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Is the IPO of Bio Venture Companies Intended for R&D? Analysis Study on Listed Bio Venture Companies in Korea

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Abstract

Bio venture companies establish a pipeline based on various studies related to the treatment and diagnosis of diseases and aim to commercialize products. Usually, it is understood that they strive for an initial public offering (IPO) with the primary purpose of raising capital for research and development (R&D). However, research on how IPO affects the R&D performance of bio venture companies is lacking. In this study, the R&D performance of bio venture companies in Korea was compared and analyzed for 2 years before and after IPO. Results show that patent applications did not change considerably during 2 years after IPO compared the number during 2 years before IPO in 24 bio venture companies listed from 2018 to 2021 in the Korean stock market. In addition, the cases of licensing in/out were not significantly changed in those companies for 2 years before and 2 years after IPO. The number of entering the next phase of clinical trials decreased substantially during the 2 years after IPO compared with the 2 years before IPO. Meanwhile, Korean bio venture companies were found to attract significant investment from financial investors (FIs) before the IPO, and the FIs recovered their investment immediately after the IPO. In the end, it seems that another main purpose of the IPO of Korean bio venture companies is to make an opportunity for the FIs to recover their investment rather than to secure funds for R&D investment. This study found that the IPO of Korean bio venture companies does not show the primary effects of IPO, such as effective financing of companies and provision of attractive investment opportunities to investors. These results provide sufficient evidence that new policies may be needed to address the possibility of the bio venture companies' ill-timed IPO.

Keywords

IPO, Bio Venture Company, Research and Development Performance

1. Introduction

Venture companies seeking to develop biopharmaceuticals and biotechnologies are experiencing significant difficulties in sales (Lazonick & Tulum, 2011). In particular, considering that these companies aim to develop new biological medications, most do not have products that can generate sales. Instead, they run the company through investment (Rosiello & Parris, 2009). Unlike synthetic drugs, biological medications use biological molecules, including antibody treatment, gene therapies using nucleic acids, cell therapies, and protein treatments for cancer, inflammation, and infectious diseases (Chow et al., 2022; Cohen et al., 2019). Compared with other industries, biopharmaceutical development is highly technology-intensive, requires high expertise, has a long investment period, and is subject to high risks (Kesik-Brodacka, 2018). However, if it has successfully developed a new global blockbuster drug, it can create enormously high added value. Therefore, biopharmaceutical development is classified as a future growth industry (Kesik-Brodacka, 2018). An immune checkpoint inhibitor, known as an antibody treatment, is a new type of treatment that induces the activity of immune cells and eliminates tumors (de Miguel & Calvo, 2020). Keytruda, developed by Merk in the United States, is a representative example of an immune checkpoint inhibitor (Emancipator, 2020). Keytruda generated sales of $1.11 trillion in 2019 and is expected to reach $2.49 trillion by 2026 (Urquhart, 2021). However, notably, the development of these biological medications requires significant costs, and their development success is not guaranteed.

The startup of a bio venture company is based on intangible technology. Proving the future value of these technologies is important, as securing immediate sales is difficult (Strömsten & Waluszewski, 2012). Most bio venture companies announce their technologies as patents, and they secure corporate value based on these to attract investment (Michelino et al., 2017). Furthermore, they can secure funds through licensing in/out based on patents. However, attracting these investments alone is inefficient in completing the development of biological medications pursued by bio venture companies. Therefore, most bio venture companies secure funds through initial public offering (IPO) and further use them as research and development (R&D) funds for biological medications.

Biological medications require an extensive R&D process and considerable funding to be approved for market release (Kesik-Brodacka, 2018). New drug development consists of basic research, preclinical trials, and clinical trials 1, 2, and 3. After successfully completing these studies, the medication can only be sold once the product is approved (Taylor, 2015). After basic research, in the preclinical trial stage, side effects, toxicity, and therapeutic effects of newly developed candidates are checked in animals before using them in humans (Taylor, 2015). This stage is for safety evaluation through animal testing, which also involves studying the drug's *in vivo* kinetics and pharmacology (Mohs & Greig, 2017; Sinha & Vohora, 2018). Phase 1 clinical trials focus on confirming the

drug's safety in healthy people, including the drug's administration method, absorption, side effects, and body dynamics. The number of people recruited ranges from 20 to 80, which takes 1 - 3 years, and the cost is approximately $4 million. The efficacy of a new drug in humans is examined in phase 2 clinical trials. Drugs are administered to 100 - 200 patients to verify side effects and effectiveness during phase 2 clinical trials. In addition, phase 2 clinical trials determine the optimal method and dosage for entering phase 3 clinical trials. Phase 2 clinical trials will be conducted over 2 - 4 years and require approximately $15 million in funding. Phase 3 clinical trials evaluate the effectiveness of a drug on a large number of patients. Drug efficacy, including safety, is established by administering the drug over a long period to hundreds to thousands of patients. As the final stage of clinical trials to obtain marketing approval, a comparative control group and a test treatment group are simultaneously established to determine efficacy, effectiveness, usage, dosage, and precautions for use. This process takes 3 - 5 years and costs more than $80 million (Mohs & Greig, 2017; Sinha & Vohora, 2018).

Developing these new biological medications requires a total period of 10 - 15 years and over 0.1 - 1 billion dollars in funding (Kesik-Brodacka, 2018; Mohs & Greig, 2017). In a business that requires enormous funds, bio venture companies without sales are bound to experience great difficulties. Bio venture companies in South Korea are exploring methods such as attracting investment or IPO to secure funds for R&D of biological medication. For the growth of the biological medication field, being listed on the Korean stock market (KOSPI, KOSDAQ) is supported and encouraged to bio venture companies. Hence, about 70 venture companies have been listed on the Korean stock market since 2018. Among them, 24 companies are biological medication developing companies; the rest are testing agencies and chemical pharmaceutical companies.

As the development cost of biological medication is considerable, most Korean bio venture companies hope to be listed on the Korean stock market. Although research funds can be secured through IPO, an analysis of the funds invested in research is lacking. In addition, analysis data on the progress of R&D of biological medication in the companies after IPO are lacking. Therefore, this study aims to compare and analyze the progress of the R&D stage according to the financing of companies developing biological medications among bio venture firms listed on the Korean stock market since 2018. Particularly, the number of patent applications, licensing in/out, and entering next phase of clinical trials during 2 years before and 2 years after listing on the Korean stock market has compared to understand the impact of listing on the KOSDAQ. Therefore, the remaining of the study is structured as follows: 1) The changes of numbers in patent applications for 2 years before and 2 years after the IPO. 2) The changes of numbers in technology transfer for 2 years before and 2 years after the IPO. 3) The changes in the numbers of clinical trials entering the next phases during 2 years before and 2 years after the IPO is statistically analyzed.

2. Previous Literature

Companies are IPO owing to the ease of raising necessary funds, increased corporate awareness, and smooth corporate restructuring promotion, among others. Most studies have focused on revenue reform, and very few direct studies have been conducted on the relationship between R&D performance and IPO. In this study, patents, licensing, and clinical trials were selected as R&D outcomes of bio venture companies. The analysis focused on how patent applications, licensing in/out, and the progression to the next phase of clinical trials changed in the 2 years before and the 2 years after the IPO. Accordingly, the previous research literature related to this topic was confirmed below.

2.1. Patent as an Indicator of R&D Performance

Many pharmaceutical and bio venture companies regard patents as the potential value of the company. Considering that the secured patents serve as models for the pharmaceutical business, the dependence on patents is relatively high (Stevens et al., 2013). In particular, the correlation between many patent and corporate performance indicators, often used as indicators to evaluate the value of a firm, is significant (Bloom & Van Reenen, 2002). Patent indicators are also an important checklist in technology transfer and licensing agreements (Chitale et al., 2016).

Hong-Wen Tsai et al. (2021) analyzed stock prices and stock returns, including patent effects, invention notices, invention notices, utility model grants, and design grants, of Chinese A-shares to evaluate the value of patents and stocks. A-shares in the top 25% group by the number of invention patents had the highest stock returns compared with those in other groups with fewer patents. This finding improved the state-of-the-art patent and listed firm valuation (Tsai et al., 2021).

Disclosing patent information in financial statements affects the corporate value of high-tech listed companies. Yu and Zhang (2023) used event study methods to examine stock market reactions to patent information in financial statements (Yu & Zhang, 2023). Their results show that patent information disclosure is associated with changes in stock returns. The impact of patent information disclosure on stock returns depends on the reliability and quality of the patent information. As expected, when the reliability and quality of patent is high, the stock price return owing to patent information disclosure is positive. By contrast, when the reliability and quality of patent is low, patent information disclosure has a negative effect on stock price return. Research results show that securing patents can increase a company's value, but research on whether a company's IPO has a positive effect on securing patents is lacking.

2.2. Technology Licensing as an Indicator of R&D Performance

Technology transfer refers to all activities that transform intangible technology

into tangible products and obtain economic benefits accordingly. Similar to bio venture firms, firms with insufficient sales either directly commercialize their technology or sell it to global pharmaceutical firms through licensing agreements. Technology licensing can better reflect the nature of technological innovation compared with papers and patents (Ni et al., 2016). In this sense, bio venture companies pursue technology transfer and commercialization strategies through R&D development.

From another aspect, bio venture companies can license those that lack technological capabilities from other companies or universities. Companies can save on R&D costs by licensing technologies with high potential. In addition, universities or other companies have sufficiently proven the advantage that advancing to preclinical or clinical trials by licensing in technology is easy. Therefore, analyzing licenses in the technology development indicators of bio venture companies is necessary.

According to Arnold et al. (2002) the traditional technology transfer strategy of pursuing licensing in phases 1 - 4 clinical trials is emphasized rather than preclinical trials because the value of licensing deals increases with each stage of development. This case can be seen as a shortcut for developing new drugs by global pharmaceutical firms, considering that the probability of success owing to R&D investment is extremely low (Arnold et al., 2002).

According to a case study of U.S. pharmaceutical firms by DiMasi et al. (2010) the success rate of self-developed new drugs among the top 50 pharmaceutical companies between 1993 and 2004 was 16% (DiMasi et al., 2010). However, the success rate of licensed new drugs was 27%. This result proves that introducing new drug candidates from outside, such as bio venture firms, is very efficient. Hay et al. (2014) suggested that new drug candidates developed and verified through licensing are sought to reduce R&D expenditures and the risk of failure of new drug development (Hay et al., 2014). In this way, technology transfer and licensing are used as a strategy for the survival of bio venture firms. However, there is a lack of research on whether bio venture companies use IPOs as an opportunity for technology transfer.

2.3. Clinical Trials as an Indicator of R&D Performance

Preclinical and clinical trials are the largest portion of costs for developing biological medications in bio venture firms. As mentioned earlier, funds are secured through IPO as it requires considerable money and time. In addition to the considerable cost and time required for bio-new drugs, the possibility of success is very slim, which is also a factor of concern. The success rate is so low that only one out of approximately 10,000 new drug candidates is approved as a final product (DiMasi et al., 2010; DiMasi et al., 2013). In addition, in the case of rare and incurable diseases, the clinical trials take more than 20 years, which means that approximately 10 more years is needed compared with the development of a typical new drug (Ashley et al., 2015). The development of new drugs by clini-

cians was evaluated as having a high possibility of being licensed to companies. Preclinical and clinical results and commercialization potential were also high (Gittelman & Alia, 2016).

The positive results of the clinical trial are recognized as one of the successful R&D performances and have a positive effect on the stock prices of listed companies. Bio venture companies are in a situation where they want to conduct clinical trials as one of the most important R&D activities, even if it requires a huge amount of funds, and are considering an IPO to secure these funds. It is necessary to compare and analyze the performance of clinical trials in the bio venture companies after their IPO.

In this way, bio venture companies' initial R&D activities are important for the future growth of the company. However, as shown in previous studies, the R&D activities of bio venture companies require a large amount of funds over a long period of time. In a situation where it is difficult to generate cash through their own business, R&D must be carried out through external investment. In this respect, bio venture companies can use IPO as an effective means of securing funds for R&D. Bio ventures emphasize expectations for future corporate value and attempt to attract massive funds for R&D through IPO. Then, does raising funds through IPO affect the R&D performance of bio venture companies? There is not much research on this. In particular, there is not much systematic research on how much the IPO of listed Korean bio ventures affects the R&D performance. Therefore, this study aims to examine whether the IPO affected the R&D performance of bio ventures listed on the Korean stock market between 2018 and 2021. The patents, technology transfer, and clinical performance were applied as R&D performance indicators.

3. Methods and Hypothesis

3.1. Setup of Research Model

To analyze the impact of the IPO of a bio-venture companies on its R&D performance, patents, license in & out, and clinical trial performance were selected as analysis factors. And the period for measuring R&D performance was set to 2 years, which is the average period for preclinical and clinical trials. Therefore, this study analyzes the degree and number of patents, licensing in/out, and preclinical and clinical trials for 2 years before and 2 years after IPO.

Patents were analyzed based on application as a difference exists between the application and registration period. In addition, Korean and overseas patents were distinguished and applied as performance indicators, respectively. The alterations in licensing in/out in Korea and overseas were also applied to this study. As an indicator of the R&D performance related to clinical trials of bio venture companies, the number of cases entering the next stage of clinical trials was used. Finally, all of these indicators were compared and analyzed using a paired-samples t-test for the results for 2 years before and 2 years after IPO on

the Korean stock market.

3.2. Research Hypothesis

- Hypothesis 1. Patent applications will increase for 2 years after IPO compared with 2 years before IPO.
- Hypothesis 2. Technology transfer and licensing contracts will increase for 2 years after IPO compared with 2 years before IPO.
- Hypothesis 3. Preclinical and clinical research will increase for 2 years after IPO compared with 2 years before IPO.

3.3. Targets of Investigation

This study targeted bio venture companies listed on the Korean stock market (KOSPI, KOSDAQ) from 2018 to 2021. A total of 24 bio venture companies were included in the R&D increase/decrease analysis, excluding experimental agency companies and small molecule compound development companies. These indicators were obtained from their annual reports disclosed in the Financial Supervisory Service (https://dart.fss.or.kr) in Korea, and some patents of firms were obtained from KIPRIS, a patent search website (http://www.kipris.or.kr/).

3.4. Statistical Analysis Method of Data

A paired-samples t-test analysis was conducted using IBM SPSS Statistics on the changes of numbers in patent applications, technology transfer, and entering next phases of clinical trials for 2 years after IPO compared with 2 years before IPO for 24 companies, which are developing biological medications and listed on Korean stock market (KOSPI, KOSDAQ).

4. Results

4.1. Analysis of the Patent Applications for 2 Years before and after IPO

For this study, 24 bio venture firms that were recently listed on the Korean Stock Exchange were analyzed. The number of patents applied for in Korea by 24 listed bio venture companies in the 2 years prior to their IPO was 99, with an average of 4.12 per company. The number of patents applied for in Korea in the 2 years after their IPO decreased to 75, with an average of 3.12 per company. The number of patents applied for overseas in the 2 years before the IPO was 71, with an average of 2.95 per company. The number of patents applied for overseas in the 2 years after the IPO was 69, with an average of 2.87 per company. The total number of patent applications for the 24 listed bio venture companies in the 2 years before the IPO was 170, with a total number of patent applications decreased to 144 in the 2 years after the IPO (**Table 1**).

By conducting a paired-samples t-test using these variable values, the study confirmed that patent applications did not significantly change for 2 years after

IPO compared with 2 years before IPO for all patents (Table 2, $p = 0.343$). No significant difference was found in the patent applications of bio venture companies between the 2 years before and the 2 years after IPO even when analyzing Korean or overseas patents separately (Table 2). Therefore, these data showed that the number of patent applications for Korean bio venture companies did not increase for 2 years after IPO compared with 2 years before IPO. This result indicates that Hypothesis 1 cannot be accepted.

Table 1. Paired samples statistics (Patent applications).

Category		Time classification	Total Number	Mean	N	Std. Deviation	Std. Error Mean
Patent application	Korea	ⓐ 2 yr → IPO	99	4.1250	24	3.9376	0.8037
		ⓑ IPO → 2 yr	75	3.1250	24	2.7396	0.5592
	Oversea	ⓒ 2 yr → IPO	71	2.9583	24	3.1961	0.6524
		ⓓ IPO → 2 yr	69	2.8750	24	2.4193	0.4938
	Total	ⓔ 2 yr → IPO	170	7.0833	24	5.4046	1.1032
		ⓕ IPO → 2 yr	144	6.0000	24	4.3936	0.8968

Source: Annual report of each company, https://dart.fss.or.kr (electronic disclosure fining system), KIPRIS.

Table 2. Results of Paired Samples Test (Patent applications).

Category		Paired Differences					t	df	Significance Two-Side p
		Mean	Std. Deviation	Std. Error Means	95% C.I. of D.				
					Lower	Upper			
Patent application	ⓑ-ⓐ	−1.0000	3.9782	0.8120	−2.6798	0.6798	−1.231	23	0.231
	ⓓ-ⓒ	−0.0833	3.0348	0.6194	−1.3648	1.1981	−0.135	23	0.894
	ⓕ-ⓔ	−1.0833	5.4845	1.1195	−3.3992	1.2325	−0.968	23	0.343

4.2. Analysis of Licensing in/out for 2 Years before and after IPO

Compared with patents, licensing in/out does not show much activity as it incurs relatively high costs. Five Korean bio venture companies from 24 companies introduced 12 cases of licensing in for 2 years before IPO, whereas 13 licenses were introduced by 8 bio venture companies for 2 years after IPO (Table 3). In the case of licensing out, the number decreased from 16 cases for 2 years before IPO to 8 cases for 2 years after IPO. No significant change was observed in licensing in/out before and after IPO, but the number of licensing out was considerably reduced by half (Table 3). However, it was found to be insignificant, so it could not be recognized as a trend (Table 4, $p = 0.103$). The changes in all licensing in/out performances, including licensing in, out, and in-out sum, were found to be insignificant. Therefore, Hypothesis 2, which states that licensing in/out performance will increase for 2 years after the IPO, was also rejected.

Table 3. Paired samples statistics (Licensing In/Out).

Category		Time classification	Total Number	Mean	N	Std. Deviation	Std. Error Mean
Licensing	In	ⓖ 2 yr → IPO	12	0.5000	24	1.3187	0.2691
		ⓗ IPO → 2 yr	13	0.5417	24	0.8836	0.1803
	Out	ⓘ 2 yr → IPO	16	0.6667	24	1.1671	0.2382
		ⓙ IPO → 2 yr	8	0.3333	24	0.7613	0.1554
	Total	ⓚ 2 yr → IPO	28	1.1667	24	1.6854	0.3440
		ⓛ IPO → 2 yr	21	0.8750	24	1.4836	0.3028

Source: Annual report of each company, https://dart.fss.or.kr (electronic disclosure fining system).

Table 4. Results of paired samples test (Licensing In/Out).

Category		Paired Differences					t	df	Significance Two-Side p
		Mean	Std. Deviation	Std. Error Means	95% C.I. of D.				
					Lower	Upper			
Licensing	ⓗ-ⓖ	0.0416	1.1970	0.2443	−0.4638	0.5471	0.171	23	0.866
	ⓙ-ⓘ	−0.3333	0.9630	0.1965	−0.7400	0.0733	−1.696	23	0.103
	ⓛ-ⓚ	−0.2916	1.0417	0.2126	−0.7315	0.1482	−1.372	23	0.183

4.3. Analysis of the Entering Next Phase of Clinical Trials for 2 Years before and after IPO

As mentioned above, clinical trials require enormous funds; therefore, bio venture companies do not conduct as many clinical trials as they do patent applications. The total number of cases that advanced from the preclinical to the phase 1 clinical trial was 24 cases by 14 companies for 2 years before IPO. However, the number decreased considerably to 6 cases by 5 companies in the 2 years after the IPO (Table 5). Moreover, 16 cases of entered from phase 1 to phase 2 clinical trials were conducted in 11 companies for 2 years before IPO, and 17 cases of entered from phase 1 to phase 2 clinical trials were conducted in 11 companies for 2 years after IPO, which indicated that the number of entering phase 1 to phase 2 clinical trials showed no considerable changes for 2 years before and 2 years after IPO (Table 5). The one case of entering from phase 2 to phase 3 clinical trials for 2 years before IPO was conducted, and even for 2 years after IPO two cases of entered from phase 2 to phase 3 clinical trials were conducted by two companies (Table 5). The total number of entering next phases of clinical trials for 24 companies decreased from 41 cases for 2 years before IPO to 25 cases 2 years after IPO (Table 5). The number of cases that advanced from preclinical to phase 1 clinical trial decreased. The number of cases that advanced from phase 1 to phase 2 clinical trials and from phase 2 to phase 3 clinical trials increased, but this was found to be insignificant in statistical analysis. (Table 6, p = 0.846, 0.575). Therefore, Hypothesis 3, which states that the performance of

Table 5. Paired samples statistics (Entering next phase of clinical trials).

Category		Time classification	Total Number	Mean	N	Std. Deviation	Std. Error Mean
Entering next phase of clinical trials	Preclinical → Phase1	ⓜ 2 yr → IPO	24	1.0000	24	1.2510	0.2553
		ⓝ IPO → 2 yr	6	0.2500	24	0.5316	0.1085
	Phase1 → Phase2	ⓞ 2 yr → IPO	16	0.6667	24	0.9168	0.1871
		ⓟ IPO → 2 yr	17	0.7083	24	0.9079	0.1853
	Phase2 → Phase3	ⓠ 2 yr → IPO	1	0.0417	24	0.2041	0.4167
		ⓡ IPO → 2 yr	2	0.0833	24	0.2823	0.5763
	Total clinical trials	ⓢ 2 yr → IPO	41	1.7083	24	1.9666	0.4014
		ⓣ IPO → 2 yr	25	1.0417	24	1.0417	0.2126

Source: Annual report of each company, https://dart.fss.or.kr (electronic disclosure fining system).

Table 6. Results of Paired Samples Test (Entering next phase of clinical trials).

Category		Paired Differences					t	df	Significance Two-Side p
		Mean	Std. Deviation	Std. Error Means	95% C.I. of D. Lower	95% C.I. of D. Upper			
Entering next phase of C.T.	ⓝ-ⓜ	−0.7500	1.2247	0.2500	−1.2671	−0.2328	−3.000	23	0.006
	ⓟ-ⓞ	0.0416	1.0417	0.2126	−0.3982	0.4815	0.196	23	0.846
	ⓡ-ⓠ	0.0416	0.3586	0.0732	−0.1097	0.1931	0.569	23	0.575
	ⓣ-ⓢ	−0.6666	1.7362	0.3544	−1.3998	0.0664	−1.881	23	0.073

entering the next phase of clinical trials will increase during the 2 years after the IPO compared to the 2 years before the IPO, was also rejected.

5. Discussion

As mentioned before, IPO plays a crucial role in securing the necessary funding for the company, given that bio venture companies often have minimal sales. Bio venture companies seem to make various efforts to be listed on the stock market. In addition, the funds secured through IPO were expected to be invested in R&D and affect R&D performance, for the company's survival and expansion. However, this study produced results that were completely different from expectations. Most of the patent application performance and licensing in/out performance decreased and were found to be statistically insignificant. In the case of licensing in, even if it increased, it was found to be completely insignificant in statistical analysis. In the case of entering the next phase of clinical trials, there was no statistical significance at all in the cases where there was an increase, and even in cases where there was statistical significance (when entering from preclinical to phase 1), the performance decreased for 2 years after the IPO. The

hypothesis of this study that R&D performance would improve after the IPO was rejected. In the end, it can be concluded that the IPO is not directly related to the R&D investment of Korean bio venture companies and is not a clear factor in improving R&D performance.

What should be additionally considered through the results of this study is that the R&D performance of Korean bio venture companies tends to decrease in the 2 years after IPO than in the 2 years before IPO. It must consider why R&D performance tends to reduce for 2 years after IPO. The following three points can be regarded as against the background of the tendency for R&D performance to slow down after IPO. First, the company may have focused on its short-term competency with the goal of IPO. Ultimately, corporate capabilities concentrated for IPO were exhausted, leading to a decline in R&D performance after IPO. The second reason for the decreasing R&D performance of bio venture companies during the 2 years after IPO may be the preemptive recognition and announcement of results from R&D to list their stocks on the market. Third, the IPO of the bio venture companies may proceed regardless of the funding schedule for R&D. For some other reason, IPO may have pursued irrespective of the company's R&D schedule and the need for funds to support it. Therefore, the IPO of bio venture companies had no significant impact on R&D performance.

The answer to the question in the title of this paper was "no". Therefore, it has faced with a new question. Why do bio venture companies work hard to get listed on the stock market? By analyzing the results of this study, it determined that other factors may be related to the IPO strategy of Korean bio venture companies, other than R&D investment. Most bio venture companies in Korea receive investments from various investors before IPO to fund R&D based on technology, although they have virtually no sales. The investment structures of a bio venture company starts with angel investment at the startup stage and goes through stages such as Series A–C and Pre IPO. This investment is used for R&D. Prior to investing, financial investors (FIs), mainly venture capital, require IPO of the bio venture companies at a certain point in the future as a condition of initial investment. This is because the most successful recoup on investment or the most effective exit strategy for FI' investments can be smoothly carried out through the IPO of bio venture company stocks. In other words, the IPO of the bio venture companies may have been influenced by the exit strategy of the FI rather than securing funds for R&D. This idea is supported by the fact that 22 out of 24 biotech ventures secured significant investments from FIs before the IPO and used the funds for R&D activities, and most of these FIs recovered their investments immediately after the IPO.

Share ratios found that bio venture companies gearing up for an IPO have previously secured investments from investors. The 24 bio venture companies that were the subject of this study attracted investment from FIs before IPO, and FIs were found to hold an average of more than 32.0% of the shares per 24 bio venture companies (**Table 7**). Only two companies did not receive investment

from FIs, in the case of bio venture companies that showed the highest FI shareholding ratio before IPO, FI held more than 72.9% of the shares. The shares ratio of FI was remarkably higher than it expected.

Table 7. Number of companies by financial investor (FI) share ratio before IPO.

Share ratio	0%~10%	10%~20%	20%~30%	30%~40%	40%~50%	50%~60%	60%~70%	70%~80%	Sum
Number of companies	3	3	4	5	4	3	1	1	24

Source: Annual report of each company, https://dart.fss.or.kr (electronic disclosure fining system).

Table 8. Changes in the number of FI holding more than 5.0% of the shares and the average share ratio after IPO.

	Before IPO		One year after IPO	
	Number of FI (>5%)	Avg. share rate of FI	Number of FI (>5%)	Avg share rate of FI
24 Companies	45	14.5%	12	4.1%

In addition, before IPO, the number of FI holding more than 5% of the shares in the 24 bio venture companies was 45 FI (Table 8). They held an average of 14.5% of the shares per the companies. In other words, 1.88 investors hold more than 5% of the shares per bio venture company, and the average share is more than 7.7%. Interestingly, this number of FI (more than 5% of the share) remained only 12 institutions 1 year after IPO, and the average rate of FI shares per company dropped substantially to 4.1%. Particularly, the number of investors holding shares of more than 5% decreased dramatically to 0.50 per bio venture company (Table 8). Moreover, 14 out of 24 bio venture companies do not have FIs with more than 5% of their shares a year after the IPO. Although the analysis results were limited to FIs holding more than 5% of the shares, it believes that FI who had invested to bio venture companies collected their investments by selling considerable shares on the stock market after the IPO.

If the exit rate of FIs post-IPO was that high, would this have had an impact on the stock price? It further analyzed the stock price changes of 24 bio venture companies 2 years after their IPO. There was difficulty in setting the starting price after the IPO to check the stock price fluctuation. It was possible to set the starting price under various conditions, such as the publicly announced stock price at the time of the IPO, the stock market closing price on the first day of the IPO, or the average price for three months after the IPO. It applied the closing price on the first day of stock market trading after the IPO as the starting price, under the assumption that the value of the company after the IPO should be evaluated by the market. Among the 24 companies, one company had an unusually high stock price increase of more than 600%. Hence, it was excluded from

these statistics, and the stock prices of the remaining companies were analyzed.

The stock prices of 6 out of 23 companies increased, whereas the stock prices of 17 companies showed a decreasing trend (Figure 1(a)). The average stock price change rate of these 23 companies 2 years after IPO was found to be −21.51% (Table 9). Looking at the relative rate of return compared to the KOSPI and KOSDAQ index of the Korea Exchange, the stock price of bio venture companies over the 2 years after IPO was found to be even lower (Figure 1(b)). The average relative return rate of 23 companies was -34.19% (average difference = −21.51% - 12.68%), which was lower than the absolute rate of return (Table 9). The average rate of return of 23 bio venture companies' stock 2 years after listing was lower than the average KOSPI or KOSDAQ index increase rate during the same period, and the statistical analysis results show that the difference between the average stock price return and the average index increase rate is significant (Table 10).

In the end, considering the decline in R&D performance after IPO, the associated decline in stock prices, and the collection of investments from existing

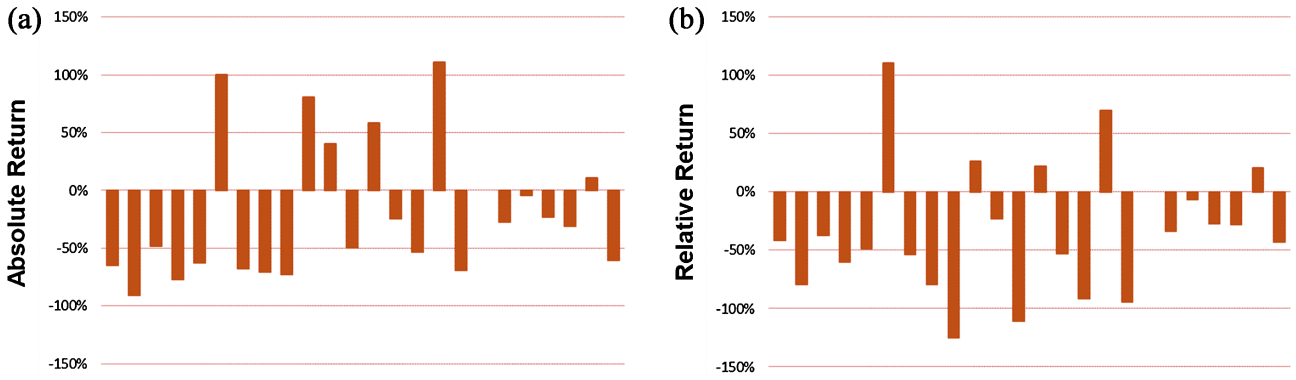

Figure 1. Rate of return on stock price of bio venture companies 2 years after IPO. (a) Stock price return (absolute rate of return) 2 years after IPO (n = 23). (b) Stock price return (relative rate of return to KOSPI & KOSDAQ) 2 years after IPO (n = 23).

Table 9. Group statistics (rate of return of stock price & index).

Category		Mean	N	Std. Deviation	Std. Error Mean
Rate of return (IPO→2yr)	Bio venture	−0.2151	23	0.6001	0.1251
	Index	0.1268	23	0.2844	0.0593

Table 10. Result of independent sample test (rate of return of stock price & index).

Category		Levene's Test for E. of V.		t-test for Equality of Means						
		F	Sig.	t	df	Sig. T-S p	Mean Diff.	Std. Error Diff.	95% Conf.	
									Lower	Upper
Rate of return	E.V. assumed	8.497	0.006	−2.469	44	0.017	−0.3419	0.1384	−0.6210	−0.0628
	E.V. not assumed			−2.469	31.411	0.019	−0.3419	0.1384	−0.6242	−0.0596

investors, the investment in newly listed bio venture companies in the Korean stock market will require careful consideration. The IPO of Korean bio venture companies does not show the primary effects of IPO, such as effective financing of companies and provision of attractive investment opportunities to investors. These results provide sufficient evidence that new policies may be needed to address the possibility of the bio venture companies' ill-timed IPO.

6. Conclusion

It examined changes in R&D performance and stock price of Korean bio venture companies for 2 years before and 2 years after their IPO. When evaluated based on domestic and foreign patents, licensing in/out, and entering next phases of clinical trials, the study found that overall R&D performance did not increase for 2 years after IPO, rather R&D performance tended to decrease for 2 years after IPO. This result is contrary to the existing hypothesis that IPO bio venture companies on the stock market will lead to improved R&D performance. In addition, bio venture companies showed a tendency for their stock prices' relative returns to KOSPI and KOSDAQ were found to be significantly poor. It is assumed that these phenomena were because the intention of bio venture companies' IPO was more influenced by FIs' exit strategies than by raising funds for R&D strategies of the bio venture companies.

This study revealed that the IPO of bio venture companies tends to be used as a means for FI to recoup their investments rather than as a means of R&D performance. IPOs are generally conducted with the purpose of attracting investment from the public and enhancing the future growth of corporate value. However, based on the results of this study, the purpose and meaning of the IPO are considered limited. Therefore, more complementary institutional or administrative procedures may be needed for the IPO of bio venture companies. In the listing review process in stock market for bio venture companies, there is a need to make the evaluation of future R&D plans and expected performance more stringent, focusing on the plan for using the public offering funds. Furthermore, more efficient disclosure of R&D information is needed, and systematic provision of information on the existence of FIs and their investment conditions should be reported as more important disclosure information during the IPO process.

In this study, R&D performance was compared for 2 years before and after IPO. It was thought that 2 years would be sufficient to derive R&D performance, but confirming changes in performance over a longer period would also be necessary. In addition, the COVID-19 pandemic may have occurred during the period covered by this study and caused various variables. Moreover, this study provides information limited to bio ventures listed on the Korean stock market. In future studies, considering these matters, it has plan to conduct research to analyze the correlation between R&D performance and IPO of bio venture companies in foreign countries such as the U.S., the U.K., and China as well as

the behavior of FIs in post-IPO.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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