International Journal of Organizational Innovation

IDENTIFYING THE TECHNOLOGY POSITION ON PATENT ACQUISITION OF CARDIOVASCULAR STENT BY COMPLEMENTARITY AND SUPPLEMENTARY KNOWLEDGE

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Abstract

The most common way for an organization to expand its innovation capability is to acquire technological patent. Consequently, it is an important issue for firms to identify and estimate the target patent. Before acquiring, firms also have to make sure whether the target patents is matching the strategic purpose, and whether the target patent is suitable for the adopting after acquiring. And the result of patent citation analysis can be referred for estimating target patent as the result reveals the technology relationship between firms, the market value of technologies and the technology development strategy. Moreover, technology network analysis can visualize the overall social structure of actors in the technology network and illuminate their relationships and roles. However, few scholars have examined the relative positions of firms in technology networks from the viewpoint of individual social networks. This research uses the idea of the "ego-network", defining the firm's core technology patent portfolio as "ego" while patents which directly cite core patents are defined as the "neighborhood. The purpose of this research is to understand how the firm, through patent transfers, alters its technology position and performs inductive analysis as a reference for future changes in its patent portfolio strategies. The results of this research demonstrate that irrespective of patent transfer strategy, the relative position of firms in the technology network is displaced by patent transfers. By dividing the trajectory of displacement into quadrants the data set may be named as pioneers, leaders, followers, and laggards. And the result shows firms may exit markets, reduce internal subdivisions, carry out cost control, or sell off patents, moving their position to the left or downward and making them followers or laggards. By the same token, when firms enter a new technology area or market, increase their technological capabilities, or acquire technology patents, their position shits to the right or downward, and they become leaders or pioneers.

Keywords: patent acquisitions, supplementary, complementary, social network, patent citation

Introduction

For technology-intensive industries, the rapid expansion of the ability to innovate is a key element in maintaining long-term competitiveness. Corporate mergers and acquisitions of other patented technologies are the most common methods for expanding innovative abilities (Hagedoorn, 2002 ; King et al., 2008; Gantumur & Stephan, 2010).

When the technological resources of potential partners or acquisition targets are rich or diverse, companies are more likely to choose mergers and acquisitions than other methods to obtain the desired knowledge or technology (Phene, Tallman, & Almeida, 2012). However, such an acquisition is not a panacea for rapid access to the new technology.

When the technology gap between the new technology obtained by the firm and its original technology is too great, the firm's ability to absorb new knowledge may be affected. By the same token, when the similarity between the new technology and the firm's original technology is too high, innovation performance may also be greatly reduced (Hagedoorn & Wang, 2012).

Consequently, companies must clearly understand and evaluate the desired technology resources and select cooperation or merger partners to effectively achieve their strategic purposes, in order to enhance innovation performance after the acquisition of the new technology. Further, how firms analyze their own and competitor technologies and position in technology networks, as a basis for assessing future patent acquisition, transfer, and targets for cooperation, in order to successfully obtain the required patented technology and achieve strategic objectives, is critical.

Therefore, firms should consider how to use patent acquisition strategies and to identify shifts in technology among groups of firms in the industry, as well as how to effectively use patent analysis to locate valuable technology resources.

Patent citations not only reveal flows of knowledge and technologies, commonalities of knowledge (Yoon & Park, 2004 ; Stuart & Podolny, 1996), and the market value of technologies, they also reveal the layout of technology development strategies and cooperative relationships between firms. By following the direction of patent citations and links, the technological dependency relationships between firms may be illuminated, enabling elucidation of the structure of technological networks, which are similar to social networks.

From the decision-making point of view, the results of a patent citation analysis may enable the firm to make judgments about partner firms for cooperation and provide a basis for patent acquisition (Park & Yoon, 2013). Moreover, a broad technology network analysis can illuminate the overall social structure of actors in the technology network, their relative positions, and their relationships and roles (Podolny et. al., 1996 ; Yoon & Park, 2004; Marianna et al., 2010).

Most studies investigate the overall industry technology development pattern from the outside looking in, exploring technology development trends, firm strategic behavior (Stuart, 1996), and industry or national competitiveness. From the viewpoint of individual social networks, few scholars have examined the relative positions of firms in technology networks. To address this lack, this research uses the idea of the "ego-network". The firm's core technology patent portfolio is defined as the "ego" while patents which directly cite core patents are defined as the "neighborhood," which includes cited patents, patent citations, and the firm's own patent citations. We pool all patent to form the core of the firm's ego- centered technological network (ETN) (Wasserman & Faust, 1994; Yan-dong & Chan, 2011). From the inside looking out, using specific areas of patent litigation as the basis for analysis, the analysis of individual and social network levels enables understanding of the firm's technology types and trends, the attributes of patent acquisitions and firm technology types, the relationship between acquired patents and their technology development trends, and changes in their relative positions within technology networks

Based on the different considerations of their actions and functions, firms search for supplementary or complementary knowledge and technology. The purpose of this research is to understand how the firm, through patent transfers, alters its technology position and performs inductive analysis as a reference for future changes in its patent portfolio strategies.

Data and Analysis Method

Data

The subjects of this research are two companies, Cordis and Boston. Initially we retrieved patent data used in a patent infringement case involving a cardiovascular stent. This research collected news items from LexisNexis during the period 2003 to 2016. After processing, items regarding a total of ten patents were retrieved for the period from Aug 12, 2003 to Dec 7, 2016. These ten patents formed the basis for analysis. We next retrieved patents citing and cited by these ten patents from the USPTO. We collected a total of 1,657 cardiovascular stent-related technology patents, which formed the patent database for analysis in this research.

Analysis Method

This research uses the perspective of ego technology networks for its analysis. The patent analysis method used in this research which is based on overlap of technological knowledge used to measure the supplementing and complementing effect of a technology. Two indicators of technological knowledge position, technology knowledge status (TKS) and technology knowledge reliability (TKR), are used to examine the traits of technology development in the firm and the frequency of cooperative activities with external firms, the changes in firms' relationships. The measurements for the analysis are described below.

(Editor's Note: the following section is printed in single column format in order to facilitate easier reading of formulas)

Affiliated Condition

The definition and mathematics 1 of the matrix of the affiliated condition of the two companies and their patents is:

(1)When the K_{th} patent P_k is the rth firm's A_r patent, P_k and A_r affiliation = 1, and α_{kr} =1; otherwise, it is 0.

(2)When the K_{th} patent P_k cites any patent of the rth firm A_r, P_k and A_r affiliation = 1, and α_{kr} =1; otherwise, it is 0.

$$M = [\alpha_{kr}]_{ph}, \quad \alpha_{kr} = \begin{cases} 1 & P_k \text{ and } A_r \text{ affiliation } = 1 \\ 0 & \text{overwise} \end{cases} \quad (1)$$

k=1,2,…g 和 r=1,2,…h ,g≥h (1)

(Equation 1: k denotes the K_{th} patent, r denotes the r_{th} firm, g represents the number of patents in the network, and h represents the number of firms in the network

Technological Knowledge Status (TKS) - Measures the firm's technological knowledge position in the network. The measurement indicator is based on the total number of patents defined as all patents cited by other firm's patents plus the sum of the number of patents the firm manages internally. The measure is defined as given in 2:

$$[TKS_{ii}]_{hxh} = M^T M, \quad TKS_{ii} = \sum_{k=1}^{g} \alpha_{ik}\alpha_{ki} \quad (2)$$

((i=1, 2,.., h ((

Equation 2: the matrix $[TKS_{ii}]$ is calculated by Equation. 1 using technology knowledge relationship matrix M of the firm and patents and the "plot" of its transposed matrix M^T. $[TKS_{ii}]$ represents the sum of the overlapping patents (or product) of firm i itself, the $[TKS_{ii}]$ diagonal matrix values. α_{ik} represents the (K_{th} associated patent of firm i, while g denotes the number of patents in the network and h represents the number of firms in the network.

Technological Knowledge Reliability (TKR) - This indicator measures the degree of "common knowledge" overlaps in the firm's network. In 3, the matrix $[TKS_{ij}]$ is formed from 1 using the technology knowledge relationship matrix M of the patents and the "plot" of the M^T. $[TKS_{ij}]$ represents the sum of the overlap (or product) of patents associated with firms i and j, where α_{ik} represents the K_{th} associated patent of firm i; α_{kj} where k is the K_{th} associated patent and j the j_{th} firm, while g denotes the number of patents in the network and h represents the number of firms in the network.

$$([TKR_{ij}]_{hxh} = M^T M, \; TKR_{ij} \sum_{k=1}^{g} \alpha_{ik} \alpha_{kj} \qquad (3)$$

$$i = 1, 2, \ldots, h \text{ and } j = 1, 2, \ldots, h, \quad i \neq j$$

The total TKR of each firm and other firms are divided by the number of knowledge associated patents (the firm's TKS value) to obtain a mean. This is used to define individual firm's overall network TKR value. This research uses Equation 4 as a generalized expression.

$$TKR_{ii} = \frac{\sum_{j=1}^{h} TKR_{ij}}{TKS_{ii}}$$

$$i = 1, 2, \ldots, h \text{ and } j = 1, 2, \ldots, h, \quad i \neq j \quad [\; [\!["" \,]\!]$$

The matrix $[TKR_{ii}]$ represents the mean reliability of the technology knowledge of firm i in the overall technology network. $[TKR_{ii}]$ represents the total overlap of the knowledge associated patents of firms i and j and at the same time, also represents the degree of the two firms' knowledge reliability. $[TKS_{ii}]$ is the ith firm's technology knowledge position and h represents the number of firms in the network.

Common Internal Knowledge (CIK) - This indicator measures the overlap between firms' own patents direct citation links and their internal technology knowledge. The greater the number of citations, the greater the commonality of their technology knowledge. CIKij represents the degree of overlap between the patent knowledge of firms i and j or their supplementarity ratio, where represents the patents of firm i and represents patents associated with externally linked patents of firm j. Limiting condition: the approval date of patent $\mathbf{K_o}$ owned by firm i must be earlier than the approval date of externally cited patent $\mathbf{K_e}$ of firm j.

$$\mathrm{CIK_{ij}} = \frac{\sum \alpha_{\mathrm{ik_o}} \alpha_{\mathrm{kj_e}}}{\sum \alpha_{\mathrm{ik_o}}}$$

$$\mathrm{i} = 1,2,\ldots,\mathrm{h}, \text{ and } \mathrm{j} = 1,2,\ldots,\mathrm{h}, \ \mathrm{i} \neq \mathrm{j}$$

$$\mathrm{o} = 1,2,\ldots,\mathrm{n}, \text{ and } \mathrm{e} = 1,2,\ldots,\mathrm{n}, \ \mathrm{n} < \mathrm{g} \quad (5)$$

Common External Knowledge (CEK) - It is important because it measures the number of third party co-citations of two firms in the network, the degree of the external technology overlap, and the external common knowledge of the two firms. The greater the common knowledge overlap, the greater the complementary knowledge. CEKij represents the external patent knowledge overlap or complementarity ratio between firms i and j, where represents the patents of firm i and represents patents associated with externally linked patents of firm j. Limiting condition: the approval date of patent $\mathbf{K_o}$ owned by firm i must be earlier than the approval date of externally cited patent ke of firm j.

$$CEK_{ij} = \frac{TKR_{ij} - \sum \alpha_{ik_o} \alpha_{kj_e}}{TKS_{ii} - \sum \alpha_{ik_o}}$$

$$i = 1,2,\ldots,h \ \ and \ \ j = 1,2,\ldots,h \ , i \neq j$$

$$(o = 1,2,..,n \ \ and \ \ e = 1,2,\ldots,n \ , n < g \quad (6)$$

Result

A summary of the results of the data from the binary correlation matrix (after calculation using (2), (3), and (4), is given in Table 1 below.

The indicators TKS and TKR are useful for firms conducting a self technology network analysis. TKS measures the relative position of each firm in the technology network, resembling an assessment of their prestige (Podolny et al., 1996 ; Stuart, 1996 ; Wasserman & Faust, 1994). Thus, the greater the scope of knowledge firms in the self technology network can directly contact, integrate, or manage, the greater their prestige. Faust (1997) contends that the prestige position is affected by the resources the firm owns. TKR is used to measure the degree of knowledge overlap between two firms in a firm's self technology network in order to understand the degree of difference in knowledge attributes between the firm and other firms (Rindfleisch, 2001). It can act as a reference in the firm's selection of cooperation partners.

Based on the needs of the research, from the large number of companies, we selected only the first six companies as subjects for this research: ACS, BCS, Cook, Cordis, Expandable/Lifeport, and Medtronic. As shown in Table 1, after patent being (transferred, the TKS values of most firms show clear growth and their technology position in their self technology network has increased. For example, Cordis (TKS increase of 60), BSC (TKS increase of 37), Cook (TKS increase of 24), Medtronic (TKS increase of 11) all show obvious growth. The TKS value for ACS, however, fell after transfer. The related value for Expandable disappears after patent being transferred. Conversely, the related value for Lifeport appeared after patent transfer. This implies that at the same time as ACS was transferred also released a portion of its technology resource, reducing its technology knowledge position. Via patent acquisition activities, Lifeport reduced the processes and technology barriers necessary to enter this technology field. Expandable used transfers of core technology and collected funds from the transfer as a way to make quick profits for the firm. Thus, its TKS value disappears from this data set after transfer.

Looking at TKR, five firms used acquisitions to acquire desired technology, strengthening their technological capability and reducing their reliance on technology from outside firms and cooperation activity ratio. Consequently, their TKR fell after patent transfer, with the exception of Lifeport, whose TKR rose. Looking at technology development strategies, though still in the early stage in a field replete with technologically-capable firms, Lifeport has developed its own technological capabilities with the support and integration of outside technology.

Comparison of the results in Table 1 and cumulative chart of patents before and after transfer shows that, the rise or fall in the number of patents after the

Table 1.Evaluation index before/ after patent transference of the six main companies

	Company	TKS		TKR		Patent counts	
		Before	After	Before	After	Before	Aafter
1	ACS	99	80	12.626	11.062	34	33
2	BSC	65	102	17.831	10.853	13	16
3	Cook	143	167	14.014	9.287	16	22
4	Cordis	137	197	14.073	8.609	16	25
5	Expandable/Lifeport	189	58	11.831	12.621	10	18
6	Medtronic	131	142	14.305	10.120	14	17

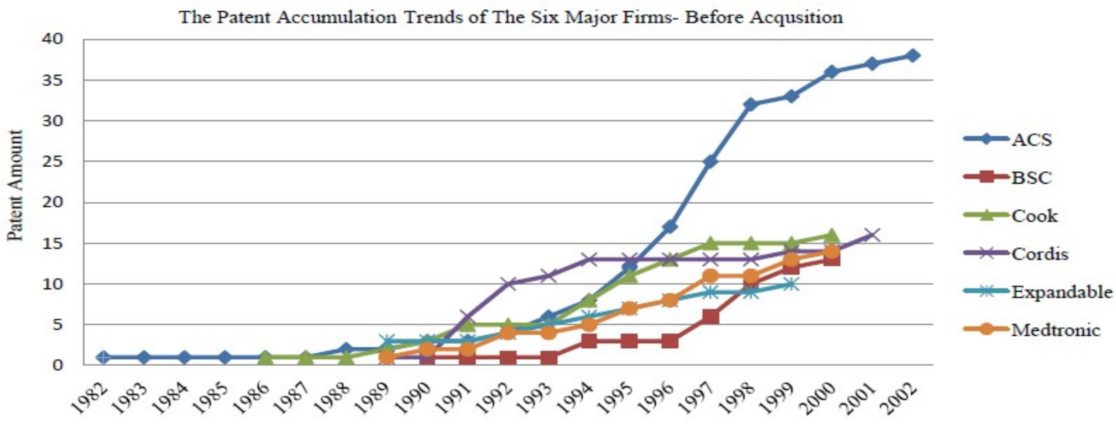

Figure 1. The Patent Accumulation trends of the Six Major firms

transfer was driven by the firm's strategic goals, depending on whether patents were acquired to increase the firm's technology capabilities, or whether they were transferred out for cash. It appears that five of the companies sought to acquire patents in order to increase their technology development capability. Though ACS transferred a patent out, this transfer caused its TKS value to fall, showing the importance of this patent.The data set for TKS value, TKR value, and number of patents before and after transfer is given in Figure 2. It shows that the patent transfer process ensured that some firms experienced changes after the development of unique technology or outside firm cooperation.

However, for other firms, the relative effect is unclear. Looking at the left side of Figure 2, the cluster is smaller. Firms with a smaller number of patents cluster on the left before and after patent transfer, with only a small portion shifting to the right. This implies that when a firm acquires a more unique patent or patent with high market value, it moves towards a higher knowledge position, gradually developing unique patented technology, reducing its competitive disadvantages and building competitiveness in its market. After the transfer, there is no great change in the position of firms on the left. They are unable to raise their technology knowledge position via patent acquisition. Such firms can only follow the market leader, or be weeded out after languishing on the fringes of the market. Firms that possess more patented technology are concentrated on the right side of Fig. 2. Though after acquiring patents they move in different directions, for such firms the direction of the movement shows the strategic implications of their technology development.

The smaller cluster located on the right in Figure 2 represents firms whose technology knowledge position is lower, after being weeded out. This displays the changes in trajectory among important firms before and after patent transfer, as shown in Figure 3. *(Note: see Figures 2 - 6 at the end of this article.)*

The six firms in this research tend to locate on the right. Their position in the technology network is higher. Because they added patents, the size of the cluster increased. Benefitting from patent transfers, after holding unique patents, BSC, Cook, Cordis, and Medtronic all shifted rightward and their knowledge technology position rose. Their reliance on outside technology fell, as did the frequency of their cooperation with outside firms. ACS, by contrast, shifted to the left after patent transfer and its knowledge technology position fell. Expandable disappeared after patent transfer, while Lifeport appeared.

For ease of interpretation, simplified Figures 4 and 5 show rightward and leftward shifting firms. Figure 4 shows that before transfer, BCS was located among the four leftmost firms, and its knowledge technology status was lowest and TKR value the highest, illustrating how reliance on outside support and cooperation played a key role in its technology development process and how acquiring its own patents was a rapid shortcut to increasing its own technology development capability. For Medtronic, Cordis, and Cook, prior to transfer they were located in mutually overlapping clusters whose size differences were not great. It is clear that the knowledge technology status, number patents owned, and degree of overlap with outside technology of these three firms is quite similar. After transfer, the number of patents owned increased. The cluster not only increased in size, but shifted rightward. As their technology status rose, their TKS values fell. This implies that the acquired patented technology was indeed helpful for these firms in developing their own unique technology. Among this firms, Cordis exhibited the most obvious change. This highlights the importance of constructing a firm's own independent technology development capability in increasing its competitiveness.

Figure 5 displays the shift in ASC's trajectory before and after transfer, along with the status of Expandable before transfer and the appearance of Lifeport after transfer. Because ACS only transferred one patent, the change in the size of the circle in the figure is not apparent. Worth noting is that the TKS value of ACS fell from 99 to 80 after the patent transfer, while TKR fell from 12.656 to 11.062, and the cluster shifted down and to the left. This implies that the patented technology must have been extremely unique in order to have reduced the knowledge technology status of ACS.

Since ACS already has a solid foundation for technology development, the effect of the transfer on its reliance on outside support is slight. Fig. 4 shows that prior to the patent transfer, Expandable had the highest knowledge technology status among the 6 firms. The cluster is below the TKR value of all the firms, implying that Expandable's technology is even more unique than that of the other firms. Thus, during the technology development process, it is clear that Expandable's reliance on outside technology resources is low. From the viewpoint of market value, Expandable's technology patents have great potential and high market value. This enables Expandable to obtain great profits from transferring them. Such profits can then act as resources for future technology development.

Unlike the other firms, Lifeport's cluster appeared after the transfer. Lifeport's strategy was to acquire patents to rapidly obtain desired technology and break out of its weak position. As a result, the clusters of Lifeport and ASC after transfer overlap, showing the commitment of Lifeport to this area of technology. Its TKR value shows a considerable overlap between Lifeport and external knowledge technology, signaling that the technology Lifeport is constructing is still in its early stages and has a strong need for integration with external support and resources. In sum, Lifeport clearly has a great interest in this area of technology and this market and has been aggressively acquiring key technology and investing substantially in the development of unique technological capabilities and closely cooperating with outside firms. This will enable it to rapidly enter target markets, shrink the technology development process, and lay the foundation for stable competitiveness.

Conclusion

The results of this research demonstrate that irrespective of patent transfer strategy, the relative position of firms in the technology network is displaced by patent transfers. An analysis of the trajectory of displacement is given in Figure 6. A division of TKS and TKR into quadrants shows that the data set may be divided into pioneers, leaders, followers, and laggards.

Cook, Cordis, Medtronic, and Expandable were located in the upper right prior to patent transfer and had a higher TKR and TKS. This means that they had a higher status in the self technology network. However, unlike the patented technology of future pioneers, current market leaders are more inclined to develop existing technologies which can be applied in current markets. Their patented technologies are more easily referenced and expanded by other firms. This research examines this field's well known, leading firms. After patent transfer, these firms' technology status moves into a leading position, perhaps demonstrating that the strategic goal of these firms is to acquire the unique patented technology of other firms in order to rapidly enter new markets. Consequently, they have higher TKR and

TKS. Though these firms have great technology development potential, one risk they take is developing technology more rapidly than market demand requires or moving in a different direction than the market, leading to the phenomenon of destructive innovation.

After patent acquisition, Cook, Cordis, and Medtronic shifted downward and rightward and had a relatively higher TKS and TKR than firms in the other quadrant. This indicates that these three firms developed technology that was more unique than the technology common in the market and thus had greater market potential. Because their ability to develop unique technology is more stable than that of other firms, they are more active in cooperating with outside firms. Further, since their technology is more unique and not available in the market, the number of citations of their patents by outside firms is lower while internal citations are higher.

This research treats such well-known firms as pioneers. After firms have undertaken patent transfer and their quadrant has shifted, their strategic goals become similar in order to rapidly enter new markets and acquire key technology patents. However, this type of market is typically already mature. After patent acquisition, the firm will integrate the technology, producing synergies and developing superior new products.

Hence, when developing technologies for the market, current leaders need to consider the necessary resources for effective integration, and gradually build their own unique technology capabilities to avoid the limitations imposed by market demand development, risks from sudden changes in the market, and the threats of new pioneers.

ACS before transfer and Lifeport after transfer are both located in the upper left quadrant. Firms located in that area are followers of trends set by the leading firms. Lacking their own technology capability, they are forced to rely on outside firms for support and integration and cite great numbers of outside technology patents. Thus, these firms have higher TKR and lower TKS. After transfer firms that shift quadrants may reduce their internal subdivisions, engage in resource integration, or carry out entrepreneurial development in new areas of technology or new markets. They may even sell off key technologies in unique areas, reducing their TKS. However, because their technology resources have market value, they are cited often by other firms, giving them higher TKR.

In order to establish long-term competitive superiority, current followers should aggressively develop their technological capabilities and acquire patents for key technologies, a rapid shortcut to technological capability. However, if such firms face limited internal resources or integration capabilities, and cannot invest heavily in R&D, then their patent strategy becomes even more important. Such firms can surround competitors' key technology patents, to obstruct their strategic technology development or slow their entrance into particular markets.

After transfer, ACS shifted from the upper left quadrant to the lower right. Fig.3 shows that firms in that quadrant have fewer patents and their TKS and TKR values are lower. This indicates that these firms both lack market technology development capability and infrequently cooperate with outside firms, and their patents are less cited as well. Such firms are treated as laggards in this research. After transfer, they shift to a new quadrant, indicating that their strategy has moved to reducing internal subdivisions, exiting certain technology fields, and selling off core technology patents, reducing TKR and TKS. In sum, firms in this area have fewer patents and lower levels of internal resources. They have no extra resources to devote to R&D activities aimed at new technology development or to acquire technologies from the market. Consequently, their patent design should avoid patents already existing in the market, to reduce opportunities for competitors to sue them. After obtain funds from profits, investment should be made in raising R&D capabilities, cooperative opportunities with outside firms should be seized, and the ability to develop unique technologies should be fostered.

The resource-based view stresses that when drafting a competitive strategy, firms must analyze their internal resources and the strengths of competitors and their likely adaptive strategies. However, when forming resources for a firm's competitive strengths, they must be heterogeneous, immobile, valuable, rare, inimitable, and irrplaceable. In the technology-intensive cardiovascular stent industry, the critical resource is the firm's possession of unique technology development capabilities and patent portfolios with high market value. From the point of view of network analysis, when firms can occupy a higher position in the technology network, this is equivalent to having greater competitiveness.

Few researchers have used the individual social network perspective to explore the position of firms in the technology network. To address this gap in the literature, this research uses an inside-out perspective, focusing on a firm's litigation against other firms in order to understand the relative positions of firms in a technology network and the changes in trajectory wrought by patent transfers.

Transfer and purchase of technology patents is a major driving force behind firm strategic activities aimed at maintain competitiveness and a stable position in the market. Firms may exit markets, reduce internal subdivisions, carry out cost control, or sell off patents, moving their position to the left or downward and making them followers or laggards. By the same token, when firms enter a new technology area or market, increase their technological capabilities, or acquire technology patents, their position shits to the right or downward, and they become leaders or pioneers. We hope the results of this study can contribute to the performance of appropriate analysis when firms engage in internal evaluation of their own resources when acquiring patents, as well as serving as a basis for evaluation of the effectiveness of patent acquisitions to ensure that after patent acquisition, the firm moves to the expected position and reaches its strategic goals.

This research only explores and classifies the trajectory of firm technology position shifts. Future research can use central or mean figures for a more accurate determination of firm position within the technology network. Further, this research investigated only a handful of firms in the cardiovascular stent field. Future scholars should include all the firms in the industry in their research and carry out a more general analysis, exploring technology clusters, observing the shifts within groups of firms, obstacles to movement, and changes and adaptations in the role of individual firms within groups, to act as a reference for firms performing internal evaluation and formulating strategies. The generalizability of the results of this research are limited by its exploration of only one industry. Future researchers should investigate other industries in order to develop more comprehensive strategic implications.

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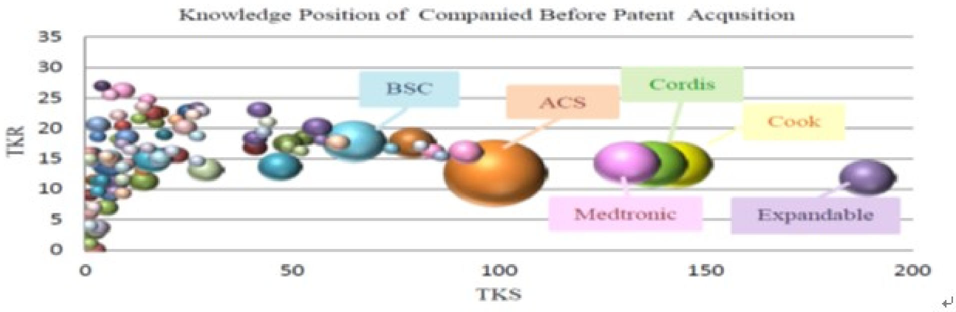
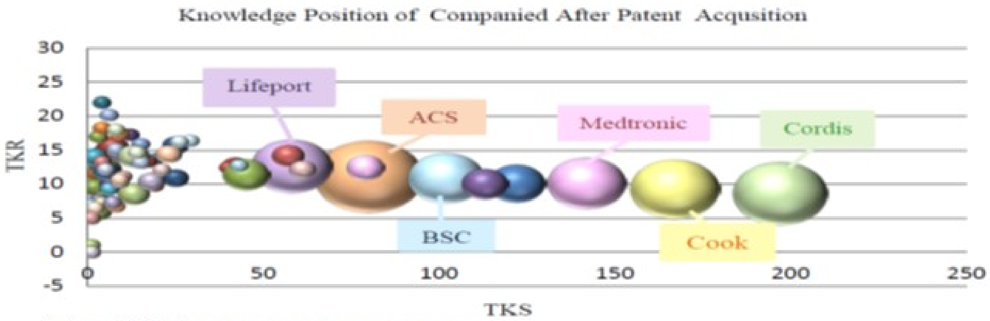
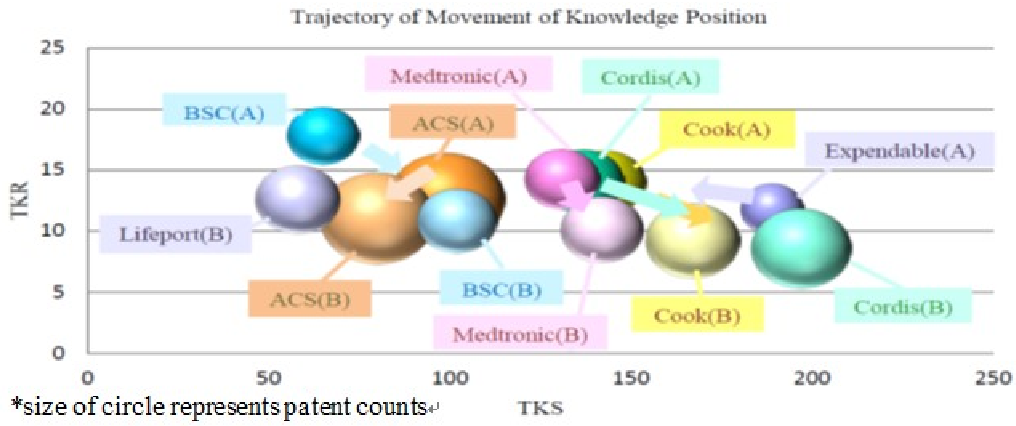


*size of circle represents patent counts



*size of circle represents patent counts

Fig. 2: Knowledge Position of Companied Before/ After Patent Acquisition



*size of circle represents patent counts

Fig. 3: Trajectory of Movement of Knowledge Position

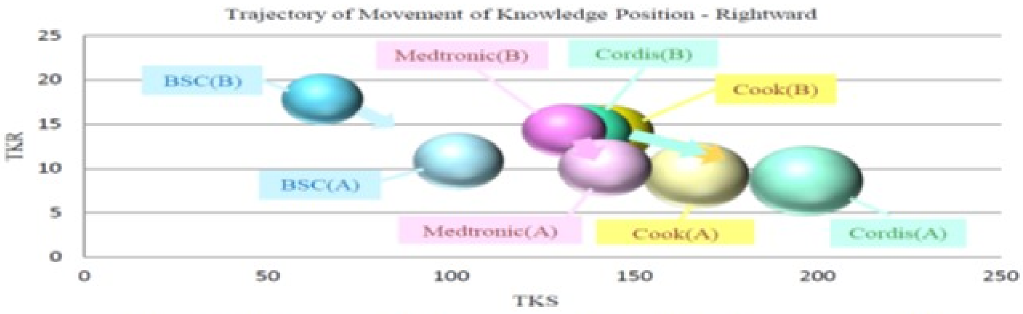


Fig. 4: Trajectory of Movement of Knowledge Position – Rightward

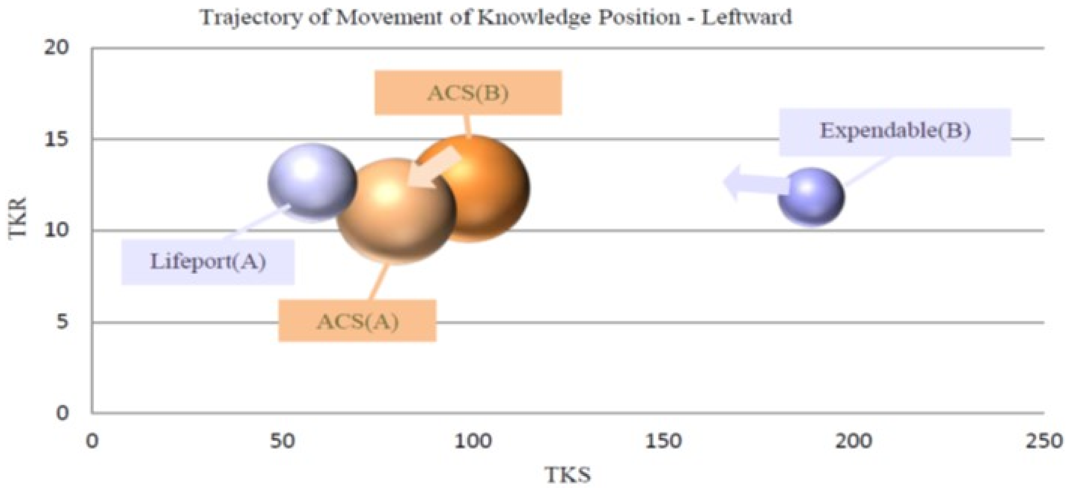


Fig. 5: Trajectory of Movement of Knowledge Position – Leftward

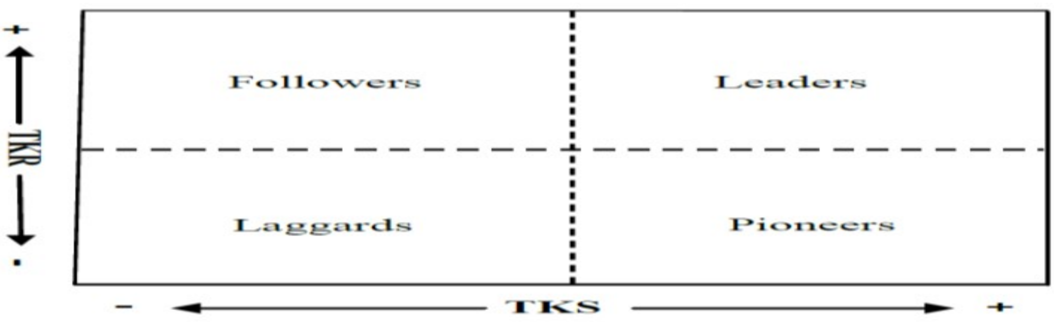


Fig. 6: the Strategic Implication of the Trajectory