Attaining Operating Performance through Pas De Trios of IT, Competitive Brokerage and Innovation

Abstract

Antecedents to operating performance are found not only at the organizational or supply chain level of analysis, but also at the network level of analysis. Prior research has largely neglected the role of IT in facilitating operating performance while applying the theoretical lens of multi-firm networks. Our interdisciplinary research proposes two ideas that extend the IS literature. First, a brokerage position within a competition network (competitive brokerage) enhances operating performance by increasing innovation efficiency – mediation relationship. Second, IT for operational integration, which refers to the use of IT for intra- and inter-organizational integration of firm’s operations, strengthens the benefits realized from competitive brokerage on innovation efficiency – mediated-moderation relationship. Panel regression analysis on a longitudinal dataset of a multi-firm competition network, IT, innovation, and operational performance data, supports our theory. We demonstrate that operating performance can be attained through pas de trios of IT, competitive brokerage and innovation.

Keywords: Business Value of IT, Competition networks, Operational performance, IT for operational integration, inter-organizational networks.

Introduction

The great recession and the aftermath of a slow economic recovery have amplified the importance of utilizing information technology (IT) to achieve high operating performance for organizations. The business value of IT has never been more important. While the pursuit and understanding of antecedents of operating performance has been an enduring and overarching objective for practitioners and researchers respectively, prior research has often viewed operating performance from a static lens of either the organizational or the supply chain level of analysis. However, organizations are bound within multi-firm networks that are a function of the strategic behaviors of constituent organizations. Correspondingly, the operating performance of an organization is not only a function of variables at the organizational or supply chain level of analysis, but also the network level of analysis.

Further, even though some research has addressed the role of information technology (IT) in industry-level and consumer driven spillovers (Zhuo and Barrie 2007; Zhuo and Barrie 2012), prior research has largely neglected the role of IT in facilitating operating performance while applying the theoretical lens of...
multi-firm networks\(^1\). *IT for operational integration* refers to the use of IT for the intra- and inter-organizational integration of the firm’s operations and thus captures the use of IT for the integration of a firm’s operations with those of its supply chain partners. Such an IT system integrates Wal-Mart’s distribution centers to Procter and Gamble’s factories, thereby reducing inventory levels at both Wal-Mart and Procter and Gamble through the creation of production and shipping orders based on stockout information (Saldanha et al. 2013).

While prior research has considered these notions of the embedded economy (Burt 2001) and demonstrated the influence of network positions inhabited by organizations on firm performance and innovation (Zaheer and Bell 2005), little attention has been paid to operating performance as a focal parameter. Extant literature is also primarily focused on either collaboration networks, that reflect patterns of collaboration between firms, or co-opetition networks, which depict patterns of both competition and collaboration across firms. However, pure competition networks, that are defined as *multi-firm networks based on competitive relationships*, which capture only patterns of competition across firms, have been bereft of research attention, barring a few examples (Andrade Rojas and Kathuria 2014a; Andrade Rojas and Kathuria 2014c). While some studies have attempted to utilize co-opetition or collaboration networks as surrogates to study the effect of competitive relationships on performance, this approach has its limitations. This is because co-opetition or collaboration networks are poor substitutes for pure competition networks since the nature of transactions in a network directly influences networks’ effects and structures (Afuah 2013).

Competition networks consist of organizations linked together by the markets and product categories in which they compete through differing product offerings. These networks play a key role in determining organizational outcomes such as innovation and operating performance. Organizations, such as Wal-Mart Stores Inc., which attain prominent positions in competition networks by resting either between paths of other competitors or between disconnected competitors in the network, often exhibit innovation and operating performance that is superior to competitors in less prominent positions. Given that competition networks consist of distinct competitor communities, firms that bridge multiple communities have access to diverse and novel information and knowledge (Burt 1992; Newman 2009). Consequently, such firms are plausibly able to amalgamate knowledge and business practices to introduce innovations more efficiently and achieve enhanced operating performance. Consequently, *competitive brokerage*, defined as an advantageous position in competition networks (Andrade Rojas and Kathuria 2014a; Andrade Rojas and Kathuria 2014c), plays a critical role in enhancing operating performance directly and through fostering of innovation efficiency.

We assert that the benefits of competitive brokerage are enhanced when complemented by IT for operational integration. While prior research has examined the operational benefits of IT at the plant, organizational or supply chain levels in isolation, our understanding of the operating performance related benefits of IT manifested through the network level is nascent. Specifically, the causal pathways and interactions between positioning at the network level, and IT used to achieve operational integration at the supply chain level, which enhance firm level operating performance, are yet to be conceptually developed and empirically demonstrated. This paper aims to address these gaps by considering the following overarching research question:

*How do positioning in competitive networks and IT for operational integration influence operating performance?*

Utilizing the literature on multi-firm networks and the business value of IT as theoretical edifices, we develop two key ideas. First, we theorize that competitive brokerage position enhances operating performance both directly and because it increases innovation efficiency – a mediation relationship. Second, we theorize that IT for operational integration complements the benefits realized from competitive brokerage on innovation efficiency – a mediated-moderation relationship. Panel regression analysis on a 7 year unbalanced longitudinal dataset consisting of a multi-firm competition network spread across 11 industries, matched with IT, innovation, and performance data, supports these ideas.

This paper makes several contributions to literature. First and foremost, we highlight the strong complementarity between IT for operational integration and a brokerage position in competition networks.

\(^1\) Due to space limitations a throughout review of the literature is not provided in this version of the paper.
networks, thereby contributing to the IT business value literature in information systems (IS). Second, and most critically, this paper focuses not only on why, but on how competitive brokerage influences operating performance by offering innovation efficiency as an explanation, thereby contributing to the operations management (OM) literature. Third, we add to the growing stream of inter-disciplinary research on OM and IS. Fourth, this paper contributes back to the literature on multi-firm networks by demonstrating the operating performance enhancing effects of competitive brokerage. Overall, we demonstrate that operating performance can be attained through pas de trios of IT, competitive brokerage and innovation.

**Literature and Hypotheses**

Theory on multi-firm networks provides the theoretical foundations for the proposed research model (Figure 1) that we develop in this section. We theorize how competitive brokerage position enhances operating performance by fostering innovation efficiency and is complemented by IT for operational integration. We also theorize the implications of innovation efficiency on operating performance within the relationship between competitive brokerage position and operating performance.

![Figure 1. Conceptual Model](image)

**Multi-firm Networks and Competitive Brokerage Position**

Theory on multi-firm networks is predicated on the principle that organizations are bound together in networks defined through patterns of strategic behavior. Over the past two decades, scholars have recognized and demonstrated the strategic importance of positions within these networks and have postulated that network positioning is a strategic resource of the firm (Afuah 2013; Zaheer and Bell 2005). Extant research, both in strategy and IS, has frequently considered the outcomes of positioning within multi-firm collaboration networks on performance, innovation and market competition (Ahuja 2000; Chellappa and Saraf 2010; Milanov and Shepherd 2013). While early studies primarily focused on the direct effects of network structures, more recent work has argued that network structures cannot be considered in isolation from firms’ internal capabilities (McEvily and Marcus 2005; Zaheer and Bell 2005).

Despite the continuous focus on collaboration networks, scholars have recognized that the nature of the transactions carried out in a network imply differences in structural properties, such as centrality and density (Afuah 2013). Therefore, multi-firm networks of competition should be analyzed separately from networks of collaboration, as their patterns and structures may have differing effects on firm performance and innovation. Though studies have attempted to combine the effects of simultaneous collaboration and competition (thereby creating the concept of co-opetition) within a single network (Brandenburger and Nalebuff 2011; Casseres 1996), we cannot substitute the structures of competition networks with those of collaboration networks due to differing strategic intents of firms’ engaged in these relationships. While firms in collaboration relationships may share and exchange information and resources to create new products, processes and technology (Gulati and Singh 1998; Inkpen and Tsang 2005), firms in competition relationships continuously look for strategies to outperform their competitors. Thus, it is
necessary to build networks based on competitive relationships to fully understand the effects of competition in structural environments (Smith et al. 2001).

Extant literature has documented the value obtained by actors that lie on brokerage or bridging ties (Tiwana 2008). For instance, nodes that lie on paths between other nodes have a considerable influence within a network by virtue of their control of the flow and access to information (Newman 2009). Hence, competitive brokerage is defined as the degree of control of the flow of competitive actions that a firm has at a particular unit of time and importance of this firm in bridging the indirect competitive relationships between other competitors (Andrade Rojas and Kathuria 2014a; Andrade Rojas and Kathuria 2014b). Structurally, a firm in a competitive brokerage position lies between the competitive links or relationships of otherwise unconnected competitors\(^2\). Given the advantageous position of competitive brokers, firms that hold competitive brokerage enjoy several performance enhancing advantages compared to firms in less prominent positions. To further illustrate the concept of competitive brokerage, we provide some examples. Unilever is a firm that occupies a high competitive brokerage position; it competes across multiple markets with several product categories and multiple products in each of these product categories. On the other hand, the Boston Beer Company occupies a low competitive brokerage position as they participate in relatively fewer product categories and their offer less products.

**The Influence of Competitive Brokerage Position on Operating Performance**

Operating performance is defined as the efficiency and effectiveness of a firm’s operations and is indicative of firm performance that is more immediate and intermediate as compared to performance reflected in financial measures. We posit that competitive brokerage enhances operating performance both directly as well as by fostering innovation efficiency. Building on Lanjouw and Schankerman (2004), Hirshleifer et al. (2013), Almeida et al. (2013); (Baker et al. 1986), we define innovation efficiency as the ratio of innovation output to innovation input, reflecting the ratio of patenting outcomes and expenditure on research and development. Thus innovation efficiency is the capability of the firm to orchestrate its innovation resources, which are the stock of expenditure on research and development, to produce product and process innovations.

While raw materials are needed to prevent interruptions in production, maintaining a stock of raw materials entails holding costs. Thus, organizations must maintain an optimal level of raw materials to balance holding and stockout costs. Consequently, the level of raw materials inventory held by a firm is a key measure of operating performance. We assert that innovation efficiency is a critical antecedent to enhanced operating performance, reflected by lower levels of raw material inventory, due to three reasons. First, the traditional reorder-point model indicates two components of raw materials: the mean demand during the lead time as well as the safety stock. Suppliers’ lead time of delivery (and hence the mean demand during the lead time) for products does not change with the focal firm’s innovation efficiency. However, the safety stock does. A firm with greater innovation efficiency is able to introduce and produce multiple products across multiple categories. If the firm faces a shortage of raw materials for certain products, the production flexibility enabled by the diversified product portfolio enables it to switch production to other products that do not require such raw materials, thereby reducing the requirements of safety stock. Thus product innovation enabled by higher innovation efficiency results in an immediate, but short lasting effect on raw material requirements (Lee et al. 2015). Second, a firm with greater innovation efficiency can also pool the demand risks of multiple products by using common raw materials to enjoy the effect of risk pooling (Baker et al. 1986) in lowering the safety stock requirement for the common raw materials. Third, greater innovation efficiency can also result in process innovation that streamlines production processes, reduces defects, and hence reduces the need of raw materials. These effects are more consistent and long lasting (Lee et al. 2015)\(^3\).

\(^2\) There are significant differences between structural holes and the competitive brokerage construct. First, unlike structural holes, brokerage incorporates the concepts of asymmetry and link weight (Tiwana 2008). Second, while structural holes are often utilized to measure ego networks, brokerage is used to study whole or more extensive networks (Chi et al. 2010).

\(^3\) Due to space limitations, the review of prior literature and theoretical discussion on this causal relationship is abridged. Please see Lee et al. 2015 for an exhaustive review.
Competitive brokers have several structural characteristics that enable them to enjoy operating performance advantages and greater innovation efficiency as compared to firms in less relevant positions. It is essential to comprehend that these advantages go further than the traditional concepts of diversification and multi-market presence, because both diversification and multi-market presence evaluate firms without considering the position or diversity of competitors. Competitive brokerage takes into account the position, bridging markets, diversification and multi-market position of the firm relative to those of its direct and indirect competitors.

Competitive brokers act as bridges between distinct product categories, industries and markets. From a structural perspective, competitive brokers extend their bridging ties across different product categories and link firms that may not be direct competitors, but that can be indirectly affected by the competitive actions of the firms that are linked to competitive brokers. This bridging mechanism provides firms with four benefits that enable them to foster innovation efficiency and achieve superior operating performance.

First, due to their ability to bridge short paths between distinct markets, product categories, and industries (Baum et al. 2012), competitive brokers are able to obtain information in a timelier manner, thereby enabling early identification of competitive threats and opportunities. Thus competitive brokers can detect patterns of demand and opportunities for cross-utilization of raw materials, enhancing operating performance. Furthermore, the timely information, as well as competitive brokers' presence in multiple product categories enables them to focus their innovation activities to tap into appropriate opportunities, thereby positively influencing innovation efficiency.

Second, competitive brokers are able to develop a rich, synergistic resource base and gain improved operating performance through better ability to cope with changes in consumer preferences and better use of excess resources (Neffke and Henning 2013; Sakhartov and Folta 2014). Further, given the information advantages of competitive brokerage, competitive brokers are likely to develop new ideas and mobilize or shift their resources from one business unit to another to support new innovation initiatives (Burt 2005), thereby ensuring that focused innovation initiatives are appropriately supported.

Third, due to their access to large numbers of product categories, markets and industries, competitive brokers are able to access diverse information and knowledge (Baum et al. 2014). This heterogeneous distribution of information improves operating performance firms in a competitive brokerage position because access to broader and more diverse information enables firms to complement their own information and knowledge, thereby facilitating the identification of arising opportunities and threats, future business options and sources of further complementary information (Mitsuhashi 2003). Access to diverse information also increases the likelihood that firms recombine information and create new knowledge, practices and cross-industry innovations (Schilling and Phelps 2007), which are more likely to address market needs, thereby improving innovation efficiency.

Fourth, firms in competitive brokerage positions are likely to receive internal and external spillovers of business practices and knowledge. As competitive brokers bridge distinct markets, they will benefit from external spillovers through observation and interactions with various competitors. Subsequently, units of the firm will have richer market knowledge, which would be exchanged across different business units through internal spillovers⁴. As Burt (2010) suggests, business practice spillover is likely to enhance the performance of organizations that participate in industries with intense competition. Uzzi and Spiro (2005) also posit that creativity can be boosted when firms are exposed to diverse ideas in several domains. Knowledge spillovers can therefore enhance the ability to develop creative innovations and improve innovation efficiency.

Consider the example of Unilever, which occupied a competitive brokerage position when it launched Dove VisibleCare Crème Body Wash. This innovative body wash incorporates NutriumMoisture™ technology, which is a combination of the knowledge, information and raw materials, of two product categories in which the firm participates, soap bars and moisturizers (Unilever 2014). Unilever combined its knowledge of mild cleansers (such as those in Dove bar), moisturizers and lipids (available in their hand creams). This knowledge and technology combination enabled Unilever to enter the high-end body wash product category and achieve greater utilization of its raw materials (Unilever 2014). Drawing on the previous arguments, we expect that a competitive brokerage position enhances innovation efficiency, and

⁴ We thank an anonymous reviewer for this insight.
exerts multiple positive influences on operating performance both directly and through innovation efficiency. Hence, our first hypothesis:

**Hypothesis 1.** Innovation efficiency mediates the positive influence of competitive brokerage position on operating performance.

**Complementarity between Competitive Brokerage Position and IT for Operational Integration**

At the operations level, IT enables firms to generate significant competitive advantage by facilitating greater information sharing and responsiveness within the organization and across the supply chain. Firms can substitute information for inventory, thereby coordinating production and driving operating performance (Rai et al. 2006; Saldanha et al. 2013). The use of IT also enhances supply chain visibility, optimization of material flow and synchronization of supply chain partners’ activities (Bharadwaj et al. 2013). IT thus facilitates the alignment of internal production processes and external inter-organizational processes, generating positive performance impacts. This notion of IT value is grounded in the premise that the ability to take advantage of changing market preferences and emerging opportunities lays in the supply chain (Bush et al. 2010). Consequently, the role of IT in the supply chain has been a focus of research in the IS and OM literatures (e.g. Cachon and Fisher 2000; Devaraj et al. 2007). Overall, IT enables organizations to integrate their operations with other firms and incorporate their complementary capabilities into their supply chains, thereby positively influencing firm performance (Rai et al. 2006).

The example of Apple, which utilizes its IT-enabled, integrated supply chain to realize stronger operating performance (Bush et al. 2010), attests to these research findings. Accordingly, we define IT for Operational Integration (ITOI) as the use of IT for the intra- and inter-organizational integration of the firm’s operations. Thus ITOI captures the use of IT for the internal integration of a firm’s operations and external integration of its operations with those of its supply chain partners.

Though competitive brokerage enhances innovation efficiency, its benefits are amplified when it is complemented by ITOI. Thus firms occupying a competitive brokerage position will experience greater innovation efficiency if they possess greater ITOI. This is achieved through four mechanisms. First, ITOI facilitates the visibility of innovation within the organization. This enables every unit of the firm to become aware of innovation and intermediary resources used and developed by other units, thereby enabling competitive brokers avoid replication of innovation effort and hence improving innovation efficiency. Second, ITOI enhances the absorptive capacity of competitive brokers, thereby improving their ability to absorb and process heterogeneous information (Shipilov 2009). Hence ITOI facilitates cross-industry innovations and utilization of knowledge and business practice spillovers by competitive brokers. Third, ITOI eliminates information asymmetry between the firm and its suppliers. Consequently, competitive brokers are able to act upon market opportunities by introducing innovations in a timelier manner due to their suppliers’ innovation and manufacturing processes being in alignment with their own. Fourth, ITOI enhances the visibility of the rich resource base within the organization. Visibility enables the identification and reassignment of excess resources towards innovation efforts, thereby complementing the effect of competitive brokerage on innovation efficiency.

Consider the example of Li & Fung, a Hong Kong based manufacturer which is a competitive broker. Li & Fung utilizes a web-based IT application to achieve operational integration with its 15,000 suppliers in 40 countries. This system coupled with the advantages of a competitive brokerage position, enables Li & Fung to achieve shorter innovation cycle times and thereby achieve innovation efficiency. In addition, the Unilever example described earlier also illustrates this relationship. Unilever has implemented a digital platform that connects its marketers, brand managers and partners in its different worldwide locations. This IT application facilitates sharing of knowledge, best practices and creative assets, thereby enhancing the innovation efficiency of Unilever. In summary, the combination of a competitive brokerage position and ITOI enables firms to be more efficient in their innovation activities. We therefore expect that ITOI will strengthen (i.e., positively moderate) the effect of competitive brokerage position on innovation efficiency, and in turn operating performance. This leads to our second hypothesis, which represents a mediated-moderation relationship.

**Hypothesis 2.** IT for operational integration enhances operating performance by strengthening the influence of competitive brokerage on innovation efficiency.
Methodology

Data

**Competition Network Data.** To test our theory, we built a longitudinal multi-industry competition network using data from a multinational, multi-market, industrial database for the period 2004 to 2010. This database provides rich market data, which includes a comprehensive list of product categories and products available in distinct distribution channels across several countries. As one of the objectives of our study is to capture the multi-industry competitive positioning of firms, this data set is excellent for our research.

To collect the data for the competition network, we first identified the companies, product categories, brands and products in the United States in 11 industries. The 11 industries include beauty and personal care, alcoholic drinks, apparel, appliances, consumer electronics, consumer food service, consumer health and wellness, beverages, pet care, tissue and hygiene, and tobacco. Products commercialized in these industries satisfy the most basic daily needs and adult consumers do not face any serious regulatory restrictions to purchase these products. In line with prior literature (Chen 1996), we used United States data to provide a clear geographical boundary definition and to facilitate cross-firm comparisons. To preserve the whole structure, the multi-industry competition network contains both private and publicly listed companies. To enrich our analysis we also included the market share and number of units sold. To study multi-industry competitive relations, we disaggregated the market data in product category, firm, market share and industry every year. As we are interested in studying the multi-industry positioning of firms, we first identified the ultimate parent companies of the firms. We used Hoovers Company Directory, Thomson Reuters Eikon (business overview section), corporate websites and annual reports to identify the ultimate parent companies.

Then we used the identified ultimate parent companies and product categories to build a bipartite network (Latapy et al. 2008). Given that firms may have subsidiaries that manage certain brands and product categories, utilizing ultimate parent companies to link firms in competitive relations is a more accurate form of representing firm-to-firm competition. Hence, to depict the competitive relations between firms, we linked companies and product categories. Compared to other methods used in the competitive dynamics literature (McNamara et al. 2003; Upson et al. 2012), this approach creates a more refined representation of competition than previously used methods. For instance, industrial economics literature considers that all the firms participating in an industry are direct competitors. Nonetheless, firms may manufacture products that satisfy different needs and are not substitutes. For a more granular representation of competitive asymmetry, we added weights to the links between product categories and firms. The weights represent the total number of products that a company utilized to compete in a specific product category.

To evaluate the firm-to-firm competitive relations, we used a one-mode projection to transform the bipartite network to a firm-to-firm competition network (Newman 2009). To ensure the accuracy of the number of links and clustering of the firms, we reflected the bipartite network into a weighted directed network (a one mode network with value on its directed links) (Padrón et al. 2011). To create directionality in the firm-to-firm competition network, we assumed that both firms compete against each other, such that we represent every competition relationship with a double link, one incoming link and one outgoing link. In this competition network, the directed and weighted links depict the concept of competition asymmetry (Desarbo et al. 2006). Furthermore, these weighted and directed links are the most immediate representation of market similarity and multi-market competition. We followed the same process to create yearly networks and their corresponding matrices from 2004 to 2010. The competition networks have an average of 1,084 firms and 37,359 competitive links. Even though we created a complete competition network, to perform further analysis we only utilized the data corresponding to publicly listed firms, which are 241 firms per year.

Each competitive relationship is represented by two directed links and the weight of each link represent the total number of products that each firms uses to compete against each other across the 11 industries. For instance, take the competitive relationship between firm X and firm Y, as $X \rightarrow Y$. This competitive relationship is formed by one outgoing link and one incoming link, the outgoing link from firm X to firm Y has a weight of 5, which represents that firm X utilizes 5 products to compete against firm Y across the 11 industries.
industries in the competition network. The link from firm Y to firm X represents that firm Y competes against firm X with 6 products across the 11 industries. The distinct weights in the ingoing and outgoing links reflect the intensities with which the companies compete against each other. Hence, these double and weighted links enable us to incorporate competitive asymmetry in our multi-industry network.

**IT for Operational Integration Data.** To alleviate the concerns about common method bias in IT usage and IT surveys (Joshi et al. 2010), we collected secondary data of firms’ IT for operational integration. Following prior IS research (Chi et al. 2010; Joshi et al. 2010), we searched six main computer journals (Computerworld, Networkworld, eWeek, eWeek security watch, Infoworld, and InformationWeek) for data about investment initiatives in IT for operational integration of the 262 firms from 2004 to 2010. We obtained 2,864 unique and relevant news reports and applied structural content analysis to identify information technologies that are part of IT for operational integration (Table 1).

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<th>Table 1. Information systems constituting IT for Operational Integration</th>
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<tr>
<td>Enterprise resource planning system (ERP)</td>
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<td>Inventory management system</td>
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<td>Just-in-time inventory system</td>
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<td>Production planning system</td>
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<td>Production scheduling system</td>
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<td>Quality audit and measurement system</td>
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<td>Quality control system</td>
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<td>Materials requirement planning II system (MRP)</td>
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<td>Product data management system (PDM)</td>
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<td>Robotics-automated system</td>
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<td>Supervisory control and data acquisition system</td>
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<td>Optimization software</td>
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<td>Supply chain management system (SCM)</td>
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**Innovation Data.** We use the firm-level patent data to capture the firm’s innovation outputs. To retrieve the patent data, we use the Harvard Business School (HBS) Patent Inventor Database provided by Li et al. (2014) which provides the patent assignees, the technology class, the application date for all patents granted by the US Patent and Trademark Office (USPTO) from 1976 to 2010. The NBER patent database provides a direct link between patent assignees and the Compustat-matched firm identifiers from 1976 to 2006 (Hall et al. 2001) to help us match patent assignees to our sample firms. For patents granted from 2007 to 2010, we do a manually match following Gao et al. (2014).

**Financial Data.** Our longitudinal multi-industry competition network contains both publicly listed and private firms. Following the conventions of previous literature (Schilling and Phelps 2007), we focus on the 262 publicly listed companies in the United States that are included in the network. Financial data was obtained from Compustat and Thomson Reuters Eikon.

**Measures**

All the independent and control variables were lagged one year in relation with the dependent variable.

**Competitive Brokerage.** We developed this measurement using the multi-industry longitudinal competition network. This measurement relies on the concept of intermediary nodes and quantifies the number of times that intermediary nodes act as bridges or brokers. Competitive brokerage is measured as:
where $g^{WS}_{ij}(t)$ is the number of weighted shortest paths that go through firm $i$ and $g^{WS}_{ij}$ is the number of weighted shortest paths between two nodes (Opsahl et al. 2010). The parameter $\alpha$ has two benchmark values, 0 and 1. If $\alpha=1$, only the weights of the links will be considered to find the shortest path and calculate betweenness centrality. If $\alpha=0$, only the length and number of links will be considered to calculate the measurement. When $\alpha=0.5$, the calculation takes into account and gives the same importance to the number of links, weight and length of the links to calculate the measure. For this study, we set parameter $\alpha$ to 0.5.

**IT for Operational Integration (ITOI).** After extracting and identifying the relevant news reports, we counted the number of IT systems that enable operational integration that were implemented each year by each company. We presumed that technologies used before certain period will continue to be used unless they were later reported as discontinued or upgraded. Two coders independently classified the news reports and any inconsistencies were re-coded by the first author. To check the reliability of the classification we used the Perreault and Leigh index (Perreault and Leigh 1989) and obtained a value of 0.80, which exceeds the 0.7 benchmark value.

**Innovation Efficiency.** We followed Lanjouw and Schankerman (2004) and Hirshleifer et al. (2013) to define innovation efficiency as the innovation output (patent counts) divided by input (R&D expenditure). However, to adjust for the potential patenting and citing propensities associated with application year and technological class, we followed Seru (2014) and Bena and Garlappi (2012) to compute the adjusted patents. Specifically, we divided the number of patents in each technological class by the average number of patents applied in the same year and the same technological class. To be consistent, we followed Almeida et al. (2013) to adjust innovative input by scaling R&D by the corresponding industry average R&D expense in the same year based on Fama and French (1997) 48 industry classifications to remove the industrial component in R&D expenditures.

**Operating Performance.** We assessed firms’ operating performance with an objective operating indicator, raw materials. Finished-goods inventory level has been regarded as one of the most commonly available operating performance measures in the literature, e.g., Chen et al. (2005) and Rumyantsev and Netessine (2007). However, as motivated in the hypothesis development, the linkage between competitive brokerage and inventory performance is tied on the concept of risk pooling at the source. Therefore, we take the annual raw materials as the operating performance measure.

<table>
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<th>Table 2. Descriptive statistics and correlations</th>
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<td><strong>Operational performance</strong></td>
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<td><strong>Competitive links</strong></td>
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<td><strong>Industry capital intensity</strong></td>
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<td><strong>Firm R&amp;D intensity</strong></td>
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Control Variables. To account for the effects of extraneous variables and account for rival explanations, we included market share, gross margins, average number of days of accounts payable outstanding, current ratio, competitive links, industrial capital intensity, firms R&D intensity, fixed assets and year trend dummy variables. To capture firms’ market share, we adapted the weighted market share measurement from Bharadwaj et al. (1999): Weighted Market share = \( \frac{MsiPi}{P} \); where \( Msi \) is a firm’s market share in each of its industries “i” and \( P \) is the proportion of the firm’s sales in the industry. To account for product margins, we use gross margin, which does not include amortization, taxes or other items that are not directly related to inventory management (Rumyantsev and Netessine 2007). Gross margin is defined as \( \frac{\text{Sales} - \text{COGS}}{\text{Sales}} \). Following prior literature, we include average number of days of accounts payable outstanding as a proxy of lead time and a year trend dummy to capture the time trend of inventory changes (Rumyantsev and Netessine 2007). Current ratio is defined as current assets/current liabilities. Current ratio can be utilized as a proxy of the efficiency of firms’ operating cycle because it reflects firms’ ability to turn their products into cash. Competitive links is the number of outgoing links that the firm has in the competition network. The number of outgoing competitive links reflects the number of product categories in which a firm participates, acting as a control for economies of scale and economies of scope. Furthermore, competitive links also represent degree centrality (Freeman 1979). We also included the multimarket contact measure proposed by (Gimeno and Woo 1999) to control for multimarket competition. Given that the competition network includes firms participating in several industries, we include industry capital intensity as an industry level control variable. Industry capital intensity is defined as Net book value of plant and equipment/Revenues (Hambrick 1983). We controlled for R&D intensity, which is defined as R&D expenses/sales. Prior literature has stated that firms’ R&D intensity reflects the strategic importance of innovation to the firm (Lim et al. 2013). We used fixed assets as an indicator of firm size. In Table 2, we present the descriptive statistics and correlations of the measures.

### Analysis and Results

#### Model Specification

We utilized the moderated causal steps approach from Edwards and Lambert (2007) to test for moderated mediation. First, we tested whether innovation efficiency influences operating performance (Model 1). Second, we examined whether IT for Operational Integration (ITOI) moderates the effects of competitive brokerage on innovation efficiency (Model 3). Finally, we examined if innovation efficiency mediates the relationship between competitive brokerage and operating performance (Model 5).

**Model 1:** \( \text{Performance}_{it} = \beta_1 \text{Innovation efficiency}_{it-1} + \beta_2 \text{Controls}_{it-1} + \epsilon_i \);  
**Model 3:** \( \text{Innovation efficiency}_{it} = \beta_1 \text{Competitive brokerage}_{it-1} + \beta_2 \text{ITOI}_{it-1} + \beta_3 \text{Controls}_{it-2} + \epsilon_i \);  
**Model 5:** \( \text{Performance}_{it} = \beta_1 \text{Competitive brokerage}_{it-1} + \beta_2 \text{ITOI}_{it-1} + \beta_3 \text{Innovation efficiency}_{it-1} + \beta_4 \text{Controls}_{it-1} + \epsilon_i \).  

In particular, we include individual firm fixed effects in the controls. There might be omitting variables that impact the dependent variables, e.g., firm size, managerial talents, inventory policy, accounting policy, etc. To correct for potential bias due to omitted firm-specific factors, we use the fixed-effect model to compare dependent variables across firms over the period of the time series (2004-2010). The Hausman test confirms that a fixed-effect model is preferred to a random-effect model for our dataset.
deal with possible multicollinearity between the interaction terms, we mean centered each variable that constitutes an interaction term and created the interaction terms by multiplying the mean centered variables (Aiken and West 1991). In these models, the largest variance inflation factor is related to competitive brokerage, with a value of 2.29, which is below the 10.0 usual benchmark. Therefore, multicollinearity is not a major issue in our analysis. To further increase the robustness of our results we included Models 2 and 4, which further show support for our hypothesized relationships.

Empirical Results

Table 3 shows the results of the panel-regression estimates. In Hypothesis 1, we consider innovation efficiency as a mediator in the relationship between competitive brokerage, its interaction with IT for Operational Integration and operating performance. Following the moderated causal steps approach proposed by Edwards and Lambert (2007), we first establish the validity of Model 1 and Model 2 and Model 3. Finally, in Model 5, we evaluate the relationship between competitive brokerage and operational performance, and assess whether the interaction between competitive brokerage and ITOI is no longer significant. If it is no longer significant, we can take it as evidence that innovation efficiency mediates the effect of this interaction on operating performance. Model 5 of Table 3 shows the insignificant interaction (b=0.007, p>0.10) and the main effect of ITOI remaining insignificant. As suggested by Edwards and Lambert (2007), evaluating whether the interaction between competitive brokerage and ITOI is significant is enough evidence to assume that innovation efficiency has a mediation relationship. Thus, we find support for Hypothesis 1.

In Hypothesis 2, we assess how the complementarity between competitive brokerage and IT for Operational Integration influences operating performance. Model 3 of Table 3 shows that the interaction between competitive brokerage and ITOI positively influences innovation efficiency, indicating that they are complements to achieve innovation efficiency (b=0.019, p<0.001). To further assess the interaction effects, we followed Aiken and West (1991) to conduct simple slope tests and plot the relationships in Figure 2. In these tests, we split the variable, ITOI, into two groups; high (low) represent the case with one standard deviation above (below) the mean. Then, we estimated the effect of competitive brokerage on innovation efficiency for both levels. As Figure 2 shows, when ITOI is high, competitive brokerage has a stronger positive effect on innovation efficiency than when it is low. Hence, we find support for Hypothesis 2. Furthermore, when the effects of the interaction between competitive brokerage and ITOI are taken into account, the effects of competitive brokerage on operational performance decrease while the effects of innovation efficiency increase. As a robustness check, we repeated our analysis with a measure of operating performance that increases as operations improve in efficiency (unlike raw materials, which decrease). The qualitatively similar results obtained on using a ratio of raw materials to finished goods inventory are not reported in due to space constraints.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Control model</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operatioal performanc e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market share</td>
<td>6.266**</td>
<td>0.256**</td>
<td>-0.016</td>
<td>-0.013</td>
<td>0.221**</td>
<td>0.223**</td>
</tr>
<tr>
<td>Gross margin</td>
<td>-0.346</td>
<td>0.005</td>
<td>-0.016</td>
<td>-0.015</td>
<td>-0.059</td>
<td>-0.059</td>
</tr>
<tr>
<td>Days accounts payable</td>
<td>0.061</td>
<td>0.066</td>
<td>-0.015*</td>
<td>-0.016*</td>
<td>0.035</td>
<td>0.035</td>
</tr>
<tr>
<td>Current ratio</td>
<td>0.209*</td>
<td>0.053</td>
<td>0.002</td>
<td>0.002</td>
<td>0.085*</td>
<td>0.085*</td>
</tr>
<tr>
<td>Year (dummy)</td>
<td>0.013</td>
<td>0.005</td>
<td>-0.010***</td>
<td>-0.010***</td>
<td>0.002</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Table 3. Regression estimates
Discussion and Conclusion

Building on multi-firm networks theory, information systems and operations management literatures, we examined the effects of competitive brokerage and IT for operational integration on operating performance and found support for two main ideas. First, we found that competitive brokerage has a positive effect on operating performance and this relationship is mediated by innovation efficiency. Thus,
firms that lie in a competitive brokerage position can leverage several structural advantages that will enable them to be more efficient in innovation and better in operating performance. This is due to four mechanisms: information timeliness, resource base richness, information diversity and spillovers. We also found that innovation efficiency has a positive effect on operational performance. Firms with higher innovation efficiency are able to introduce and produce multiple product categories. These multiple product categories make firms’ production processes flexible, such that in case of raw materials shortage, they are able to adapt their production processes and manufacture products that do not require such raw materials. Second, we found that IT for operational integration complements the benefits realized from competitive brokerage on innovation efficiency. Further, innovation efficiency mediates the effects of competitive brokerage and IT for operational integration on operational performance. Hence, the operational benefits of the complementarity between competitive brokerage and IT for operational integration are realized through innovation efficiency.

This paper makes several contributions to literature. First, and foremost, our findings highlight the strong complementarity between IT for operational integration and competitive brokerage position. Thus we add positioning in a multi-firm network to the growing list of resources to which IT serves as a complement, thereby contributing to the IT business value literature. Second, and most critically, this paper focuses not only on why, but on how competitive brokerage influences operating performance by offering innovation efficiency as an explanation. Therefore we add to our collective conceptual understanding of the mechanisms that drive operating performance and introduce the multi-firm competition networks to this discourse in the OM literature. Third, though IT and OM are symbiotic in practice, empirical evidence is not proportionate to the strength of this relationship due to lack of cross-fertilization between the OM and IS literatures (Saldanha et al. 2013). We add to the growing number of studies that address this gap. Fourth, this paper contributes back to the literature on multi-firm networks by demonstrating the operating performance enhancing effects of competitive brokerage. We show that positioning in not just collaboration or co-operation, but also pure competition networks has innovation and performance enhancing effects. This positive influence is reflected not only through financial measures of performance, but also at the intermediate level of operating performance.

Even though this paper provides novel insights to the IS and OM literatures, it suffers from some limitations that could be addressed in future research. First, our competition network is limited to the domain of consumer products. Future research should examine competition networks in other domains and investigate the role of positioning, and innovation efficiency in those contexts. Second, even though our study incorporates 11 different industries, further research will benefit from analyzing industries that differ on turbulence and innovation. Third, although prior research has highlighted the advantages of utilizing secondary data to assess firms’ IT (Joshi et al. 2010), we cannot discount the possibility of biases of the media causing over or under reporting of IT of certain firms. Some important systems may have not been covered in the popular press. Future research will benefit from complementing secondary data with more subjective measures of IT gathered through surveys. Fourth, although patents have been used in prior literature as an indicator of innovation outputs, we are aware that firms may not patent all their innovations due to strategic reasons. Hence, even though patents are a robust measure of innovation outputs, future research will benefit from complementing patent data with survey data to evaluate innovation outputs. Fifth, future research will highly benefit from considering the potential endogeneity of network measures.

Finally, future research can consider alternative objective measures of operational performance that are intuitively related to the benefits of competitive brokerage such as production costs, lead time, diversification, information sharing across industries, and risk-spreading.

In conclusion, through this paper, we demonstrate that operating performance can be attained through pas de trios of IT, competitive brokerage and innovation.

References

5 We thank an anonymous reviewer for this valuable insight.


