Knowledge Transfers In The US Biopharmaceutical Market During A Time Of Transition

By: **David R. Williams**

Abstract

The purpose of the paper is to examine the effects that firm factors, multinational corporations, and location have on explicit and tacit knowledge transfers originating in US biopharmaceutical firms during a time of transition. Examination of all known biopharmaceutical formal tacit and explicit knowledge transfers was done. The study performs logistic regression to test its hypotheses. The study identifies tacit knowledge transfers with full or partial equity acquisitions in firms. Explicit knowledge transfers are associated with licensing agreements or product and technology acquisitions. The study finds biotechnology firms and private firms are more likely to transfer tacit knowledge than explicit knowledge. Multinational firms are more likely to acquire tacit knowledge than explicit knowledge. Local transfers (compared with non-local or foreign transfers) are more likely to be tacit knowledge transfers. Firms within clusters are also more likely to transfer explicit knowledge than tacit knowledge. Given the choice between tacit and explicit knowledge transfers, firms prefer tacit knowledge transfers.

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ORIGINAL ARTICLE

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Methods Examination of all known biopharmaceutical formal tacit and explicit knowledge transfers was done. The study performs logistic regression to test its hypotheses.

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Results The study finds biotechnology firms and private firms are more likely to transfer tacit knowledge than explicit knowledge. Multinational firms are more likely to acquire tacit knowledge than explicit knowledge. Local transfers (compared with non-local or foreign transfers) are more likely to be tacit knowledge transfers. Firms within clusters are also more likely to transfer explicit knowledge than tacit knowledge.
Conclusions Given the choice between tacit and explicit knowledge transfers, firms prefer tacit knowledge transfers.

Keywords Pharmaceutical companies · Biotechnology firms · Knowledge transfers · Diffusion of innovation · Organizational learning

Introduction

For the past several decades, knowledge has been viewed as a key resource related to the individual, firm, industry, and economy's success [1, 2]. This realization has led to the burgeoning knowledge-based view (KBV) of the firm [3, 4]. From this perspective, proponents argue that heterogeneous knowledge bases and capabilities are the primary drivers leading to a firm's competitive advantage and superior performance [5], particularly in high-technology markets [6].

KBV suggests that the firm's reason for existence is the creation, transfer, and application of knowledge [7, 8]. Given that no one firm can generate internally all of its needed knowledge, firms must actively and continuously acquire and/or transfer knowledge [9, 10]. Researchers [11, 12] suggest that firms that are able to transfer knowledge effectively are more productive than firms that are less capable of knowledge transfer. An associated, more practice-oriented stream [13] in the knowledge literature called knowledge management (KM) also examines knowledge transfers. Carayannis [14: 219] describes KM as "a sociotechnical system of tacit and explicit business policies and practices." Within both literature streams, it remains unclear, however, as to what the nature and direction are of knowledge transfers [15, 16].

Building upon the KBV and the KM literatures (hereinafter knowledge literature or KL), the present paper seeks to examine (1) the nature (i.e., forms) and (2) direction (i.e., by and to whom and location) of knowledge transfers generated in the US biopharmaceutical market during a time of transition. Broadly speaking, we propose that firms of different types and residing in different locations are involved in the transfer of different forms of knowledge. We examine the external contractual forms of these transfers. Moreover, we examine this phenomenon during a time of market transition or merging of industries, which is understudied. This may be helpful for firms and industries facing disruptive innovations, such as

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the pharmaceutical industry were facing with respect to the biotechnology industry and its heterogeneous knowledge base.

The knowledge literature can be divided into two natures or forms of knowledge: explicit and tacit [17, 18]. Explicit knowledge represents the *knowing about* (objective knowledge), whereas tacit knowledge represents the *knowing how* (subjective knowledge). Both forms of knowledge can be externally sourced or transferred by various means [19].

Explicit knowledge can be codified and is readily transferable [7]. Blueprints, copyrights, patents, and trademarks are examples of explicit knowledge. For purposes of this study, we identify explicit knowledge transfers with two forms of transfers: (1) license agreements and (2) product or technology acquisitions (hereinafter technology acquisitions). Tacit knowledge resides in individuals and is less readily transferrable [20]. Firms acquire other firms in order to gain access to tacit knowledge [21]. We identify tacit knowledge transfers with full or partial equity acquisitions in firms (hereinafter equity acquisitions). Both of these forms represent inter-firm knowledge transfers.

Most KL research has focused on the transfer of tacit knowledge [16], especially within firms (i.e., intra-firm transfers). Few studies have examined the determinants of explicit and tacit knowledge transfers (i.e., the *forms* of knowledge) between firms together [16, 22]. Understanding the forms of knowledge transfers is important, as researchers [23, 24] have observed that firms can enhance their competitive positions by facilitating and managing intra- and inter-firm knowledge transfers. We focus on one aspect of this: the transfer of inter-firm knowledge, and within the context of biopharmaceutical firm knowledge transfers.

In addition to the forms of knowledge, characteristics of the transferor and transferee play an important role [25]. This in part may be because the transfer of explicit and tacit knowledge represents differing levels of commitment and control. Equity acquisitions are viewed as higher levels of commitment and control compared with licensing and technology acquisitions [26], with different firms, such as multinational corporations (MNCs), desiring different levels of control.

The location of the firm also may affect the form of knowledge transfer. Much of the early knowledge transfer literature assumed that knowledge mainly transferred locally [27, 28]. This may have been particularly true of biotechnology firms that tend to cluster in specific geographic regions [29]. The literature on location and knowledge transfers continues to evolve with most focusing on tacit knowledge [29].

The present study adds to the knowledge literature by examining the nature and direction of knowledge transfers. Specifically, the study's main research questions are the following: (1) are biotechnology firms and private firms more likely to transfer tacit knowledge than explicit knowledge; (2) are MNCs more likely to acquire tacit knowledge than explicit knowledge; (3) are local transfers more likely to be explicit knowledge than tacit knowledge; and (4) are firms located within clusters more likely to transfer explicit knowledge than tacit knowledge. Similar to other studies on knowledge [8, 15, 30], we examine these questions within the context of the biopharmaceutical market sector. We choose a specific time period (e.g., 2000–2006), which represents a market in transition by way of the merging of two industries with distinct knowledge and competencies [31]. The time period under study represents a time when biotechnology products became the majority of products in the clinical pipeline and with some biotechnology firms beginning to become profitable. The study seeks to fill the gaps in the knowledge literature about forms of knowledge transfers and their relationships with firm factors, MNCs, and location effects, specifically during a time of market disruption and transition.

Theory and Hypotheses Development

The Knowledge Literature

The knowledge-based view suggests that knowledge is the most important resource for the firm [1, 32]. Without focusing on the epistemology of knowledge or the discussion on the loci (e.g., individuals, groups, and organizations) of knowledge (which is beyond the scope of this paper), we note that knowledge and KBV are closely associated with several theories and literature streams.

The resource-based view [33, 34] can be regarded as the foundation of KBV [8, 18]. The resource-based view (RBV) and KBV both see knowledge as a resource leading to performance differences among firms [4]. RBV suggests that a firm's resources have the potential to provide enduring competitive advantage when they are inimitable and not readily substitutable [35]. Much focus in the KBV literature has been on tacit knowledge because it is difficult to imitate and not readily substitutable. Explicit knowledge on the other hand is appropriable [1], and thus, inimitable and readily substitutable. Some types of explicit knowledge, however, such as patents and copyrights are legally protected [36], which makes them scarce and embeds them with value. Both KBV and RBV note, "the more rare and valuable knowledge a firm has, the better its performance" [6: 376].

KBV differs from the RBV in that KBV sees knowledge as the most important resource. Another distinction is that the RBV treats knowledge as a generic resource, rather than having special properties [37]. Compared with KBV, RBV also does not specify the differences between resources and capabilities, and whether they are internal to the firm or can be acquired externally [38]. We investigate the dynamic nature of knowledge transferred externally by firms.

Market in Transition and Firm Factors

From a simplified perspective, the pharmaceutical industry is based on long-established, vertically integrated (R&D to sales) firms with a knowledge base in organic chemistry (and its application) that seeks to produce "block-buster" drugs [39]. Biotechnology came about in the early 1970s and is grounded in recombinant DNA technology and molecular genetics [40]. Since this time, it has expanded and diversified its competencies and knowledge bases to include, among others, gene and cell therapies, monoclonal antibodies, combinational chemistry, genomics, and bioinformatics. For pharmaceutical firms, biotechnology may represent a "dramatic case of a competence-destroying innovation" [41: 368].

Firms facing research and development issues and threats can resolve these issues by acquiring the necessary competencies from external sources of knowledge [42]. Although, pharmaceutical firms can choose to focus on pharmaceutical products alone (which some still do), they can also seek to enter into the biotechnology industry. They can do this by internal development, joint ventures, acquisition or licensing of technologies, or acquisition of firms [39]. By the mid-1990s, most large pharmaceutical firms had begun to engage in biotechnological R&D by one or more of the above means [40]—thus, the merging of the two industries into the biopharmaceutical market sector.

Much of the research on relationships between pharmaceutical firms and biotechnology firms has focused on strategic alliances of various forms, such as licensing agreements and equity joint ventures. Lerner and Merges [43] noted that funding from strategic alliances with pharmaceutical firms became the largest single source of financing of biotechnology firms through the mid-1990s. The literature on strategic alliances in biotechnology has been extensive [44]. Much of this literature focuses on alliances where the biotechnology firm engages in research and development, leaving other aspects (i.e., approval process, manufacturing, and marketing) to the pharmaceutical firm.

In strategic alliances, firms seek to both access and acquire the knowledge related to the capabilities of its partners [45]. It has been argued that learning alliances permit organizations to increase the speed of capability development and reduce uncertainty by acquiring and exploiting knowledge developed by other firms [46]. Yet, as Rothaermel and Deeds [46: 218] note, "the opportunity costs of an exploration–exploitation alliance strategy in the new product development process can potentially outweigh its benefits." This is true for both partners in an alliance.

Product acquisitions and licensing agreements also may not transfer tacit (know how) knowledge, which is more closely related to the creation of innovative drugs and therapies, and which has historically been the means of sustained competitive advantage for pharmaceutical firms. For example, Mowery et al. [47] studying equity joint ventures and non-equity licensing agreements found that equity joint ventures were more effective for the transfer of complex capabilities than licensing agreements, and that higher levels of knowledge transfer occurred in equity joint ventures than non-equity (such as licensing) arrangements. We do not study joint ventures (i.e., two entities forming a third new entity), but believe an extension of this can be made for the comparison of non-equity acquisitions or transfers to equity acquisitions of firms.

The biopharmaceutical market also has been the subject of the mergers and acquisition (M&A) literature. Our study examines acquisitions, but not mergers (i.e., two entities becoming a new entity). Related to our study, this stream of research examines opportunities for firms to reconfigure their businesses and alter their pool of capabilities and resources [48]. For example, Lodh and Battaggion [49] studying biotechnology M&As show that acquisitions of unrelated firms develop the breadth of knowledge compared with acquisitions of related firms that mainly increase the depth of knowledge.

Additionally, the biopharmaceutical market sector is a process-enabling sector, where process and product knowledge must be well coordinated [50]. Within biotechnology, as firms attempt to create new drugs, new processes must be developed. As Feldman and Ronzio [51: 2] note, "biomanufacturing is in itself a knowledge-generating activity." Furthermore, the Food and Drug Administration (FDA) requires that material used in the market authorization process be the same process that is used for the final product [52]. This is to say that there are market authorization (FDA) reasons as well as knowledge reasons for owning and controlling both the drug discovery and development process.

Ultimately, given the growth in biotechnology [53] and its perceived disruptive potential, many pharmaceutical firms sought to further commit resources into the biotechnology industry. During the period of our study, the pharmaceutical industry was perceived as facing a productivity crisis with fewer approved drugs entering the market [54]. Although there were few biotechnology products on the market at the end of the 1990s [55], by 2004, 60 % of the drugs in the clinical pipeline were biotechnology products [53].

Because of the above, the extreme duration of the market authorization process [46] and costs (which DiMasi and Grabowski [55] estimate to be similar for pharmaceutical and biological products during this time), pharmaceutical firms continued to acquire both explicit and tacit knowledge. In addition, beginning in the mid-1990s, the acquisition price of biotechnology knowledge had decreased and may have been lower than internal development costs [39]. This may be because the biotechnology industry as a whole remained unprofitable until 2008 [56]. Additionally, other external sources of financing (e.g., venture capital and initial public offerings) were slowing down after 2000 [57], leaving

financing from pharmaceutical firms as a major source. Because of these factors, we note this as a period of transition for these two industries.

Lerner and Merges [43] examining the control rights in strategic alliances between R&D firms (biotechnology) and financial firms (pharmaceutical) found that the most profound effect on the allocation of control rights is the financial condition of the R&D (biotechnology) firm. In addition, their research suggested that pharmaceutical firms in some cases protracted negotiations weakening the financial (and thus bargaining) position of biotechnology firms. Lerner and Merges [43] also note that when external financial resources were lower for the biotechnology firm, then the financing firm had the greater leverage or bargaining power.

We extrapolate from Lerner and Merges' [43] research and suggest that a financing pharmaceutical firm would likely seek an equity position in the firm (compared with a product acquisition or licensing agreement) as it may give greater access and control of present and future technologies and knowledge. As Kogut and Zander [58: 391] observe "creating new knowledge does not occur in abstraction from current abilities," and the "language of chemical pharmaceuticals may be inadequate for the development and transfer of biotechnologies." Given the perceived disruptive threat of biotechnology, the financial condition of the industry, and the lack of internal knowledge of pharmaceutical firms in this area during this time, the following hypotheses are offered:

- H_{1a}: Biotechnology firms (compared with pharmaceutical firms) are more likely to transfer tacit knowledge than explicit knowledge.
- H_{1b}: Private firms (compared with public firms) are more likely to transfer tacit knowledge than explicit knowledge.

Multinational Corporations

It has been suggested [59] that multinational corporations are the major global producers and disseminators of technology. Reus, Lamont, and Ellis [60: 933] also suggest that "multinationals are a superior organizational form for transferring knowledge." This may be because as previous research has argued transferring knowledge within firms is less complicated than transferring knowledge across firms [9]. Furthermore, Gupta and Govindarajan [32: 473] suggest "the primary reason MNCs exist is because of their ability to transfer and exploit knowledge more effectively and efficiently in the intra-corporate context than through external market mechanisms." The transfer of knowledge is critical in global businesses as MNCs serve to adopt intra-organizationally the transfer of knowledge across borders [16].

As noted above, during the time under study, the pharmaceutical industry and biotechnology industry are merging. Initially, all pharmaceutical firms, whether foreign or domestic, face the same lack of knowledge challenges, with R&D being one of the least internationalized of all activities for firms [2]. Thus, MNCs engage in both inter-firm tacit and explicit knowledge transfers [10], as there remains increasing pressure on MNCs to gain knowledge from their business environments [61].

Kogut and Zander [3: 639] note, "firms grow on their ability to create new knowledge and to replicate this knowledge so as to expand their market." MNCs can expand into new markets by several different vehicles: licensing, exporting (such as a technology), joint ventures, or wholly owned subsidiaries [62, 63]. This typically is viewed from the perspective of the firm already possessing the knowledge, but can be applied to the firm acquiring the knowledge as well. This is to say that MNCs can access and acquire knowledge by these vehicles.

MNCs typically operate as a network of geographically scattered subsidiary units [64]. Kale and Singh [65] suggest that when most large firms acquire smaller firms or when firms in less developed countries acquire firms in more developed countries that they do not integrate the acquired firm into a single corporation, but rather maintain their identity and capabilities separately. Thus, an MNC may wish to acquire the biotechnology firm as this reduces the threat of knowledge dissemination to other firms compared with a license agreement [62]. This is because transfers between subsidiaries represent the transfer of tacit knowledge, which protects against unwanted imitation [63].

Berry [2: 871] also notes that firms are less receptive to knowledge coming from outside the firm, with firms being reluctant to embrace technology transfers due to the "not invented here syndrome." Thus, strong relational ties may be necessary for tacit knowledge transfers, in particular [2]. The acquisition of a firm and incorporation of tacit knowledge may help reduce this "foreignness" issue for MNCs and strengthen intra-firm knowledge transfers.

Similar to our arguments above, it may be that the reduced prices for equity acquisitions in this market combined with the greater need for control and access to knowledge will lead MNCs to pursue tacit knowledge (equity) acquisitions compared to acquisitions of explicit knowledge. Shan and Song [66] found that foreign MNCs in the biotechnology industry make equity investments in US biotechnology firms sourcing country-specific, firm-embodied knowledge advantages [67]. We believe this to be true for US MNCs and pharmaceutical MNCs. Thus, the hypothesis is

H_2: Multinationals (compared with non-MNCs) are more likely to acquire tacit knowledge than explicit knowledge.

Location and Clusters

The effect of the firm's location in the knowledge literature as applied to the biopharmaceutical market has been studied

extensively [15, 68]. Geographical distance has been argued as both a hindrance and benefit to the firm's innovative capabilities [69]. As Phene et al. note [69: 374] note, "the very distance of the knowledge that makes it valuable creates difficulties in its acquisition and absorption."

Much of the knowledge literature has examined the location of biopharmaceutical and other firms from a social network perspective. Researchers have suggested that access to new sources of knowledge is one of the most important direct benefits of social networks [12]. Many of the social networks in biotechnology are formed during the researcher's formal education, with many firms being the product of university spin-offs [70]. For example, Herbert Boyer of Genetech, the first biotechnology firm, was associated with the University of California at San Francisco. Several of Genetech's first employees were Boyer's former students [71].

The creation of the biotechnology industry as an offshoot of the university setting is different than that of the pharmaceutical industry [31]. Historically, pharmaceutical firms have resided mainly in the eastern portion of the USA whereas biotechnology has been bi-coastal in the USA if not more geographically dispersed. It also has been noted that biotechnology firms tend to cluster in areas where intellectual capital (i.e., universities) and financial capital (i.e., venture capital) co-exist [72]. Arikan [73: 658] observes that the "knowledge-based theory places primary emphasis on inferfirm knowledge exchanges among cluster firms in explaining enhanced knowledge creation within clusters."

Studies on clusters usually concern the transfer of tacit knowledge [12]. The clustering of embryonic firms near universities is partly explained by the need to transfer tacit knowledge between university-based scientists and biotechnology firms [74]. Biotechnology firms also engage in the transfer of tacit knowledge between firms. This clustering is not limited to start-ups, but multinational corporations also are present in clusters due to the tacitness of local technological knowledge [15].

From a social network perspective, much of this knowledge sharing is performed on an informal basis [72]. This knowledge sharing may at times lead to knowledge or technology spillovers, which occur involuntarily [62] and for which the transferor receives no monetary compensation [73]. As Chiaroni and Chiesa [29: 1065] note "firms working in the same field naturally benefit from information exchanges concerning markets, technologies, and business partners, etc." Given this, the potential for knowledge spillovers may lessen the need for tacit knowledge in the form of equity acquisition of the firm. Thus, the hypothesis is

H_{3a}: Local knowledge transfers (compared with non-local transfers) are more likely to be explicit knowledge than tacit knowledge.

Additionally, Breschi and Lissoni [74: 27] studying patent citations in the biopharmaceutical market find that "mobile inventors and short social chains of co-inventors are largely responsible for the localization of knowledge flows," implying that researchers are not likely to relocate outside of these clusters, but they do change employers and take tacit knowledge with them. We extrapolate from the above and suggest that firms within clusters may be able to hire talent (i.e., access to tacit knowledge) at a rate sufficient to lessen the need for equity (tacit knowledge) acquisition. Thus, the hypothesis is

H_{3b}: Firms within clusters (compared with non-cluster firms) are more likely to transfer explicit knowledge than tacit knowledge.

Methods

In order to examine knowledge, we use a database compiled by Irving Levin Associates, Inc. The database includes all known biopharmaceutical formal tacit and explicit knowledge transfers originating from private and publicly traded firms in the USA from 2000 through 2006. There are 555 transfers of knowledge during our period of study. We perform binary logistic analysis to test our hypotheses. We define explicit knowledge transfers as license agreements or technology acquisitions. We define tacit knowledge transfers as full or partial equity interests in a firm.

The database gives us qualitative information. The following describes how we re-code this information into an appropriate quantitative format for purposes of the study. For our dependent variable in the binary logistic regression analysis, we use a binary variable noting if the knowledge being transferred is by way of a license agreement or product/technology acquisition (0) or partial or full acquisition of equity in the transferring firm (1). An example of a license agreement would be Ascent Pediatrics' licensing of OPRAMED, a liquid corticosteroid for treating pediatric asthma to BioMarin. An example of a product/technology acquisition is Chiron Corporation selling its San Diego-based gene therapy manufacturing facility to Cell Genesys. An example of a partial acquisition of equity would be GlaxoSmithKline acquisition of an additional 16% of Theravance. An example of a full acquisition of equity would be Amgen's acquisition of Abgenix. We control for the date that the transfer occurs by way of a continuous variable (i.e., 2000 = 1; 2001 = 2).

For our firm factor independent variables, we code a firm (0) if the transferring (i.e., selling) firm is a biotechnology firm, or (1) if the transferring firm is a pharmaceutical firm. We code if the transferring (i.e., selling) firm is a private firm (0) or a publicly traded firm (1). To determine if the firm acquiring knowledge is a multinational firm, we use Gray's [75] list of top 20 biopharmaceutical firms, which is based upon 2004 revenues. Eleven of the top 20 firms have corporate headquarters outside of the USA. We code an acquiring firm (1) if it is a top 20-biopharmaceutical firm or (0) if not.

For the variable related to local transfer or non-local transfer, we use Mapquest (www. Mapquest.com) to plot the distance between the two firms. In general, we consider a distance between the firms of 50 miles or less to be "local." A local knowledge transfer is coded (1) and a non-local knowledge transfer is labeled (0). For bio-clusters, we use Powell et al.'s [74] nine bio-pharmaceutical regions. We code the variable of the transferring firm headquartered in a geographic bio-cluster (1) or (0) if not. Within our binary logistic regression analysis, we use different reference categories. The following categories use the first reference variable as the comparison group: multinational, local, and cluster. The following categories use the last reference variable as the comparison group: biotechnology/pharmaceutical and private/public.

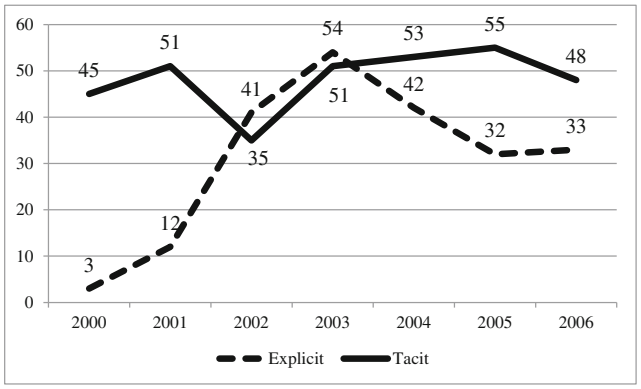

Chart 1 Explicit and tacit knowledge transfers by year

Results

Table 1 shows the means and correlations associated with the binary logistic regression analysis related to knowledge transfers being either explicit (e.g., license or technology acquisition) or tacit (e.g., equity position in the firm). For our sample of 555 knowledge transfers, there were 217 (39.1%) explicit transfers and 338 (60.9%) tacit transfers. Chart 1 shows explicit and tacit transfers by year.

There were 275 transfers originating with biotechnology firms (49.5%) and 280 transfers originating with pharmaceutical firms (50.5%). There were 273 (49.2%) private firms transferring knowledge compared with 282 (50.8%) public firms. Chart 2 illustrates biotechnology/pharmaceutical firms and private/public firms' transfers by year.

There were 66 (11.9%) explicit or tacit knowledge acquisitions by multinational firms compared with 489 (88.1%) non-multinational firms. There were 71 (12.8%) transfers that were local compared with 484 (87.2%) that were non-local transfers. Three hundred sixty (64.9%) transfers originated in a cluster, compared with 195 (35.1%) of the transfers originating in a non-cluster.

Table 2 presents the results of our binary logistic regression analysis between firms transferring either explicit or tacit knowledge. The results indicate a good fit of the model to the data (Model $\chi^2 = 154.418$ ($p = 0.000$) and Nagelkerke $R^2 = 0.329$) and correctly classify 74.4% of the cases. Our results show that all of the variables in the model are statistically significant.

Biotechnology firms were 3.475 times more likely to transfer tacit knowledge than pharmaceutical firms. Private firms were 5.800 times more likely to transfer tacit knowledge than publicly traded firms. These two findings support our two hypotheses related to firm factors (i.e., H_{1a}: biotechnology firms (compared with pharmaceutical firms) are more likely to transfer tacit knowledge than explicit knowledge; and H_{1b}: private firms (compared with public firms) are more likely to transfer tacit knowledge than explicit knowledge).

MNCs were 1.838 times more likely to acquire tacit knowledge than non-multinational firms. This supports our hypothesis (H_2) that multinationals (compared with non-MNCs) are more likely to acquire tacit knowledge than explicit knowledge.

Local transfers were 2.078 times more likely to be tacit knowledge transfers than non-local transfers. This does not support our hypothesis (H_{3a}) that local knowledge transfers (compared with non-local transfers) are more likely to be

Table 1 Descriptive statistics and correlations

	Mean	S.D.	Explicit/ tacit	Date	Bioteh/ pharma	Private/ public	MNC	Local	Cluster
Explicit/tacit	0.609	0.488							
Date	4.299	1.843	− 0.133**						
Biotech/pharmaceutical	0.505	0.500	− 0.292**	0.030					
Private/public	0.508	0.500	− 0.404**	0.025	0.171**				
MNC	0.119	0.323	− 0.014	0.131**	− 0.003	0.183**			
Local	0.128	0.334	0.141**	− 0.156**	− 0.074	− 0.120**	− 0.091*		
Cluster	0.649	0.448	− .0.102*	0.013	− 0.125**	0.091	0.061	0.112**	–

$N = 555$; *Sig = 0.05; **Sig = 0.001

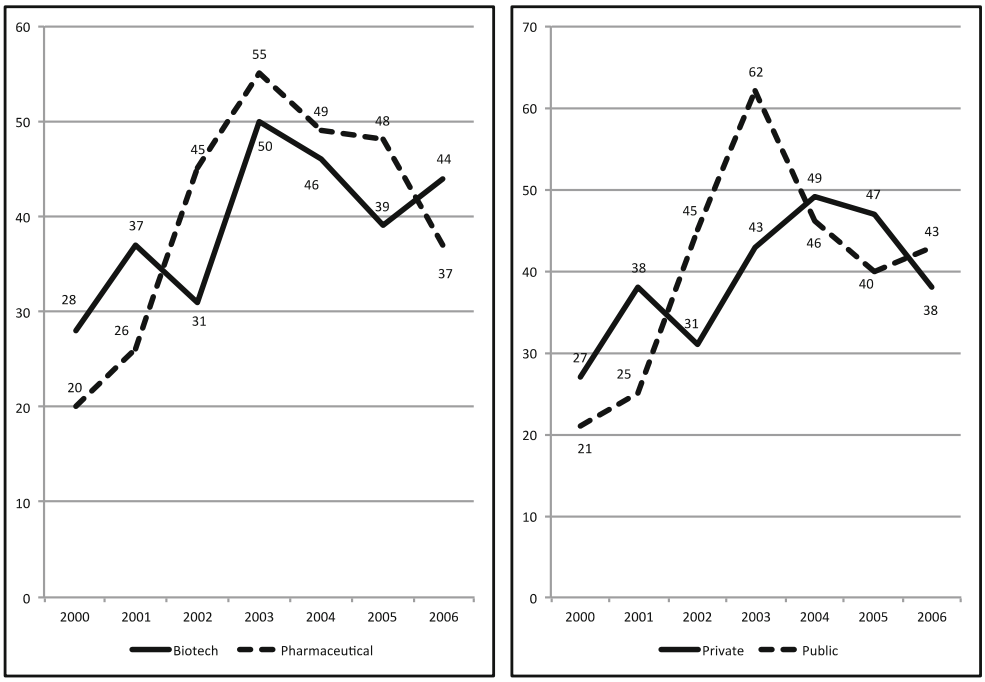

Chart 2 Biotech/pharmaceutical and private/public transfers

explicit knowledge than tacit knowledge. However, firms within clusters were 0.522 times less likely to transfer tacit knowledge than non-local firms. In other words, firms within clusters were 1.916 times more likely to transfer explicit knowledge. This supports our hypothesis (H_{3b}) that firms within clusters (compared with non-cluster firms) are more likely to transfer explicit knowledge than tacit knowledge.

Discussion

The purpose of the paper is to examine the effects that firm factors, multinational corporations, and location have on explicit and tacit knowledge transfers originating in US biopharmaceutical firms during a time of transition. The study confirms four of the five hypotheses. The study finds biotechnology firms and private firms are more likely to transfer tacit knowledge than explicit knowledge. Multinational firms are more likely to acquire tacit knowledge than explicit knowledge. Local transfers are more likely to be tacit knowledge transfers. Firms within clusters are also more likely to transfer explicit knowledge than tacit knowledge.

Table 2 Binary logistic regression testing explicit vs. tacit knowledge transfers

	B	S.E.	Sig.	Exp (B)
Date	− 0.175	0.058	0.003	0.840
Biotech/pharmaceutical	1.246	0.209	0.000	3.475
Private/public	1.758	0.213	0.000	5.800
MNC	0.609	0.304	0.045	1.838
Local	0.731	0.343	0.033	2.078
Cluster	− 0.650	0.220	0.003	0.522

Few studies have examined the determinants of the forms of knowledge transfers between firms together [16]. Understanding the forms of knowledge transfers is important, as researchers have observed that firms can enhance their competitive positions by facilitating and managing inter-firm knowledge transfers. The study extends the work on knowledge transfers, specifically as it relates to a market in transition that is dealing with disruptive innovation in the form of heterogeneous knowledge. Its findings may be generalizable (but of need of further study) to other industries dealing with disruptive innovations, specifically during the inflection point or time of transition (i.e., when one technology becomes prevalent over another such as was the case in our study [53]).

The study's finding implies that the market sector is not entrenched with the established knowledge related to pharmaceutical products, but rather is embracing new knowledge in the form of biotechnology. These findings may show that firms are attempting to expand their dynamic capabilities [76] to address changes in their external environments. In this regard, the present study adds to our knowledge about how firms deal with disruptive innovation by the expansion of their knowledge base via tacit knowledge transfer, specifically the preference to acquire equity positions in biotechnology firms. Perhaps, one significant interpretation of the results is that given the choice between explicit and tacit knowledge, firms are choosing tacit knowledge to be transferred or acquired. This may be due to the importance (i.e., value) that firms in

this market sector place on R&D, as historically firms engaged in R&D in this market sector were associated with the highest economic rents [31]. Thus, firms may not wish to be merely providers of downstream services (i.e., marketing and sales) as these may be more easily replicated and replaced than creators of innovative products.

It may also highlight a unique aspect of the biopharmaceutical market related to generic drugs. Generic drugs represent a substitute for innovative pharmaceutical products and were increasing their market share of all pharmaceutical products during this time [77]—thus, increasing competition within industry. As noted above, biotechnology at this time is more difficult to replicate. Hence, the acquisition of this biotechnology knowledge may create additional strategic space for the established firm, enhancing its reasons to enter this industry.

The study is not without limitations. We study biopharmaceuticals and do not know if our results apply to other markets. We do not include mergers or joint ventures in our analyses, as it is too difficult to differentiate between the firm that is transferring and the firm that is receiving knowledge. Nor do we know what (previous) arrangement the firms have or had (i.e., are/were they party to joint ventures). It would have been helpful to include total assets and other financial and market measures; unfortunately, we did not have access to the financial records of private firms. We did not examine the performance (e.g., entry of marketable drugs, financial) between firms engaged in either explicit or tacit knowledge transfer. We study a limited time period (2000–2006) and do not know if our results would be the same for other time periods, before or after.

The present study should add to our knowledge about the forms and direction of knowledge transfers in a time of market transition. These practices may continue as knowledge and capabilities for one biopharmaceutical therapeutic class do not necessarily transfer to others [31, 72]. The present study should be of interest to scholars of knowledge, multinationals, and location, as well as those within the biopharmaceutical community. It should also be of interest to those studying disruptive innovations and how firms deal with the transition to new innovations and industries.

Compliance with Ethical Standards

Conflict of Interest The author declares that he has no conflict of interest.

References

1. Grant RM. Toward a knowledge-based theory of the firm. Strateg Manag J. 1996;17(S2):109–22.
2. Berry H. Global integration and innovation: multicountry knowledge generation within MNCs. Strateg Manag J. 2014;35(6):869–90.
3. Kogut B, Zander U. Knowledge of the firm and the evolutionary theory of the multinational corporation. J Int Bus Stud. 1993;24(4):625–45.
4. Felin T, Hesterly WS. The knowledge-based view, nested heterogeneity, and new value creation: philosophical considerations on the locus of knowledge. Acad Manag Rev. 2007;32(1):195–218.
5. Albino V, Garavelli AC, Schiuma G. Knowledge transfer and inter-firm relationships in industrial districts: the role of the leader firm. Technovation. 1998;19(1):53–63.
6. Arend RJ, Patel PC, Park HD. Explaining post-IPO venture performance through a knowledge-based view typology. Strateg Manag J. 2014;35(3):376–97.
7. Nonaka I. A dynamic theory of organizational knowledge creation. Organ Sci. 1994;5(1):14–37.
8. DeCarolis DM, Deeds DL. The impact of stocks and flows of organizational knowledge on firm performance: an empirical investigation of the biotechnology industry. Strateg Manag J. 1999;20(10):953–68.
9. Van Wijk R, Jansen JJ, Lyles MA. Inter-and intra-organizational knowledge transfer: a meta-analytic review and assessment of its antecedents and consequences. J Manag Stud. 2008;45(4):830–53.
10. Teigland R, Wasko M. Knowledge transfer in MNCs: examining how intrinsic motivations and knowledge sourcing impact individual centrality and performance. J Int Manag. 2009;15(1):15–31.
11. Kostova T. Transnational transfer of strategic organizational practices: a contextual perspective. Acad Manag Rev. 1999;24:306–24.
12. Inkpen AC, Tsang EW. Social capital, networks, and knowledge transfer. Acad Manag Rev. 2005;30(1):146–65.
13. Girard J, Girard J. Defining knowledge management: toward an applied compendium. OJAKM. 2015;3(1):20.
14. Carayannis EG. Fostering synergies between information technology and managerial and organizational cognition: the role of knowledge management. Technovation. 1999;19(4):219–31.
15. Biggerio L. The location of multinationals in industrial districts: knowledge transfer in biomedicals. J Technol Transfer. 2002;27:111–22.
16. Park C, Vertinsky I, Becerra M. Transfers of tacit vs. explicit knowledge and performance in international joint ventures: the role of age. Int Bus Rev. 2015;24:89–101.
17. Polanyi M. Tacit knowing: its bearing on some problems of philosophy. Rev Mod Phys. 1962;34(4):601–16.
18. Blome C, Schoenherr T, Eckstein D. The impact of knowledge transfer and complexity on supply chain flexibility: a knowledge-based view. Int J Prod Econ. 2014;147:307–16.
19. Leal-Rodríguez A, Leal-Millán A, Roldán-Salgueiro JL, Ortega-Gutiérrez J. Knowledge management and the effectiveness of innovation outcomes: the role of cultural barriers. Electron J Knowl Manag. 2013;11(1):62–71.
20. Howells J. The geography of knowledge: never so close but never so far apart. J Econ Geogr. 2012;12:1003–20.
21. Ranft AL, Lord MD. Acquiring new knowledge: the role of retaining human capital in acquisitions of high-tech firms. J High Technol Manag Res. 2000;11(2):295–319.
22. Hedlund G. A model of knowledge management and the N-form corporation. Strateg Manag J. 1994;15(S2):73–90.
23. Quintas P, Lefrere P, Jones G. Knowledge management: a strategic agenda. Long Range Plan. 1997;30(3):385–91.
24. Hall LA, Bagchi-Sen S. An analysis of firm-level innovation strategies in the US biotechnology industry. Technovation. 2007;27(1):4–14.
25. Minbaeva DB. Knowledge transfer in multinational corporations. Manag Int Rev. 2007;47(4):567–93.
26. Pekár P, Margulis MS. Equity alliances take centre stage. Bus Strateg Rev. 2003;14(2):50–62.

27. Bell GG, Zaheer A. Geography, networks, and knowledge flow. Organ Sci. 2007;18(6):955–72.
28. Eisingerich AB, Bell SJ, Tracey P. How can clusters sustain performance? The role of network strength, network openness, and environmental uncertainty. Res Policy. 2010;39:239–53.
29. Chiaroni D, Chiesa V. Forms of creation of industrial clusters in biotechnology. Technovation. 2006;26(9):1064–76.
30. Xia T, Roper S. From capability to connectivity—absorptive capacity and exploratory alliances in biopharmaceutical firms: a US–Europe comparison. Technovation. 2008;28(11):776–85.
31. Malerba F, Orsenigo L. Innovation and market structure in the dynamics of the pharmaceutical industry and biotechnology: towards a history-friendly model. Ind Corp Chang. 2002;11(4):667–703.
32. Gupta AK, Govindarajan V. Knowledge flows within multinational corporations. Strateg Manag J. 2000;21(4):473–96.
33. Wernerfelt B. A resource-based view of the firm. Strateg Manag J. 1984;5(2):171–80.
34. Barney J. Firm resources and sustained competitive advantage. J Manag. 1991;17(1):99–120.
35. Peteraf MA. The cornerstones of competitive advantage: a resource-based view. Strateg Manag J. 1993;14(3):179–91.
36. Hall R, Andriani P. Managing knowledge associated with innovation. J Bus Res. 2003;56(2):145–52.
37. Theriou NG, Aggelidis V, Theriou G. A theoretical framework contrasting the resource-based perspective and the knowledge-based view. Eur Res Stud. 2009;12(3):177.
38. Kaplan S, Schenkel A, von Krogh G, Weber C. Knowledge-based theories of the firm in strategic management: a review and extension. Int J Proj Manag. 2001;25:1–47.
39. Schweizer L. Organizational integration of acquired biotechnology companies into pharmaceutical companies: the need for a hybrid approach. Acad Manag J. 2005;48(6):1051–74.
40. Galambos L, Sturchio JL. Pharmaceutical firms and the transition to biotechnology: a study in strategic innovation. Bus Hist Rev. 1998;72(2):250–78.
41. Powell W, Brantley P. Competitive cooperation in biotechnology: learning through networks? In: Nohria N, Eccles R, editors. Networks and organizations. Boston: Harvard Business School Press; 1992. p. 366–94.
42. Natalicchio A, Petruzzelli AM, Garavelli AC. A literature review on markets for ideas: emerging characteristics and unanswered questions. Technovation. 2014;34(2):65–76.
43. Lerner J, Merges RP. The control of technology alliances: an empirical analysis of the biotechnology industry. J Ind Econ. 1998;46(2):125–56.
44. Williams DR, Young CC, Coffey BS. Acquisitions in the biopharma-ceutical IPO market: collaboration, competition and co-opetition. Manag Decis Econ. 2017;38(8):1162–71.
45. Grant RM, Baden-Fuller C. A knowledge accessing theory of strategic alliances. J Manag Stud. 2004;41(1):61–84.
46. Rothaermel FT, Deeds DL. Exploration and exploitation alliances in biotechnology: a system of new product development. Strateg Manag J. 2004;25(3):201–21.
47. Mowery DC, Oxley JE, Silverman BS. Strategic alliances and interfirm knowledge transfer. Strateg Manag J. 1996;17(S2):77–91.
48. Ferreira MP, Santos JC, de Almeida MIR, Reis NR. Mergers & Acquisitions Research: a bibliometric study of top strategy and International Business Journals, 1980–2010. J Bus Res. 2014;67(12):2550–8.
49. Lodh S, Battaggion MR. Technological breadth and depth of knowledge in innovation: the role of mergers and acquisitions in biotech. Ind Corp Chang. 2014;24(2):383–415.
50. Pisano G. The development factory. Boston, MA: Harvard Business School Press; 1997.
51. Feldman MP, Ronzio CR. Closing the innovative loop: moving from the laboratory to the shop floor in biotechnology manufacturing. Entrep Reg Dev. 2001;13(1):1–16.
52. Lim PL, Garnsey E, Gregory M. Product and process innovation in biopharmaceuticals: a new perspective on development. R&D Manag. 2006;36(1):27–36.
53. Carlson PE. Biotechnology industry trends. 2006. http://www.regionalgrowth.com/ pubs/industry-studies/Biotech_Industry_Trends.pdf.
54. Cockburn IM. The changing structure of the pharmaceutical industry. Health Aff. 2004;23(1):10–22.
55. DiMasi JA, Grabowski HG. The cost of biopharmaceutical R&D: is biotech different? Manag Decis Econ. 2007;28(4–5):469–79.
56. Ernst & Young. Beyond Borders: global biotechnology report 2009. 2009. http://www.ey.com/Publication/ vwLUAssets/Global_ biotechnology_report_2009./$FILE/ Beyond_borders_2009.pdf. Accessed 20 March 2017.
57. Williams DR, Young CC. Trends in biopharmaceutical IPOS: 1996-2005. J Health Care Finance. 2005;33(2):39–54.
58. Kogut B, Zander U. Knowledge of the firm, combinative capabilities, and the replication of technology. Organ Sci. 1992;3(3):383–97.
59. Eden L, Levitas E, Martinez RJ. The production, transfer and spillover of technology: comparing large and small multinationals as technology producers. Small Bus Econ. 1997;9(1):53–66.
60. Reus TH, Lamont BT, Ellis KM. A darker side of knowledge transfer following international acquisitions. Strateg Manag J. 2016;37(5):932–44.
61. Kramer JP, Marinelli E, Iammarino S, Diez JR. Intangible assets as drivers of innovation: empirical evidence on multinational enterprises in German and UK regional systems of innovation. Technovation. 2011;31(9):447–58.
62. Hill CW, Hwang P, Kim WC. An eclectic theory of the choice of international entry mode. Strateg Manag J. 1990;11(2):117–28.
63. Martin X, Salomon R. Knowledge transfer capacity and its implications for the theory of the multinational corporation. J Int Bus Stud. 2003;34(4):356–73.
64. Reilly M, Scott PS. Subsidiary driven innovation within shifting MNC structures: identifying new challenges and research directions. Technovation. 2014;34(3):190–202.
65. Kale P, Singh H. Managing strategic alliances: what do we know now, and where do we go from here? Acad Manag Perspect. 2009;23(3):45–62.
66. Shan W, Song J. Foreign direct investment and the sourcing of technological advantage: evidence from the biotechnology industry. J Int Bus Stud. 1997;28(2):267–84.
67. Almeida P, Phene A. Subsidiaries and knowledge creation: the influence of the MNC and host country on innovation. Strateg Manag J. 2004;25(8–9):847–64.
68. Waxell A, Malmberg A. What is global and what is local in knowledge-generating interaction? The case of the biotech cluster in Uppsala, Sweden. Entrep Reg Dev. 2007;19(2):137–59.
69. Phene A, Fladmoe-Lindquist K, Marsh L. Breakthrough innovations in the US biotechnology industry: the effects of technological space and geographic origin. Strateg Manag J. 2006;27(4):369–88.
70. Bagchi-Sen S. Strategic considerations for innovation and commercialization in the US biotechnology sector. Eur Plan Stud. 2007;15(6):753–66.
71. Kenney M. Biotechnology and the creation of a new economic space. Private Science: Biotechnology and the Rise of the Molecular Sciences, 1998;131–143.
72. Powell WW, Koput KW, Bowie JI, Smith-Doerr L. The spatial clustering of science and capital: accounting for biotech firm-venture capital relationships. Reg Stud. 2002;36(3):291–306.

73. Liang H, Zhang Z. The effects of industry characteristics on the sources of technological product and process innovation. J Technol Transf. 2012;37(6):867–88.
74. Breschi S, Lissoni F. Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows. J Econ Geogr. 2009;9(4):439–68.
75. Gray N. Untying the Gordian knot, PharmExec. 2005;84–100.
76. Teece DJ, Pisano G, Shuen A. Dynamic capabilities and strategic management. Strateg Manag J. 1997;18(7):509–33.
77. Berndt ER, Mortimer R, Bhattacharjya A, Parece A, Tuttle E. Authorized generic drugs, price competition, and consumers' welfare. Health Aff. 2007;26(3):790–9.