.219)
$Profitability$	-0.078***	-0.079***	-0.259***	-0.262***	-0.060	-0.063
	(-2.703)	(-2.670)	(-3.831)	(-3.860)	(-1.100)	(-1.139)
$Leverage$	-0.075**	-0.074**	-0.362***	-0.361***	-0.179***	-0.179***
	(-2.429)	(-2.450)	(-4.560)	(-4.553)	(-3.181)	(-3.179)
Observations	11,857	11,857	11,866	11,866	11,866	11,866
R-squared	0.832	0.832	0.815	0.815	0.774	0.774
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

destruction channel really exists. I test this conjecture by running the following regression:

$$\begin{aligned} Innovation_{it} =& \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot Cap_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot Cap_{i,t-1}) \\ &+ \beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it}, \end{aligned} \tag{5}$$

where Cap is a dummy equal to one if supplier i is in an industry with $CTUR$ larger than 0.5. If the conjecture holds, I expect to see a negative and statistically significant estimate for the coefficient μ on the interaction term in equation (5).

Table 13 reports the results for tests of this conjecture. The estimate for the coefficient on the interaction term between vertical common ownership and a dummy for a capital-goods producer is negative and significant for both the quantity and the quality of innovation output, but does not achieve significance for innovation input. For the innovation output variables, the magnitudes of coefficients on the interaction terms are larger than those of coefficients on VCO. This result implies that the positive effect of vertical common ownership on innovation is offset by the negative effect caused by vertical creative destruction suppliers that mainly producing capital goods. The positive associations between vertical common ownership and innovation exist only for intermediate-goods producers. This finding is consistent with the argument that vertical common ownership can weaken innovation activities, especially for capital-goods suppliers, due to vertical creative destruction.

Pair-level Analyses

In addition to tests of possible supplier-level mechanisms, I also test the association between patent cross-citations and vertical common ownership at the supplier-customer-pair level.[15] In particular, I run the following regression:

$$ln(1 + cite_{sc,t}) = \beta_0 + \beta_1 \cdot pairwise\ VCO_{sc,t-1} + \alpha_s + \alpha_c + \alpha_t + \varepsilon_{sct}, \tag{6}$$

[15] Kogan et al. (2017)'s dataset provides the patent identifiers of citing patents linked with the patent identifiers of cited patents. Therefore, I can calculate the number of customers(suppliers)' patents cited by their suppliers(customers)' patents.

Table 13. This table reports regression results for the model:

$$Innovation_{it} = \beta_0 + \beta_1 \cdot VCO_{i,t-1} + \beta_2 \cdot Cap_{i,t-1} + \mu \cdot (VCO_{i,t-1} \cdot Cap_{i,t-1}) + \beta_3 \cdot X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{it},$$

where Cap is a dummy equal to one if supplier i is in a industry with $CTUR$ larger than 0.5. $CTUR_{jt} = Capital\ Good_{jt}/Total\ Use_{jt}$, where the use of a commodity by industry j as a $Capital\ Good$ is the sum of nonresidential fixed investment in equipment, intellectual property, and structures, and residential fixed investment. And $Total\ Use$ of the commodity by industry j includes the intermediate use, consumption, government use, and all other types of investment. The dependent variables are $ln(1 + R\&D\ Intensity)$ in columns (1) and (2), $ln(1 + \#pat)$ in columns (3) and (4), and $ln(1 + Avg.xi)$ in columns (5) and (6). VCO and TP are equally weighted in columns (1), (3) and (5); and sales-value weighted in columns (2), (4) and (6). Firm and year fixed effects are employed in all regressions. Standard errors are clustered at the industry level. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

	$ln(1 + R\&D\ Intensity)$		$ln(1 + \#pat)$		$ln(1 + Avg.xi)$	
	EW	VW	EW	VW	EW	VW
	(1)	(2)	(3)	(4)	(5)	(6)
VCO	2.509*	1.953*	23.196***	22.052***	11.210***	11.535***
	(1.870)	(1.972)	(2.853)	(2.776)	(3.659)	(4.141)
$VCO \cdot Cap$	-2.026	-1.750*	-31.575**	-29.906**	-38.528*	-39.501*
	(-1.627)	(-1.689)	(-2.151)	(-1.983)	(-1.905)	(-1.968)
$IO\ HHI$	-0.030	-0.029	-0.012	-0.012	0.057	0.056
	(-1.280)	(-1.280)	(-0.246)	(-0.251)	(1.192)	(1.186)
IO	0.081*	0.084*	0.098	0.103	0.248**	0.247**
	(1.889)	(1.877)	(0.813)	(0.862)	(2.268)	(2.254)
Q	-0.008*	-0.008*	0.015*	0.015*	0.036***	0.036***
	(-1.667)	(-1.666)	(1.869)	(1.864)	(5.888)	(5.892)
$ln(Sales)$	-0.069**	-0.069**	0.275***	0.275***	0.168***	0.168***
	(-2.067)	(-2.068)	(3.920)	(3.910)	(10.703)	(10.642)
$Capital\ Intensity$	0.025	0.025	0.034	0.037	0.043	0.045
	(0.789)	(0.789)	(0.290)	(0.317)	(0.308)	(0.327)
$Profitability$	-0.078***	-0.079***	-0.276***	-0.276***	-0.051	-0.051
	(-2.738)	(-2.738)	(-4.095)	(-4.085)	(-0.973)	(-0.963)
$Leverage$	-0.078**	-0.079***	-0.378***	-0.377***	-0.187***	-0.186***
	(-2.607)	(-2.620)	(-5.884)	(-5.881)	(-3.517)	(-3.507)
Observations	11,357	11,357	11,365	11,365	11,365	11,365
R-squared	0.834	0.834	0.817	0.817	0.777	0.777
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

where $cite_{sc}$ includes (1) total patent cross-citations between supplier s and customer c, (2) patent citations from supplier s to customer c, and (3) patent citations from customer c to supplier s. Both supplier and customer fixed effects are included in the model to absorb unobserved heterogeneity across firms that may also potentially influence patent cross-citations. The α_t captures year fixed effects. Standard errors are clustered at both the supplier and the customer industry levels.

It is a challenge to explain the implications of greater numbers of patent cross-citations between suppliers and their customers. On the one hand, patent cross-citations could be a proxy for innovation information exchange, which would be relevant to the technological spillover channel. On the other hand, patent cross-citations could be a proxy for relationship-specific innovation from the citing firm directed towards the cited firms, which would be more relevant to the hold-up channel. To clarify the theoretical ambiguity concerning the expected sign of the patent cross-citation effect, I run two more regressions:

$$\begin{aligned} ln(1 + cite_{sc,t}) =& \beta_0 + \beta_1 \cdot pairwise\ VCO_{sc,t-1} + \beta_2 \cdot pairwise\ SRR_{sc,t-1} \\ & + \mu \cdot pairwise\ VCO_{sc,t-1} \cdot pairwise\ SRR_{sc,t-1} \\ & + \alpha_s + \alpha_c + \alpha_t + \varepsilon_{sct}, \end{aligned} \tag{7}$$

$$\begin{aligned} ln(1 + cite_{sc,t}) =& \beta_0 + \beta_1 \cdot pairwise\ VCO_{sc,t-1} + \beta_2 \cdot pairwise\ TP_{sc,t-1} \\ & + \mu \cdot pairwise\ VCO_{sc,t-1} \cdot pairwise\ TP_{sc,t-1} \\ & + \alpha_s + \alpha_c + \alpha_t + \varepsilon_{sct}. \end{aligned} \tag{8}$$

If patent cross-citations between suppliers and customers are relevant to relationship-specific innovation, the impact of pair-level common ownership will be cross-sectionally different based on the hold-up issues for the supplier-customer pair. In particular, pair-level common ownership will have a less pronounced impact on cross-citations for a supplier-customer pair with weaker hold-up issues in the first place. I use the pair-level Size Rank Ratio (*pairwise SRR*) as the proxy for the hold-up issues between a specific supplier-customer pair. I expect to see a negative and statistically significant estimate for the coefficient μ in equation (7).

Similarly, if patent cross-citations are relevant to information spillover between suppliers and customers, the pair-level common ownership will have stronger impact on cross-citations for the supplier-customer pair with closer technology proximity. I use the pair-level Technology Proximity (*pairwise TP*) as the proxy for the technology proximity between a specific supplier-customer pair. I expect to see a positive and statistically significant estimate for the coefficient μ in equation (8).

Table 14 reports results for the three models specified above in equations (6), (7), and (8). Panel A shows that greater pair-level vertical common ownership increases the number of patent cross-citations between suppliers and customers, especially the number of cross-citations from suppliers towards their customers. Panel B tests equation (7), and shows a negative and statistically significant estimate for the coefficient on the interaction between the pair-level vertical common ownership (VCO) and the pair-level size rank ratio (SRR), when the dependent variable is the number of patent citations from suppliers to their customers. Panel C tests equation (8), and shows no statistical significance for the estimate of the coefficient on the interaction term between the pair-level VCO and pair-level technology proximity. In all panels, there is no significant association between pair-level VCO and patent cross-citations from customers to their suppliers. These results suggest that patent cross-citations between suppliers and their customers are more likely to be a proxy for relationship-specific innovation from suppliers towards their customers. The findings here provide additional evidence that vertical common ownership can increase a supplier's relationship-specific innovation by reducing the likelihood of hold-up by the supplier's customers.

Overall, tests of the mechanisms behind the hold-up mitigation, the technological spillover, and the vertical creative destruction channels provide plausible evidence to support the contention that vertical common ownership (1) increases a supplier's investment in innovation by mitigating the hold-up issues between the supplier and its customers, (2) increases a supplier's quantity and quality of innovation output by improving technological spillovers between the supplier and its customers, and (3) weakens a supplier's quantity and quality of innovation output due to vertical creative destruction.

Table 14. This table reports regression results for three different models.
Panel A:

$$ln(1 + cite_{sc,t}) = \beta_0 + \beta_1 \cdot pairwise\ VCO_{sc,t-1} + \alpha_s + \alpha_c + \alpha_t + \varepsilon_{sct},$$

Panel B:

$$\begin{aligned} ln(1 + cite_{sc,t}) = \beta_0 &+ \beta_1 \cdot pairwise\ VCO_{sc,t-1} + \beta_2 \cdot pairwise\ SRR_{sc,t-1} \\ &+ \mu \cdot (pairwise\ VCO_{sc,t-1} \cdot pairwise\ SRR_{sc,t-1}) \\ &+ \alpha_s + \alpha_c + \alpha_t + \varepsilon_{sct}, \end{aligned}$$

Panel C:

$$\begin{aligned} ln(1 + cite_{sc,t}) = \beta_0 &+ \beta_1 \cdot pairwise\ VCO_{sc,t-1} + \beta_2 \cdot pairwise\ TP_{sc,t-1} \\ &+ \mu \cdot (pairwise\ VCO_{sc,t-1} \cdot pairwise\ TP_{sc,t-1}) \\ &+ \alpha_s + \alpha_c + \alpha_t + \varepsilon_{sct}, \end{aligned}$$

where $cite_{sc}$ includes (1) the total cross-citations between supplier s and customer c, (2) the citations from supplier s to customer c, and (3) the citations from customer c to supplier s. Supplier, customer and year fixed effects are included in each model. Standard errors are clustered at both the supplier and the customer industry levels. t-statistics are reported in parentheses below coefficient estimates. Significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively.

Panel A			
	(1) ln(1+total cite)	(2) ln(1+supplier-citing-customer)	(3) ln(1+customer-citing-supplier)
pairwise VCO	7.112***	6.777***	-0.105
	(2.797)	(3.181)	(-0.064)
Observations	7,809	7,809	7,809
R-squared	0.720	0.662	0.662
Supplier FE	Yes	Yes	Yes
Customer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Table 14. (continued).

Panel B			
	(1) ln(1+total cite)	(2) ln(1+supplier-citing-customer)	(3) ln(1+customer-citing-supplier)
pairwise VCO	9.197**	8.694***	-0.111
	(2.366)	(3.374)	(-0.048)
pairwise SRR	0.024	-0.000	0.025
	(1.309)	(-0.048)	(0.943)
pairwise VCO× *pairwise SRR*	-2.650	-2.338**	-0.234
	(-1.271)	(-2.158)	(-0.150)
Observations	7,773	7,773	7,773
R-squared	0.721	0.662	0.663
Supplier FE	Yes	Yes	Yes
Customer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Panel C			
	(1) ln(1+total cite)	(2) ln(1+supplier-citing-customer)	(3) ln(1+customer-citing-supplier)
pairwise VCO	6.341***	6.016***	-0.482
	(3.033)	(3.261)	(-0.353)
pairwise TP	0.448**	0.601*	0.059
	(2.035)	(1.969)	(0.435)
pairwise VCO× *pairwise TP*	12.066	6.547	11.291
	(0.486)	(0.265)	(0.533)
Observations	7,809	7,809	7,809
R-squared	0.721	0.665	0.662
Supplier FE	Yes	Yes	Yes
Customer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

VI. CONCLUSION

Although there is an emerging literature concerning the impact of common ownership on corporate financial decisions, studies that specifically address vertical common ownership, especially its impacts on corporate investment and innovation, are still rare. This paper examines the impact of vertical common ownership on suppliers' innovation activities. I find that suppliers' investment in innovation, and the quantity and quality of suppliers' innovation output, all increase when common owners hold higher fractions of the equities of suppliers and their customers. The impacts of vertical common ownership on innovation activities are stronger and more robust than the impacts of horizontal common ownership. I provide plausible evidence for causality using both a difference-in-differences approach and an instrument variable approach based on mergers of financial institutions. Moreover, I test the potential channels through which vertical common ownership could influence supplier innovation activities. I find that such vertical common ownership increases investment in innovation by mitigating potential hold-up problems between suppliers and their customers and enhances innovation output performance by improving technological spillovers between the suppliers and their customers. However, my results also suggest that for suppliers producing mainly capital goods, these positive effects of common ownership on innovation are offset by a negative effect due to vertical creative destruction.

Overall, my evidence suggests that institutional common ownership enhances suppliers' innovation performance by improving relationships between suppliers and their customers. This research establishes plausible evidence for a causal association between common ownership and supplier innovation. Furthermore, by exploring potential economic channels, this study has important implications for our understanding of the impacts of common ownership along the supply chain, thereby suggesting another possible driver for corporate innovation.

The concern about potential anti-competitive effects due to common ownership has led the academics to recommend anti-trust scrutiny for institutional investors. The findings of this paper suggest a positive side of common ownership. My analyses imply that regulators may motivate institutional investors to hold firms along the supply chain, which can be beneficial for the economy by improving relationships between upstream and downstream firms.

APPENDICES

A. VARIABLE DEFINITIONS

- *VCO*: vertical common ownership. $VCO_{it} = \sum_{c=1}^{C} w_{ct} \cdot \sum_{f=1}^{F} \beta_{fit} \cdot \beta_{fct}$, where there are F institutions holding both firm i and its customer c. $\beta_{fi(c)t}$ denotes institution f's holding fraction of firm i (customer c) in year t. There are C customers for firm i. The weight w_{ct} denotes customer c's relative share among all firm i's customers in year t. Both equal weight and value weight on the basis of sales value between firm i and each customer are employed (Source: Thomson Reuters, Compustat Customer Segment).

- *HCO*: horizontal common ownership. $HCO_{it} = \sum_{j=1}^{J} w_{jt} \cdot \sum_{f=1}^{F} \beta_{fit} \cdot \beta_{fjt}$, where there are F institutions holding both firm i and its competitor j. $\beta_{fi(j)t}$ denotes institution f's holding fraction of firm i (competitor j) in year t. I use the FIC500 codes developed by Hoberg and Phillips (2016) to identify competitors. There are J competitors for firm i. The weight w_{jt} denotes competitor j's relative share among all the competitors in year t. Both equal weights and value weights on the basis of market values of competitors are employed (Source: Thomson Reuters, Hoberg and Phillips (2016), CRSP).

- *GGLVCO*: vertical common ownership under various assumptions about investors' attention: $GGLVCO_{st} = \sum_{c=1}^{C} w_{ct} \cdot GGL_{sct}$, where there are C customers for supplier s in year t. GGL_{sct} is the common ownership measure for the pair of supplier s and customer c in year t. GGL can be constructed under three different assumptions of investors' attention: linear attention, concave attention, and convex attention. More details about the construction of the GGL measures are provided in Appendix VI.. w_{ct} denotes the weight of customer c. Both equal weight and sales-value weight are employed. Following Gilje et al. (2019), I also rescale the common ownership measures by the sample mean (Source: Compustat Customer Segment, Gilje et al. (2019)).

- *R&D Intensity*: R&D expenditure (XRD) divided by sales (SALE) (Source:

Compustat).

- *#pat*: the number of patent applications at firm-year level (Source: Kogan et al. (2017)).

- *Avg.xi*: average patent value at firm-year level (Source: Kogan et al. (2017)).

- *IO HHI*: Institutional ownership concentration. $IO\ HHI_{it} = \sum_{f=1}^{F} r_{fit}^2$, where there are F institutions holding firm i's equity. r_{fit} denotes institution f's holding fraction of firm i among the total institutional holding in year t (Source: Thomson Reuters).

- *IO*: The percentage of institutional holding among a firm's total equity (Source: Thomson Reuters, CRSP).

- *Q*: Tobin's Q. Q = [Market value of equity (CSHOQ $\times$ PRCCQ) + total assets (AT) - book value of equity (CEQQ) - deferred taxes (TXDBQ)] / total assets (AT) (Source: Compustat).

- *ln(Sales)*: Natural log of sales (SALE in $million) (Source: Compustat).

- *Leverage*: Total debt divided by total assets (AT), where total debt = short-term debt (DLC) + long-term debt (DLTT) (Source: Compustat).

- *Profitability*: Earnings before interest, depreciation, taxes and amortization (EBIDTA) divided by total assets (AT) (Source: Compustat).

- *Capital Intensity*: Net property, plant and equipment (PPENT) divided by total assets (AT) (Source: Compustat).

- *PVI*: the percentage of sales from segments in downstream industries out of the total sales from all segments. The downstream industries are identified based on BEA I-O tables; more details about the identification method can be referred to in Appendix VI. (Source: Compustat Segment, BEA I-O tables).

- *SRR*: size rank ratio. $SRR_{it} = \sum_{c=1}^{C} w_{ct} SR_{it}/SR_{ct}$. $SR_{i(c)t}$ denotes supplier i (customer c)'s size rank in year t. Size rank of a firm is measured as the decile of its accumulated sales in current year and past two years in its market identified by three-digit SIC code. w_{ct} denotes the weight of customer c in year t. Both equal weight and sales-value weight are employed (Source: Compustat Customer Segment).

- IR: customer input redeployability. $IR_{it} = \sum_{c=1}^{C} w_{ct} \cdot Redeployability_{ct}$. $Redeployability_{ct}$ is the firm-level redeployability score developed by Kim and Kung (2017) for customer c in year t. w_{ct} denotes the weight of customer c in year t. Both equal weight and sales-value weight are employed (Source: Compustat Customer Segment, Kim and Kung (2017)).

- TP: technology proximity. $TP_{it} = \sum_{c=1}^{C} w_{ct}(S'_{it}C_{ct})^2/[(S'_{it}S_{it})(C'_{ct}C_{ct})]$. S_{it} (C_{ct}) is a column vector, and each element of S_{it} (C_{ct}) is the ratio of the number of supplier i (customer c)'s patents in the last three years (i.e., from year $t-2$ to year t) in a patent class to the total number of supplier i (customer c)'s patents in the last three years. w_{ct} denotes the weight of customer c in year t. Both equal weight and sales-value weight are employed (Source: Compustat Customer Segment, Kogan et al. (2017)).

- $cite$: firm-pair level patent cross-citations. $cite_{sc}$ includes (1) the total cross-citations between supplier s and customer c, (2) the citations from supplier s to customer c, and (3) the citations from customer c to supplier s (Source: Kogan et al. (2017)).

B. M&AS AMONG FINANCIAL INSTITUTIONS

Announcement Date	Effective Date	Acquirer	Target
04/19/1982	01/19/1983	Pittsburgh National Corp	Provident National Bank
08/02/1982	04/01/1983	Mellon Financial	Girard Bank
11/18/1982	04/01/1983	Huntington National Bank	Union Commerce Bank
12/21/1983	07/01/1984	Chase Manhattan Corp	Lincoln First Banks Inc.
06/30/1986	02/27/1987	PNC Financial Corp	Citizens Fidelty Bk & Tr
03/18/1987	01/01/1988	Fleet Financial Group	Norstar Trust Company
04/27/1987	11/01/1987	Sovran Financial Corp	Commerce Union Bank
07/31/1987	02/29/1988	PNC Financial Corp	Central Bancorp
05/04/1988	12/26/1988	Boatmen's Bancshares Inc	Centerre Bancorp
07/15/1991	12/31/1991	Chemical Banking Corp	Manufacturers Hanover Co
09/16/1991	07/23/1992	PNC Financial Corp	First Natl Bank/Penn
12/30/1991	11/02/1992	Banc One Corp	Affiliated Bksh/Colorado
03/18/1992	10/15/1992	NBD Bancorp Inc	INB Financial Corp
09/09/1992	07/13/1993	Bank of Boston Corp	Multibank Financial Corp
09/14/1992	05/21/1993	Mellon Bank Corp	Boston Company Inc
11/23/1992	07/22/1993	Equitable Companies Inc	Alliance Capital Mgmt
09/20/1993	05/31/1994	Marshall & Ilsley Corp	Valley Trust Co/Wisc
10/18/1993	07/01/1994	First Union Corp	Lieber & Co
03/06/1994	06/30/1994	First Union Corp	Evergreen Asset Mgmt
11/28/1994	04/12/1995	KeyCorp	Spears Benzak Salomon
02/21/1995	11/30/1995	Fleet Financial Group	Shawmut Natl Corp
06/16/1995	06/16/1995	TCW Group Inc	Continental Asset Mgmt
06/19/1995	01/02/1996	First Union Corp	First Fidelity Bancorp
08/07/1995	02/16/1996	First Bank System Inc	FirsTier Financial Inc
06/25/1996	11/01/1996	Franklin Resources Inc	Heine Securities Corp
07/10/1996	10/31/1996	LGT Asset Mgmt Inc	Chancellor Capital Mgmt
09/06/1996	12/12/1996	First Union Corp	Keystone Invt Mgmt Co
12/30/1996	06/02/1997	Banc One Corp	Liberty Bancorp Inc
01/20/1997	05/20/1997	Mellon Bank Corp	Ganz Capital Mgmt Inc
03/20/1997	08/01/1997	First Bank System Inc	U S Bancorp
11/05/1997	12/01/1997	Pimco Advisors LP	Oppenheimer & Co LP
04/06/1998	10/08/1998	Travelers Inc	Citicorp

Announcement Date	Effective Date	Acquirer	Target
04/13/1998	09/30/1998	NationsBank Corp	BankAmerica Corp
07/20/1998	12/31/1998	SunTrust Banks Inc	Crestar Bank
02/15/1999	07/06/1999	Credit Suisse Asset M	Warburg Pincus Asset M
03/14/1999	10/01/1999	Fleet Boston Corp	BankBoston Corp
06/20/2000	10/02/2000	AXA Financial	Sanford C Berstein
09/13/2000	12/31/2000	JP Morgan & Co	Chase Manhattan
10/25/2000	04/10/2001	Franklin Resources	Fiduciary Trust Intl
10/18/2000	02/14/2001	Allianz Dresdner	Nicholas-Applegate
08/26/2003	08/26/2003	Wells Fargo & Co	Benson Associate
10/27/2003	04/01/2004	Bank of America	Fleet Boston
05/26/2004	01/03/2005	Wells Fargo & Co	Strong Capital Mgmt
08/26/2004	01/31/2005	BlackRock	StateStreet Res & Mgmt
05/19/2005	08/04/2005	Transamerica Invt Mgmt	WestCap Investors
10/31/2006	12/04/2006	Morgan Stanley	FrontPoint
12/03/2006	07/02/2007	Bank of NY Trust	Mellon Bank
07/07/2008	11/07/2008	RiverSource Invt	J.&W. Seligman
09/16/2008	09/22/2008	Barclays Bank	Lehman Brothers Inc
09/15/2008	01/01/2009	Bank of America	Merrill Lynch
06/12/2009	12/01/2009	BlackRock Inc	Barclays Bank Plc

C. OPERATING SEGMENTS IN DOWNSTREAM INDUSTRIES

An operating segment is a profitable unit of a firm that (1) reports its own financial information, such as revenues and expenses, and (2) is regularly supervised by the firm's executives. I identify operating segments in the downstream industries for a firm following the procedures of Martin and Otto (2017).

First, following Acemoglu et al. (2016), I identify industry-level supplier-customer relationships based on the gross flows of commodities between industries reported in the U.S. Bureau of Economic Analysis input-output (BEA I/O) tables. The tables include "MAKE" table that links the producers' industries with the commodities' industries, and "USE" table that links the consumers' industries with the commodities' industries. By matching the two tables on the basis of commodities' industries, I can identify the upsteam industries and their related downstream industries. BEA I/O tables are provided every five years. For my data sample, I refer to the BEA I/O tables from 1982 to 2007. The BEA I/O tables report IO code as industry identification for producers, commodities, and consumers. The linking tables between IO code and SIC or NAICS are also provided.[16]

Next, the Compustat Segment database reports SIC codes for each firm and its primary operating segments. An operating segment is identified as being in the downstream industry of its firm if the SIC codes of the firm and the operating segment show that they are in the upstream industry and related downstream industry according to BEA I/O tables.

[16]According to US Census Bureau, NAICS replaced SIC in 1997. Thus, BEA I/O tables start to provide IO-linking-NAICS table instead of IO-linking-SIC table from 1997. A detailed conversion between SIC and NAICS is available from US Census Bureau.

D. CONSTRUCTION OF THE GGL MEASURES

The GGL measure of common ownership at the firm-pair level is constructed as follows:

$$GGL(A, B) = \sum_{i=1}^{I} \alpha_{i,A} \cdot g(\beta_{i,A}) \cdot \alpha_{i,B},$$

where $\alpha_{i,A(B)}$ denotes institution i's holding fraction of firm $A(B)$, $\beta_{i,A}$ denotes the weight of firm A in institution i's portfolio. $g(\cdot)$ is a function mapping from $\beta_{i,A}$ to institution i's attention towards firm A. The form of $g(\cdot)$ varies according to three assumptions about an asset manager's attention:

(1) Linear attention: $g(\beta_{i,A}) = \beta_{i,A}$.
An investor's attention is proportional to the weight of a specific firm in her portfolio.

(2) Convex attention: $g(\beta_{i,A}) = \beta_{i,A}^2$.
An investor devotes more attention to the firm with higher weight in her portfolio.

(3) Concave attention:$g(\beta_{i,A}) = \beta_{i,A}^{0.5}$.
An investor devotes less attention to the firm with higher weight in her portfolio.

The firm-pair-level measures are further aggregated to the supplier level:

$$supplier\ GGL_{it} = \sum_{j=1}^{J} w_{jt} \cdot GGL(i, j)_t,$$

where supplier i has J customers. The term w_{jt} denotes the weight of customer j among all customers in year t. I use both (1) equal weights and (2) value weights on the basis of sales from the supplier to each of its customers. Following Gilje et al. (2019), I also rescale each measure by its sample mean.

REFERENCES CITED

Daron Acemoglu, David Autor, David Dorn, Gordon H Hanson, and Brendan Price. Import competition and the great US employment sag of the 2000s. *Journal of Labor Economics*, 34(S1):S141–S198, 2016.

Miguel Antón, Florian Ederer, Mireia Giné, and Martin C Schmalz. Common ownership, competition, and top management incentives. *Ross School of Business Paper*, (1328), 2018.

Miguel Anton, Florian Ederer, Mireia Gine, and Martin C Schmalz. Innovation: The bright side of common ownership? *Available at SSRN 3099578*, 2018.

Julian Atanassov and Xiaoding Liu. Can corporate income tax cuts stimulate innovation? *Journal of Financial and Quantitative Analysis*, pages 1–51, 2019.

José Azar, Martin C Schmalz, and Isabel Tecu. Anticompetitive effects of common ownership. *The Journal of Finance*, 73(4):1513–1565, 2018.

José Azar, Sahil Raina, and Martin C Schmalz. Ultimate ownership and bank competition. *Available at SSRN 2710252*, 2019.

Shantanu Banerjee, Sudipto Dasgupta, and Yungsan Kim. Buyer–supplier relationships and the stakeholder theory of capital structure. *the Journal of finance*, 63(5):2507–2552, 2008.

Lucian Bebchuk and Scott Hirst. Index funds and the future of corporate governance: Theory, evidence, and policy. *Columbia Law Review*, 119:2029–2145, 2019.

Jan Bena and Kai Li. Corporate innovations and mergers and acquisitions. *The Journal of Finance*, 69(5):1923–1960, 2014.

Nicholas Bloom, Mark Schankerman, and John Van Reenen. Identifying technology spillovers and product market rivalry. *Econometrica*, 81(4):1347–1393, 2013.

Alon Brav, Wei Jiang, Song Ma, and Xuan Tian. How does hedge fund activism reshape corporate innovation? *Journal of Financial Economics*, 130(2):237–264, 2018.

Ling Cen, Sudipto Dasgupta, Redouane Elkamhi, and Raunaq S Pungaliya. Reputation and loan contract terms: The role of principal customers. *Review of Finance*, 20(2):501–533, 2016a.

Ling Cen, Sudipto Dasgupta, and Rik Sen. Discipline or disruption? stakeholder relationships and the effect of takeover threat. *Management Science*, 62(10): 2820–2841, 2016b.

Thomas J. Chemmanur, Elena Loutskina, and Xuan Tian. Corporate venture capital, value creation, and innovation. *The Review of Financial Studies*, 27(8): 2434–2473, 2014.

Thomas J. Chemmanur, Yao Shen, and Jing Xie. Innovation beyond firm boundaries: Common blockholders, strategic alliances, and corporate innovation. In *American Economic Association 2017 Meetings Paper, Asian Finance Association (AsianFA) 2016 Conference Paper*, 2016.

Yongqiang Chu. Optimal capital structure, bargaining, and the supplier market structure. *Journal of Financial Economics*, 106(2):411–426, 2012.

Yongqiang Chu, Xuan Tian, and Wenyu Wang. Corporate innovation along the supply chain. *Management Science*, 65(6):2445–2466, 2019.

Gjergji Cici, Scott Gibson, and Claire M Rosenfeld. Cross-company effects of common ownership: Dealings between borrowers and lenders with a common blockholder. *Available at SSRN 2705856*, 2015.

Nishant Dass, Vikram Nanda, and Steven Chong Xiao. Truncation bias corrections in patent data: Implications for recent research on innovation. *Journal of Corporate Finance*, 44:353–374, 2017.

Einer Elhauge. Horizontal shareholding. *Harv. L. Rev.*, 129:1267, 2015.

Tore Ellingsen and Magnus Johannesson. Is there a hold-up problem? *Scandinavian Journal of Economics*, 106(3):475–494, 2004.

C. Edward Fee and Shawn Thomas. Sources of gains in horizontal mergers: evidence from customer, supplier, and rival firms. *Journal of financial Economics*, 74(3):423–460, 2004.

C. Edward Fee, Charles J Hadlock, and Shawn Thomas. Corporate equity ownership and the governance of product market relationships. *Journal of Finance*, pages 1217–1251, 2006.

Kayla Freeman. Overlapping ownership along the supply chain. *Kelley School of Business Research Paper*, (16-84), 2021.

Heng Geng, Harald Hau, and Sandy Lai. Patent success, patent holdup, and the structure of property rights. *Work. Pap., Sch. Econ. Finance, Vic. Univ. Wellingt., Wellington, NZ Google Scholar Article Location*, 2017.

Erik P. Gilje, Todd A. Gormley, and Doron Levit. Who's paying attention? measuring common ownership and its impact on managerial incentives. *Journal of Financial Economics*, 2019.

Michael Gofman, Gill Segal, and Youchang Wu. Production Networks and Stock Returns: The Role of Vertical Creative Destruction. *The Review of Financial Studies*, 03 2020.

Roger H. Gordon. Do publicly traded corporations act in the public interest? *The BE Journal of Economic Analysis & Policy*, 3(1), 2003.

Todd A. Gormley and David A. Matsa. Growing out of trouble? Corporate responses to liability risk. *The Review of Financial Studies*, 24(8):2781–2821, 2011.

Sanford J. Grossman and Oliver D. Hart. The costs and benefits of ownership: A theory of vertical and lateral integration. *Journal of Political Economy*, 94(4): 691–719, 1986.

Bronwyn H. Hall, Adam B. Jaffe, and Manuel Trajtenberg. The NBER patent citation data file: Lessons, insights and methodological tools. Technical report, National Bureau of Economic Research, 2001.

Robert G. Hansen and John R. Lott. Externalities and corporate objectives in a world with diversified shareholder/consumers. *Journal of Financial and Quantitative Analysis*, 31(1):43–68, 1996.

Oliver Hart. *Firms, contracts, and financial structure*. Clarendon press, 1995.

Oliver Hart and John Moore. Property rights and the nature of the firm. *Journal of Political Economy*, 98(6):1119–1158, 1990.

Jie Jack He and Jiekun Huang. Product market competition in a world of cross-ownership: Evidence from institutional blockholdings. *The Review of Financial Studies*, 30(8):2674–2718, 2017.

Jie Jack He, Jiekun Huang, and Shan Zhao. Internalizing governance externalities: The role of institutional cross-ownership. *Journal of Financial Economics*, 134 (2):400–418, 2019.

John W. Henke and Chun Zhang. Increasing supplier-driven innovation. *IT Management Select*, 16, 2010.

Michael G. Hertzel, Zhi Li, Micah S. Officer, and Kimberly J. Rodgers. Inter-firm linkages and the wealth effects of financial distress along the supply chain. *Journal of Financial Economics*, 87(2):374–387, 2008.

Gerard Hoberg and Gordon Phillips. Text-based network industries and endogenous product differentiation. *Journal of Political Economy*, 124(5):1423–1465, 2016.

Larry Huston and Nabil Sakkab. Connect and develop. *Harvard Business Review*, 84(3):58–66, 2006.

Vincent J. Intintoli, Matthew Serfling, and Sarah Shaikh. Ceo turnovers and disruptions in customer-supplier relationships. *Journal of Financial & Quantitative Analysis*, 52(6), 2017.

Adam B. Jaffe. Technological opportunity and spillovers of R&D: evidence from firms' patents, profits and market value. Technical report, National Bureau of Economic Research, 1986.

Jayant R. Kale and Husayn Shahrur. Corporate capital structure and the characteristics of suppliers and customers. *Journal of Financial Economics*, 83(2): 321–365, 2007.

Hyunseob Kim and Howard Kung. The asset redeployability channel: How uncertainty affects corporate investment. *The Review of Financial Studies*, 30(1): 245–280, 2017.

Benjamin Klein, Robert G. Crawford, and Armen A. Alchian. Vertical integration, appropriable rents, and the competitive contracting process. *The Journal of Law and Economics*, 21(2):297–326, 1978.

Leonid Kogan, Dimitris Papanikolaou, Amit Seru, and Noah Stoffman. Technological innovation, resource allocation, and growth. *The Quarterly Journal of Economics*, 132(2):665–712, 2017.

Leonard Kostovetsky and Alberto Manconi. Common institutional ownership and diffusion of innovation. *Available at SSRN 2896372*, 2020.

Francine Lafontaine and Margaret Slade. Vertical integration and firm boundaries: The evidence. *Journal of Economic literature*, 45(3):629–685, 2007.

Katharina Lewellen and Michelle Lowry. Does common ownership really increase firm coordination? *Tuck School of Business Working Paper*, (3336343), 2020.

Gustavo Manso. Motivating innovation. *The Journal of Finance*, 66(5):1823–1860, 2011.

Thorsten Martin and Clemens A. Otto. The effect of hold-up problems on corporate investment: Evidence from import tariff reductions. *HEC Paris Research Paper No. FIN-2017-1208*, 2017.

Gregor Matvos and Michael Ostrovsky. Cross-ownership, returns, and voting in mergers. *Journal of Financial Economics*, 89(3):391–403, 2008.

Melissa Newham, Jo Seldeslachts, and Albert Banal-Estanol. Common ownership and market entry: Evidence from pharmaceutical industry. 2018.

Waldo Ojeda. Common ownership in the loan market. *University of California, Berkeley*, 2018.

Michael E. Porter. Capital disadvantage: America's failing capital investment system. *Harvard Business Review*, 70(5):65–82, 1992.

Eric A. Posner, Fiona M. Scott Morton, and E. Glen Weyl. A proposal to limit the anti-competitive power of institutional investors. *Antitrust Law Journal, forthcoming*, 2017.

William P. Rogerson. Contractual solutions to the hold-up problem. *The Review of Economic Studies*, 59(4):777–793, 1992.

Fiona Scott Morton and Herbert Hovenkamp. Horizontal shareholding and antitrust policy. *Yale LJ*, 127:2026, 2017.

Amit Seru. Firm boundaries matter: Evidence from conglomerates and r&d activity. *Journal of Financial Economics*, 111(2):381–405, 2014.

Husayn Shahrur. Industry structure and horizontal takeovers: Analysis of wealth effects on rivals, suppliers, and corporate customers. *Journal of Financial Economics*, 76(1):61–98, 2005.

Noah Stoffman, Michael Woeppel, and M. Deniz Yavuz. Small innovators: No risk, no return. *Kelley School of Business Research Paper*, (19-5), 2019.

Xuan Tian and Tracy Yue Wang. Tolerance for failure and corporate innovation. *The Review of Financial Studies*, 27(1):211–255, 2014.

Oliver E. Williamson. The vertical integration of production: market failure considerations. *The American Economic Review*, 61(2):112–123, 1971.

Oliver E. Williamson. Markets and hierarchies. *New York*, 2630, 1975.