ELSEVIER

feature

Strategic groups in the biopharmaceutical industry: implications for performance

Zeynep Erden, zerden@ethz.ch, Georg von Krogh, gvkrogh@ethz.ch, Cecilia Nytorp, cecilia.nytorp@gmail.com and Marcus Hultberg, mail@marcushultberg.com

The biopharmaceutical industry is characterized by intense competition, high uncertainty, and strong dependence on scientific knowledge. We show that in order to succeed in this industry, firms need to be positioned along three strategic dimensions: the level of inter-firm R&D partnering, the level of diversification, and the size of the firm. Prior research has revealed that a firm's membership in so-called 'strategic groups' impacts strongly on its performance. This study analyzes strategic groups in the biopharmaceutical industry along the strategic dimensions listed. The performance of the groups differs significantly. The best performing groups are the ones that consist of large firms with a high level of in-house diversification across therapeutic areas and the medium-sized firms that pursue partnership with other companies.

Introduction

A firm's long-term survival in an industry depends on its current and future revenue-generating potential and cash flow. A firm needs to ensure that it has a strong position in the market so as to guarantee a stream of funding for research and development (R&D) investments. Managers, therefore, need to make strategic choices that positively affect firm performance. Such choices are made along 'strategic dimensions' that reflect the extent to which resources and effort are allocated to various activities and areas. Past research on biotechnology firms have identified three strategic dimensions that impact on firm performance: the level of diversification, the level of inter-firm R&D partnering, and the size of the firm [1,2]. In this paper, we investigate these strategic dimensions for firms in the R&D-focused biopharmaceutical industry and identify strategic groups. The biopharmaceutical industry consists of firms whose business is human diagnostics and prophylactics or human therapeutics, and whose products and/or core technologies are based on biotechnology [3]. Strategic groups are naturally occurring subsets of firms within an industry that follow similar strategic choices [4]. Membership in a strategic group typically impacts on the firm's long-term performance. Overall, group members are set apart from other firms in the industry by performance [5] and it is often costly for non-member firms to move into the group owing to various barriers, such as access to research expertise, linkages to universities, economies of scope in R&D or economies of scale in production. This phenomenon is often referred to as 'mobility barriers' [6].

In this paper, we aim to help professionals and researchers in drug discovery understand strategic choices in the biopharmaceutical industry by identifying strategic groups and their performance implications. In the following section, we briefly discuss strategic dimensions. Next, we describe our research design, proceed to present the results of the work, and finally, discuss the implications of the study.

Strategic dimensions

Strategic groups are defined on the basis of dimensions that best capture strategic choices in an industry. Following a set of discussions with industry experts and analysis of the literature on strategic groups [4–7], we identified three

1359-6446/06/$ - see front matter doi:10.1016/j.drudis.2009.04.004

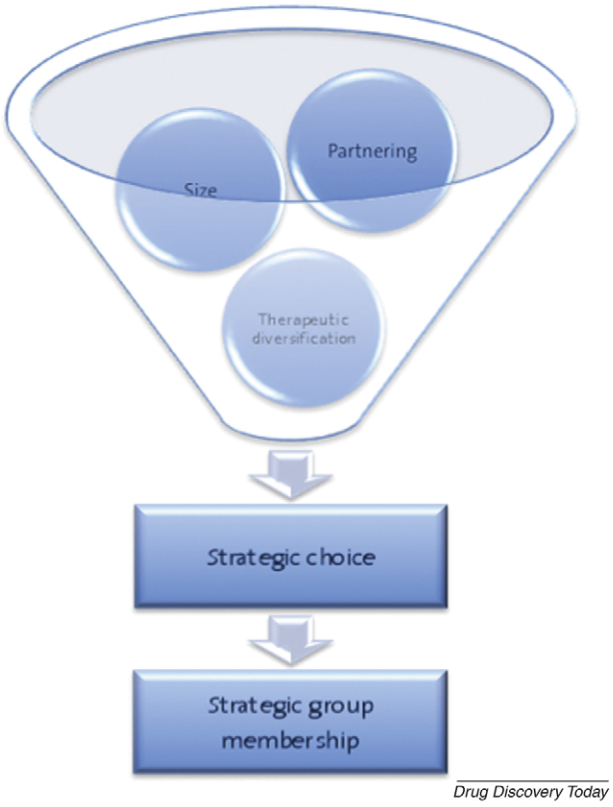

FIGURE 1

Three strategic dimensions identify the different strategic groups in the biopharmaceutical industry.'

strategic dimensions in the biopharmaceutical industry: the level of partnering, the level of therapeutic diversification and firm size. A firm's position along these dimensions determines its strategic group membership. Figure 1 depicts this logic.

Partnering level

In the biopharmaceutical industry, firms compete on the basis of access to unique and valuable research-based knowledge. Product development is costly and risky and time-to-market for a new product is crucial for the firms to appropriate sufficient returns from R&D-related investments. On the one hand, under such conditions, firms might lack the necessary funding or knowledge to be able successfully to develop products that reach the market in a timely fashion [8]. Partnering with other biopharmaceutical or established pharmaceutical firms may allow for division of labor and mitigate development costs and risks. On the other hand, the two partner firms' lack of overlap in expertise and/or willingness to share knowledge could be obstacles to effective knowledge exploitation in product development and commercialization [9]. Thus, there are conflicting findings regarding the impact of partnering on firm performance [3,10]. Moreover, partnering in product development entails a tradeoff between sharing potential future revenues and risks. Consequently, choosing to partner represents a strategic choice with implications for firm performance.

Therapeutic diversification

In the biopharmaceutical industry, diversification corresponds to the 'breadth of the knowledge base' that, in turn, corresponds to the range of expertise in different therapeutic areas available in the firm [11]. On the one hand, by diversifying into different therapeutic areas a firm may increase innovation by combining knowledge from these areas [12]. On the other hand, diversification represents a tradeoff between deepening knowledge in current therapeutic areas versus gaining new knowledge in others [13]. Moreover, diversification increases the cost of coordinating and integrating the work of scientists, engineers, and other staff. Thus, therapeutic diversification is an important strategic choice in the biopharmaceutical industry.

Size

According to organizational structure literature and the theory of inertia, the size of a firm impacts its performance [14,15,26,30]. In high-technology fields, small firms have often been characterized as more innovative compared to larger firms. An explanation offered is that informal communication between engineers and scientists enables more effective knowledge sharing [16]. Although a large firm may exploit abundant technical resources and diverse expertise in product development, bureaucracy and hierarchical structures may cause more costly communication. On the contrary, some studies have shown that small firms are less efficient in research and development because they incur higher preclinical costs [17]. Thus, a strategic choice in the biopharmaceutical industry is between remaining a small firm, protecting a 'non-bureaucratic' structure (e.g. Ligand) or striving to grow the organization (e.g. MannKind Corporation).

Firm performance

Often, traditional financial performance measures, such as earnings before interest and taxes (EBIT), do not reflect the performance of firms in the biopharmaceutical industry because, at this stage, many firms have neither launched products nor do they show a profit. Therefore, we chose two alternative measures of performance that better fit the industry's stage of maturity: total shareholder return (TSR) and pipeline strength. First, TSR has frequently been used in prior research [18,19] and measures the performance from an investor's perspective. TSR is the sum of dividends and stock price appreciation (depreciation) as a proportion of the stock price at the beginning of the period. According to many authors [20], in the long run, competitive firms are among the top TSR performers. Yet, it is difficult for a firm to reach a high TSR over an extended period. Examining TSR for only one period might be risky, since firms with low TSR in that period could still perform well in the long run. Therefore, we chose to analyze average TSR (ATSR) for two years (2006–2008).

Second, a firm's product pipeline measures its long-term competitiveness by pointing to a potential for future cash flows [21]. The product pipeline also indicates technological competence and expertise [22]. Following past research that identified a positive relationship between

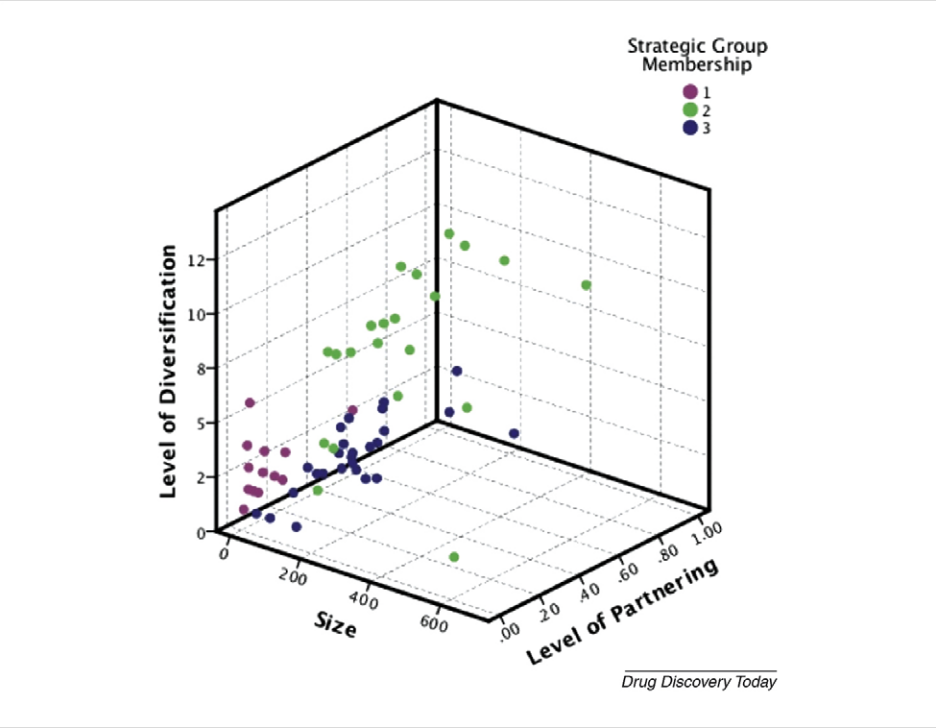

FIGURE 2

There are three strategic groups.

the product pipeline and firm performance [22,23], this study examined 'pipeline strength' (the sum of the number of products in the pipeline weighted by the market entrance probability of its development stage) as an indicator of future potential performance.

Research design

By searching on the Biotech Gate Company database[1], 256 firms were found that matched the search criteria below:

- Sector: biotechnology/therapeutics
- Business model: outlicensing R&D
- Customers: big pharmaceutical and biotechnology firms

In order to create a sample of comparable firms, we included firms focusing on the earlier stages of the value chain (i.e. development and preclinical phases) and on outlicensing their products or technologies. Therefore, we investigated the 256 firms in detail and eliminated those that are involved in commercialization and marketing. In addition, we filtered out the firms whose Initial Public Offering (IPO) was later than 01.01.2005 in order to be able to calculate average TSR for two years. The application of these criteria produced a sample of 60 firms.

[1] http://www.biotechgate.com.

There was no strong correlation between any of the strategic dimensions ($r < 0.4$). Strategic groups were identified using a hierarchical clustering algorithm (Ward's method with squared Euclidean distance measure). We conducted the analysis of covariance (ANCOVA) to see if the 'group membership' predicts the firm's performance. As a last step, we conducted the contrast analysis to compare the groups and to see which groups significantly differ from each according to their performance.

As a proxy for 'partnering level,' we used the ratio of partnered products to the total amount of products in the pipeline. Since the sample included firms focusing on the earlier stages of the value chain, most of the partnerships were early development partnerships, such as joint development agreements. As a proxy for 'size,' we used the number of employees and for 'therapeutic diversification level,' we used the number of therapeutic areas in which a firm is pursuing drug development. The data on the number of therapeutic areas were gathered primarily from each firm's annual reports by classifying the drugs in the pipeline and on the market into different therapeutic areas. International Statistical Classification of Diseases and Related Health Problems was taken as a reference while defining the scope of the therapeutic areas. Financial data were collected from the 2007 annual report of each firm, and the share prices and dividends were collected from the Bloomberg database. Data on the pipeline and partnership were collected exclusively from each firm's official website and/or annual report. Pipeline strength was calculated by adding up the number of products in the pipeline, weighted by the market entrance probability of its development stage. The estimates for market entrance probabilities were taken from a prior study [24]. Logarithmic transformation of the skewed data was carried out to ensure a normal distribution.

Control variables (covariates)

In knowledge-intensive industries, R&D expenditure is crucial for innovativeness and the market value of firms [22,25]. Previous research found a correlation between the size of the firms in the pharmaceutical industry and R&D expenditure [26]. In order to control for the separate effect of R&D intensity we included R&D expenditure per employee in the model. Moreover, research has highlighted the benefits of performing in-house scientific research [27] and some studies have shown a positive effect on the innovative performance of pharmaceutical firms [28,29]. Therefore, we also controlled for the intensity of in-house basic research that was operationalized with the total number of scientific articles published by the firm until 2008. Last, we controlled for the age of the firm.

Data analysis and results

The clustering algorithm results show three strategic groups in the sample of biopharmaceutical firms. Figure 2 shows the strategic groups and Table 1 provides descriptive statistics for the groups. In the following section, we discuss each group in turn.

Strategic group 1: non-partnered small biopharma (G1)

Firms in this group (e.g. Alizyme, Bionovo) have relatively low levels of partnering in product development. The group is the smallest, consisting of 13 firms only, and these are among the smallest in the sample. On average, the firms have low therapeutic diversification.

Strategic group 2: diversified big biopharma (G2)

The firms in this group are quite large (e.g. Nicox, Arena, and Xoma) compared to the sample with an average of 189 employees. The firms are highly diversified, with an average of approximately seven therapeutic areas, and have a high focus on partnering in product development.

TABLE 1

Descriptive statistics for the strategic groups

Group number	Number of firms	Firm size		Therapeutic diversification		Partnering level	
		Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
1	13	37.54	26.24	2.92	1.26	0.06	0.15
2	21	189.48	163.77	7.10	2.79	0.49	0.28
3	26	73.69	46.91	1.81	0.80	0.45	0.27
Combined	60	106.38	118.90	3.90	3.00	0.38	0.30

Strategic group 3: medium-sized partnered biopharma (G3)

This group consists of medium-sized firms with 73 employees on average (e.g. BioMS Corp. and Arkule). Firms in this group have, on average, a low level of diversification compared to the other groups and about 45% of the products under development are partnered.

The descriptive statistics of the performance and control variables are shown in Table 2.

The ANCOVA results show that group membership has a significant effect on both pipeline strength ($p = 0.003$) and ATSR ($p = 0.025$). According to the results, R&D expenditure per employee and the number of articles published are not significant for either performance measure. Whereas age has no significant impact on pipeline strength ($p = 0.48$), it has a significant effect on ATSR ($p = 0.011$). Contrast results show that membership in each group differs significantly from the others with respect to pipeline strength, whereas only membership in G2 differs significantly from the other groups with respect to ATSR. Firms in G2 have the strongest pipeline and firms in G1 have the weakest pipeline. On average, firms in G2 also create the highest value for their shareholders. R&D expenditure and firm size are significantly correlated ($r = 0.88$). The outperforming firms in G2 also show greater commitment to R&D. However, the groups show the opposite trend in 'R&D expenditure per employee': G1 has the highest and G2 has the lowest R&D expenditure per employee. On average, firms in G2 are the largest and they publish the most articles.

Discussion

In this paper, we identified strategic dimensions, analyzed strategic groups in the biopharmaceutical industry, and showed implications for performance. Differences in performance can be attributed to mobility barriers, such as diverse expertise in R&D or partnering with other firms, that protect group benefits from potential entrants. In order to diversify into multiple therapeutic areas or to grow the organization, a firm needs capital. Yet, small firms with low therapeutic diversification and exposed to high risk may find capital a very scarce resource that prevents them from moving into a better performing group with higher diversification.

With limited revenue streams and product development that spans several years, the biopharmaceutical firms we investigated clearly need continuous access to fresh capital and investors willing to provide it. In order to attract investors, the firms need to employ strategies focused on risk mitigation. Large firms (e.g. Arena) may diversify risk inherent in developing new compounds across multiple projects and therapeutic areas, while retaining the value of these investments for themselves and their investors. An alternative strategy for small to medium-sized firms may be to partner in product development with a pharmaceutical company with clinical resources and commercial competences. This may reduce the firm's risk exposure in product development and enable a positive cash flow faster than if the firm pursued product development in isolation.

Partnering in product development may positively impact on the pipeline performance of small to medium-sized firms, as seen in G3. However, partnering may not create excess value for their shareholders. Too much partnering in product development implies that a substantial share of the potential future value will be transferred to the partnering organization. There may be alternative approaches to mitigate risks and increase shareholder value that is illustrated by the group of diversified firms in the sample (G2). These firms employ a two-pronged strategy: on average, they partner a little less than half of their product development pipeline, while diversifying their projects over several therapeutic areas. By diversifying into several therapeutic areas, they mitigate the risk involved in developing new therapies. They partner in some projects that generate steady revenue streams, while keeping some projects under their own development.

Diversifying into new therapeutic areas is difficult and costly. Even though the technology and promising compounds may be available, the firm may simply lack clinical experience in relevant disease areas. In effect, there are potentially high mobility barriers surrounding and protecting G2. One option for firms in the non-partnered group (G1) to overcome these

TABLE 2

Performance and control variables

Group number	Pipeline strength		Average TSR (ATSR)		R&D expenditures (SMM)		R&D expenditures per employee (SMM)		Age		Published articles	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
1	2.83	1.65	0.05	0.78	19.70	19.43	0.709	0.824	11.25	5.15	21.77	28.64
2	6.87	5.03	0.21	0.56	73.70	64.66	0.403	0.187	15.48	5.81	126.76	191.63
3	4.22	2.22	0.085	0.37	28.53	20.02	0.430	0.342	12.63	4.98	33.50	48.40
Total	4.86	3.71	0.05	0.56	42.43	47.40	0.481	0.463	13.37	5.49	63.60	125.75

barriers may be to partner with a pharmaceutical company that has first-hand clinical experience in relevant disease areas. This may put the firms in a position where they can 'learn' from their partners about late stage development and new therapeutic areas.

Our findings suggest two strategies for managers to contemplate in the biopharmaceutical industry. First, if firms are large to medium-sized and possess many experts, researchers, and scientists, they may benefit from diversifying their knowledge base into different therapeutic areas and mitigating the risk of failure. A strategy that incorporates both partnering and therapeutic diversification may create an even stronger pipeline and increase shareholder value. Through partnering, the firm may access the complementary knowledge of its partners and might increase their performance in innovation. Second, if managers want their firms to stay small, they may pursue a partnering strategy in order to cope with high mobility barriers (e.g. the need for capital and knowledge) and, in the process, diversify into new therapeutic areas.

To our knowledge, this is the first study of strategic groups in the biopharmaceutical industry. Future research needs to monitor the development of the firms' performance and group membership. Future research should also enlarge the sample of firms, test the proposed strategic dimensions, and cover new dimensions. Such work helps researchers and managers in drug development to obtain a better understanding of the competitive dynamics of this exciting and emerging industry.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.drudis.2009.04.004.

References

1 Namara, M.P. and Baden-Fuller, C. (2007) Shareholder returns and the exploration-exploitation dilemma: R&D announcements by biotechnology firms. *Res. Policy* 36, 548–565

2 Shan, W. *et al.* (1994) Interfirm cooperation and startup innovation in the biotechnology industry. *Strategic Manag. J.* 15, 387–394

3 Rader, R.A. (2005) What is a biopharmaceutical. *BioExecutive Int.* 42–49

4 Porter, M.E. (1979) The structure within industries and companies' performance. *Rev. Econ. Stat.* 61, 214–227

5 Short, J.C. *et al.* (2007) Firm, strategic group, and industry influences on performance. *Strategic Manag. J.* 28 (2), 147–167

6 Drandrove, D. *et al.* (1998) Do strategic groups exist? An economic framework for analysis. *Strategic Manag. J.* 19, 1029–1044

7 Durisin, B. and von Krogh, G. (2005) Competitive advantage, knowledge assets, and group-level effects: an empirical study of global investment banking. In *Strategy in Transition: Strategic Management Society Book Series* (Bettis R., ed.), pp. 35–80, Blackwell

8 Lane, P.J. and Lubatkin, M. (1998) Relative absorptive capacity and interorganizational learning. *Strategic Manag. J.* 19, 461–477

9 Cohen, W.M. and Levinthal, D.A. (1990) Absorptive capacity: a new perspective on learning and innovation. *Adm. Sci. Q.* 35, 128–152

10 Gulati, R. and Higgins, M.C. (2003) Which ties matter when? The contingent effects of interorganizational partnerships on IPO success. *Strategic Manag. J.* 24, 127–144

11 Zhang, J. *et al.* (2007) Technological knowledge base. R&D organization structure and alliance formation. *Res. Policy* 36, 515–528

12 Quintana-Garcia, C. and Benavides-Velasco, C.A. (2008) Innovative competence, exploration and exploitation: the influence of technological diversification. *Res. Policy* 37, 492–507

13 Leten, B. *et al.* (2007) Technological diversification, coherence, and performance of firms. *J. Prod. Innov. Manag.* 24 (6), 567–579

14 Lee, R.P. and Chen, Q. (2009) The immediate impact of new product introductions on stock price: the role of firm resources and size. *J. Prod. Innov. Manag.* 26, 97–107

15 Chandy, R.K. and Tellis, G.J. (2000) The incumbent's curse? Incumbency, size, and radical product innovation. *J. Marketing* 64 (3), 1–17

16 Acs, Z.J. and Audretsch, D.B. (1990) *Innovation and Small Firms.* MIT Press

17 Dimasi, J.A. *et al.* (1995) R&D Costs. Innovative output and firm size in the pharmaceutical industry. *Int. J. Econ. Business* 2 (2), 201–219

18 Bloom, M. and Milkovich, G.T. (1998) Relationship among risk, incentive pay and organizational performance. *Acad. Manag. J.* 41 (3), 283–297

19 Miller, K. and Bromiley, P. (1990) Strategic risk and corporate performance: an analysis of alternative risk measures. *Acad. Manag. J.* 33, 759–779

20 Gardner, T. and Spiegel, E. (2006) Total shareholder return: planning a future perfect. *Public Utilities Fortnightly* 45–50

21 Ernst and Young (2005) Beyond Borders: The Global Biotechnology Report

22 DeCarolis, D.M. and Deeds, D.L. (1999) The impact of stocks and flows of organizational knowledge on firm performance: an empirical investigation of the biotechnology industry. *Strategic Manag. J.* 20, 953–968

23 Rothaermel, F.T. (2001) Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry. *Res. Policy* 30, 1235–1250

24 Struck, M. (1994) Biopharmaceutical R&D success rates and development times. *Bio/technology* 12, 674–677

25 McCutchen, W.W., Jr and Swamidass, P.M. (1996) Effect of R&D expenditures and funding strategies on the market value of biotech firms. *J. Eng. Technol. Manag.* 12, 287–299

26 Graves, S.B. and Langowitz, N.S. (1993) Innovative productivity and returns to scale in the pharmaceutical industry. *Strategic Manag. J.* 14, 593–606

27 Rosenberg, N. (1990) Why do firms do basic research (with their own money)? *Res. Policy* 19 (2), 165–174

28 Cockburn, I. and Henderson, R. (1998) The organization of research in drug 38 discovery. *J. Ind. Econ.* 45 (2), 157–182

29 Gambardella, A. (1992) Competitive advantages from in-house scientific research: the U.S. pharmaceutical industry in the 1980s. *Res. Policy* 21, 391–407

30 Lin, B.W. and Chen, J.S. (2005) Corporate technology portfolios and R&D performance measures: a study of technology intensive firms. *R&D Manag.* 35 (2), 157–170

Zeynep Erden,
zerden@ethz.ch
Georg von Krogh,
gvkrogh@ethz.ch
Cecilia Nytorp,
cecilia.nytorp@gmail.com
Marcus Hultberg
mail@marcushultberg.com
Department of Management, Technology, and Economics, ETH Zurich, 8032 Zurich, Switzerland