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Technology strategy by growth stage of technology-based venture companies

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When it comes to technology strategy, opinions diverge between internal development and external sourcing. However, none of theoretical or empirical researches have succeeded in drawing an effective strategy. This study sheds light on the question of choice between make and buy by renewing the existing growth model from the viewpoint of technology strategy. In the incubation stage, entrepreneurs should acquire technologies as quickly as possible regardless of the sources of technology. Then, they should enlarge the capability of internal R&D to internalize and further technologies acquired during the incubation stage. In order to achieve sustainable growth after IPO, they should pursue both internal technology development and outsourcing in parallel. This three-staged technology strategy lays stress on the successive combination of internal and external sourcing from the complementary aspect instead of considering them as substitutes.

Field of Research: Management of Small Business, Strategic Policy and Entrepreneurship

1. Introduction

Technology-based start-up companies or venture companies are important vehicles driving innovations in various industries and they play an important role in national economic development (Autio 1994, 1997; Kortum and Lerner 2000). However, it is very difficult for these venture companies to survive the competition with existing players due to their lack of resources, legitimacy and network with outside stakeholders (Nesheim 1997). Stinchcombe (1965) called this phenomenon as liability of newness. One of the key strategies to overcome these disadvantages of start-up companies is initial public offering (IPO), or listing the company on the stock market. Through IPO, venture companies can obtain legitimacy in the business community and expand their funding channels through bank loans. In addition, IPO provides investors with opportunities to collect their investment. In this context, IPO is often used as a barometer of performance for venture companies whose performance is difficult to gauge in traditional performance measures like revenue or profit (Deeds et al. 1997; Stuart et al. 1999). In Korea, Korean Securities Dealers Automated Quotation (KOSDAQ) stock market was opened on July 1st, 1996 under the objectives of securing funding for venture companies and offering high-risk and high-return investment opportunities. To activate the incubation of technology-based small and medium-sized companies, the Korean government introduced “Venture Certification System” in

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1997 and about 9,000 small and medium-sized companies have earned this venture certification so far. However, only five percent of these venture certified companies are listed on KOSDAQ. One of the main reasons for this poor IPO performance is the lack of capital during the early growing stage, which is often called as the phenomenon of “Death Valley.” To overcome this issue, the Korean government has implemented various supportive policy measures like “Policy Fund Loan Project,” and has strived to activate investment from angel investors or venture capitalists. However, still these efforts are faced with their limitations. Given the high-risk nature of start-up business, venture companies always face difficulties in expanding early investment. Therefore, a fundamental solution to this problem would be to narrow the width of “Death Valley” by expediting IPO.

In this context, the purpose of this study is to review factors that affect IPO of technology-based venture companies and develop strategies that can expedite their IPO. Previous studies relevant to this topic include studies by Wilbon (1999, 2002), who proved that companies that still survive in five years after IPO acquire patents through technology development more frequently than those who do not survive in the same period after IPO. He also proved that the top management team of the former has more management experience than that of the latter. Deeds et al. (1997) found out that the size of capital raised through IPO is determined by technological capability of the company, qualities of R&D staffs, and the number of products. According to an empirical study by Chang (2004), IPO of a venture company can be expedited by the reputation of venture capitalists who invest in the start-up company and the size of its strategic alliance network. However, these studies have failed to deal with the technology aspect, especially technology strategy, which is one of the most apparent characteristics of technology-based start-up companies.

When it comes to technology strategy, opinions diverge between “make” strategy (internally develop technologies) and “buy” strategy (outsource technologies) regardless of whether it is a theoretical or empirical research. According to transaction cost theory (Pisano 1990), technology outsourcing has advantages in that it saves time and cost for technology development but it has disadvantages as it requires extra cost for transaction, exploring transaction partners, negotiation, and contract. According to property rights theory (Grossman and Hart 1986; Veugelers and Cassiman 1999), low level of appropriation weakens the need for internal technology development, but to turn spill-over technologies into useful assets, enhancing R&D capability is also required. Though there have been various transaction cost theories and intellectual property rights theories like these, none of them have succeeded in drawing an effective strategy. Given this challenge, this study aims to prove that 1) an effective technology strategy of a venture company may vary by growth stage (incubation stage, growing stage, and maturing stage) and 2) technology strategy that can expedite IPO should be developed in close linkage to the different growth stages of a venture company.

By renewing the existing growth model from the viewpoint of technology strategy, this study sheds light on the question of make or buy. The three-staged technology strategy lays stress on the successive combination of internal and external sourcing from the complementary aspect instead of considering them as

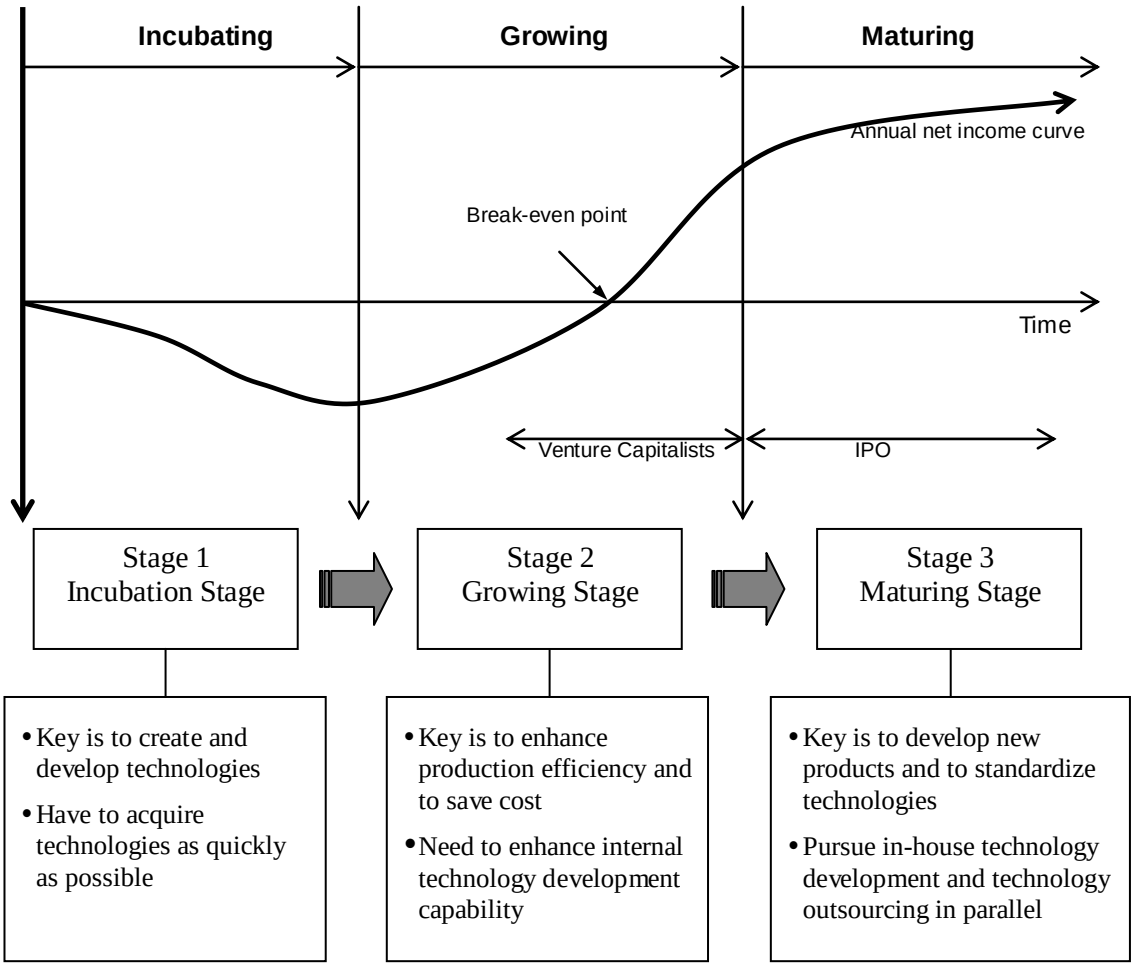
substitutes. In the incubation stage, entrepreneurs should acquire technologies as quickly as possible regardless of the sources of technology. Then, they should enlarge the capability of internal R&D to internalize and further technologies acquired during the incubation stage. In order to achieve sustainable growth after IPO, they should pursue both internal technology development and outsourcing in parallel.

This paper is organized as follows. Section 2 describes growth stage theory and hypotheses on the technology strategy by growth stage. Section 3 provides methodology including a detailed description of the data and a regression model. Section 4 presents the regression results. Lastly, concluding remarks summarize the key findings and suggest implications.

2. Literature review and Research model

Common findings from the previous studies on corporate growth stage reveal that companies evolve through various predictable growth stages and they also adopt strategies, structure, and different kinds of management activities that are suitable for each growth stage. Of course, when it comes to the definition of each growth stage, different researchers use different classifications. For example, Lippit and Schmidt (1967) presented a three-staged growth model while Quinn and Cameron (1983) proposed a four-staged model. Some researchers even suggested five or more growth stages (Churchill and Lewis 1983; Miller and Friesen 1984; Van de Ven et al. 1984). Most of the studies conducted by Korean researchers on the growth stage of venture companies have also adopted existing growth stage models. One of the most commonly adopted growth stage models for venture companies is one developed by Kazanjian (1988), which defines corporate growth with four stages of conceptualization and development stage, commercialization stage, growth stage, and stabilization stage.

Figure 1
Technology strategy by growth stage



The purpose of this study is to present a three-staged growth model which is focused on technology strategy as shown in Figure 1. Recently, there is a common understanding that R&D and commercialization are not separate or consecutive issues. In other words, a common trend in the research community is to adopt R&BD (Research and Business-Linked Development) approach, which helps researchers achieve practical commercialization through market-oriented development instead of technology-oriented development. Considering such trend, it seems more appropriate to integrate technology development and commercialization together into the incubation stage. Especially in IT area where the technology life span is short and the demand for new product development is high, it is even more difficult to discern between technology development and commercialization. Likewise, for companies whose businesses are focused on products and whose main income source during the incubation stage is not from technology services, the discernment between technology development and commercialization is also difficult. To identify key issues of each stage in the three-staged growth model and to expedite IPO, which is often considered as the barometer of a success of a venture company, the study develops hypotheses and reviews strategies, especially technology strategies that are effective for each stage.

2.1 Incubation stage

During this stage, companies develop technologies and acquire resources to start business. In other words, companies identify practical business ideas from research outcome, review and evaluate commercialization possibility, and, based on this, produce early products. This stage is when companies start manufacturing prototypes and selling products and business ideas to investors. The review of the previous studies reveals that, during this incubation stage, sourcing necessary resources and clarifying business concepts are important activities (Kazanjian 1988). Especially, sourcing necessary resources and capital funding, setting up organizational leadership, building up systems, hiring employees, and meeting product and market demands are very important (Scott and Bruce 1987; Churchill and Lewis 1983).

Since most of the activities during this stage are mainly led by the business founder, the role and experience of the founder in the relevant areas are reported to be key success factors of venture companies. In addition, prestigious top management team at the time of an IPO enhances organizational legitimacy and thereby provides a signal to potential investors (Lester et al. 2006). The important characteristics of top management teams are divided into two classes. One is technological side and the other is managerial side. McGee and Dowling (1994) proved that top management's technology development experience in the relevant areas affect revenue growth of venture companies. Wilbon (1999, 2000) also suggested that top management's technology development experience helps improve IPO performance. Given that the founder's management capability is very important, the wider the founder's social network from his or her business experience in the relevant industries is, the higher is the performance of the venture company (Cooper et al. 1994).

Hypothesis 1. Founder's technology development and business experience in relevant industries help expedite IPO of a venture company.

In fact, most of the activities during this period are focused on technology-related issues. Developing good technologies may be important. However, what is more important especially during this period is how quickly a company can acquire technologies and turn them into products. In relation to this, Kotabe and Murray (1990) proved that rapid acquisition of core elements is important to the performance of venture companies. Aspenlund et al. (2005) also argued that initial technology acquisition and technological capability are essential elements for the performance and future growth of venture companies. This can be understood as a natural outcome for venture companies who have to survive with limited resources and capital. Therefore, an effective strategy is to "buy" technologies from outside rather than to develop technologies internally, since internal development may require significant time investment during the early incubation stage.

Hypothesis 2-1. During the incubation stage, venture companies who are quick to acquire technologies regardless of the sources of technology can expedite IPO faster.

Hypothesis 2-2. To expedite an early IPO of a venture company, an effective technology strategy during the incubation stage would be to introduce technologies from outside rather than developing technologies internally.

2.2 Growing stage

Growing stage of ordinary venture companies is when these companies start producing, launching, and selling products as result of technology development (Kazanjian 1988). Therefore, during this stage, companies should implement activities to resolve various issues in production, technology, and marketing initiated by product launching. In this context, companies need to acquire complementary assets like new production equipments as well as new capital required for business expansion (Churchill and Lewis 1983). Especially, in case of technology-based venture companies, since they do business using high technology, the environmental uncertainty of these venture companies is higher than that of general small and medium-sized companies (Sapienza and Clercq 2000). As result, technology venture companies experience difficulties in securing funding. In order for technology venture companies to resolve these funding issues, attracting investment from venture capital companies is important. Though venture capital (VC)-backed firms do not always show higher performance than nonVC-backed firms (Brau et al. 2004), many researches stress the role of venture capitalists. For example, Davila et al. (2003) asserts that venture companies who successfully attract large amount of investment can hire capable employees, a key success factor for growth, and train them, which, in turn, expedite IPO process. Shane and Stuart (2002) also proved that successful attraction of investment from venture capital companies expedites IPO.

Hypothesis 3. Venture companies who successfully attract large amount of investment from venture capital companies can expedite IPO process faster.

During this stage, to meet increasing production, companies need to automate production lines and improve production processes and continue to develop products through product improvements (Wolff and Pett 2006). Improving production efficiency and saving cost are also important strategies (Kazanjian 1990). Therefore, it is important to develop capabilities for internal R&D during this period. Through these strategies, companies can improve product quality, save cost and innovate their production processes by internalizing and furthering technologies acquired during the incubation stage. Growing stage is a period when companies need to pursue product differentiation and new product development in preparation for the entry of competitors. During this stage, companies should build a product portfolio focused on their specialty areas. However, companies should also avoid developing too many products. What is more important during this stage is to develop internal technology development capabilities since the production efficiency and cost down are the most important issues.

Hypothesis 4-1. During the growing stage, venture companies who are centralized in technology innovation can expedite IPO faster.

Hypothesis 4-2. To expedite an early IPO of a venture company, an effective strategy would be developing internal technology development capabilities during the growing stage.

2.3 Maturing stage

The last growth stage of venture companies is maturing stage, when the growth rate of venture companies comes near to the average growth rate of the concerned industry. During this stage, the focus is on maintaining growth rate and developing additional products. Sometimes, managers or management teams are replaced with those with expertise and experience. However, this stage has a key challenge of defining an appropriate organizational culture including presenting corporate vision and mission that can be shared among all the employees of the company, improving efficiency of decision-making system, and facilitating communication among employees (Barringer et al. 2005).

During this period, companies need to decide whether to expand or diversify their business by expanding their product markets and further segmenting their markets and products. They should also try to expand sales and distribution network to develop new markets and increase exports. On the R&D side, this is a very important period as companies develop new follow-up products that can succeed existing life span of successful products and standardize technologies. So, one of the key reasons for failure during this stage is companies' ignorance of the importance of developing follow-up products as they are too much focused on single product (Huang et al. 2002). To overcome this limitation, companies need to step up their absorptive capacity by maintaining technology development capability accumulated during the growing stage and diversify products by actively introducing technologies from outside. In addition, they can enhance their capacity for forming alliances by building portfolios of technologies and increasing their value through patents (Kelley and Rice 2002). In other words, this stage is a period when companies should pursue both strategies of internal technology development and technology outsourcing in parallel.

Hypothesis 5. In order to achieve sustainable growth after IPO, venture companies should pursue both internal technology development and technology outsourcing in parallel.

3. Data and Methodology

3.1 Data and Variables

The corporate disclosure data including IPO prospectus describes a firm, its business plan, financial data, management structure, products, risks, and many other detailed data. These corporate disclosure data can be obtained from electronic disclosure system of Data Analysis, Retrieval and Transfer (DART) System. A content analysis is performed on the disclosure data of 165 IT-hardware firms that are registered on the KOSDAQ between 2000 and 2004. Especially, data for external sources of technology, for example M&A, technical tie-up, technology transfer from other institutes can be obtained through content analysis

using corporate disclosure data.

The data for patenting indicators can be retrieved from available databases of the Korea Industrial Property Rights Information Service (KIPRIS). The definitions of variables are reported in Table 1. In addition, some detailed explanations are presented below the Tables.

Table 2 shows the descriptive statistics of data from 165 IT-hardware firms. On an average, CEO has experience in related industry more than in the research. The ratio of firms whose CEO has research experience is about 42 percent. The average equity shares of CEO and venture capitalists are 33.3 percent and 13.3 percent respectively. The ratio of internal development for the first technology acquisition is about 84 percent, and that for the technology near IPO decreases to 63 percent. The average ratio of R&D expenditures to sales is about 7.6 percent and as a result, firms have 12.6 patent applications on an average. From the viewpoint of size and growth, there are big differences among firms. From these facts, we can know that there are some differences among firms in IT industry. Thus, it may be understood that some of these differences among firms' characteristics enable several firms to go public early.

Table 1
Definition of variables

Variables	Definition
Experiences of CEO	
CEO's experience in research field	The dummy variable that takes on the value 1 if the CEO has research experience, e. g. researcher or professor, and zero otherwise.
CEO's experience in industrial field	The dummy variable that takes on the value 1 if the CEO has experience of working in the related industries, and zero otherwise.
Equity share of CEO (%)	The equity share of CEO just before IPO.
Venture Capital Financing	
Equity share of venture capital (%)	The equity share of venture capitalists just before IPO.
Technology Sourcing and Timing	
First source of technology	The dummy variable that takes on the value 1 if the first source of technology is internal development, and zero otherwise [a)].
Time to first technology (month)	The time taken from company establishment to the first technology acquisition.
Source of technology near IPO	The dummy variable that takes on the value 1 if the primary source of technology for last 3 years before IPO is internal development only, and zero otherwise [b)].
Share of technology near IPO (%)	The ratio of technology acquisitions for last 3 years before IPO to total technology acquisitions.
Research and Development	
Patent application	The number of patent applications before IPO.
R&D expenditure to sales (%)	The last 3-year average ratio of R&D expenditures to total sales before IPO.
Firm Characteristics	
Setup year	The index for the setup-year of a firm [c)].
Sales [d)] (100,000,000 won)	The real sales at IPO.
Sales growth	The last 3-year average sales growth before IPO calculated by the ratio of sales to the previous year's sales.
Profit (100,000,000 won)	The real trading profit at IPO.
Product	The number of manufactured goods just before IPO.
Stock market environment	
IPO market index	The 3-month average ratio of public offering stock price to the par-value for all IPO firms in each quarter.
Dependent Variable	
Time to IPO (month)	The time taken from company establishment to the IPO.

notes: [a)] Internal development means patent application, and external sources are M&A, technical tie-up, technology transfer from other institutes, and jointly applied patents.
[b)] Since there is little case that the source of technology is external source only, zero means that the technologies come from both internal development and external source.
[c)] If a firm is established before opening the OTC market (April, 1987), this value is 0. If a firm is established between opening the OTC market and introducing the OTC dealer system (October, 1991), this value is 1. This value is 2 if a firm's setup-year is between introducing the OTC dealer system and opening the KOSDAQ (July, 1996). This value is 3 if a firm's setup-year is between opening the KOSDAQ and introducing the preliminary examination system (August, 1999). Firms that are established after August, 1999 have value 4 for this index.
[d)] 1,050 Korean won=1$. The sales include the sales of intangible assets, for example. licensing as well as product sales

Table 2
Descriptive statistics

Variables	Mean	Standard Deviation	Max	Min
CEO's experience in research field	0.418	0.495	–	–
CEO's experience in industrial field	0.588	0.494	–	–
Equity share of CEO (%)	33.281	17.953	79.95	0.00
Equity share of venture capital (%)	13.305	10.845	50.00	0.00
First source of technology	0.841	0.366	–	–
Source of technology near IPO	0.630	0.484	–	–
Time to first technology (month)	54.789	72.892	373	-86
Share of technology near IPO (%)	63.625	31.644	100	0
Patent application	12.576	31.620	329	0
R&D expenditure to sales (%)	7.552	20.431	252	0
Sales (1,000,000 won)	40,864.727	50,610.596	383,608	5,302
Sales growth	1.903	0.865	7.384	0.926
Profit (1,000,000 won)	4,602.758	6,995.099	54,020	-5,968
Product	5.564	3.931	41	1
IPO market index	11.209	6.425	29.41	5.03
Time to IPO (month)	104.842	76.994	407	16

The Pearson correlations between important variables are shown in Table 3. For the Pearson correlations between all the variables, the most significant correlation is between the time to IPO and the time to first technology (correlation=0.799). There are other significant correlations between the following pair wise correlations; the number of patent applications and the sales (correlation=0.698), the sales and the profit (correlation=0.621). Tests for multicollinearity are performed to ensure that high correlations do not exist between the explanatory variables. By the tolerance of variances, the variance inflation factor (VIF) test and the collinearity diagnostics, it has been confirmed that there is no multi-collinearity problem because the lowest tolerance of variance is over 0.4, the VIF is less than 2.5 and the eigenvalues are not approximately the same (Hocking 1996). As it is described in hypothesis, significant relationships between time to IPO and several explanatory variables are found. However, since these correlations do not fully account for the relationships among variables, a regression analysis is also conducted.

Table 3
Pearson correlations

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. *Time to IPO*	1.000													
2. *CEO's experience in research field*	-0.244‡	1.000												
3. *CEO's experience in industrial field*	-0.028	-0.039	1.000											
4. *Equity share of venture capital*	-0.308‡	0.239‡	-0.051	1.000										
5. *First source of technology*	0.011	-0.171†	-0.085	0.058	1.000									
6. *Time to first technology*	0.799‡	-0.245‡	-0.019	-0.208‡	0.073	1.000								
7. *Source of technology near IPO*	0.097	-0.063	-0.029	0.052	0.275‡	0.235‡	1.000							
8. *Share of technology near IPO*	-0.391‡	0.027	0.018	0.206‡	-0.217‡	-0.210‡	-0.228‡	1.000						
9. *Patent application*	0.013	0.012	-0.009	-0.141*	0.102	-0.139*	-0.053	-0.104	1.000					
10. *R&D expenditure to sales*	0.016	0.045	0.065	0.124	-0.020	0.039	-0.018	0.114	-0.017	1.000				
11. *Sales*	0.057	-0.038	-0.001	-0.138*	0.155†	-0.079	0.053	-0.143*	0.698‡	-0.050	1.000			
12. *Profit*	0.012	-0.006	0.091	-0.067	0.103	-0.065	0.003	-0.067	0.319‡	-0.041	0.621‡	1.000		
13. *Product*	0.033	-0.065	0.136*	-0.121	-0.046	-0.002	-0.088	0.131*	0.065	-0.030	-0.052	-0.096	1.000	
14. *IPO market index*	-0.028	-0.012	-0.053	0.028	-0.015	0.014	-0.022	0.095	-0.031	0.093	-0.114	-0.042	-0.030	1.000

‡ 1% level significancy † 5% level significancy * 10% level significancy

3.2 Regression framework

These data are used to analyze the IPO as a measure for start-up performance. It is estimated by duration analysis. Duration model is related with binary dependent variable model and event count model. Thus, the duration model treats how long it takes till the first event occurs. This duration model is used mainly in labor economics which deals with the employment or unemployment problem (Collier 2005; Cueto and Mato 2006). A useful function for characterizing the duration model is the hazard rate. The hazard rate is a continuous-time version of the sequence of conditional probabilities and is defined as (1). For more detailed information on the hazard rate model, see Kiefer (1988) or Greene (2003).

$$(1)\quad \lambda(t) = \lim_{h \to 0} \frac{\text{Prob}(t \le T \le t + h \mid T \ge t)}{h} = \frac{f(t)}{S(t)}$$

where S(t) is the survival function and is defined as (2).

$$(2)\quad S(t) = 1 - F(t) = \text{Prob}(T \ge t)$$

A parametric duration or survival model is one of which duration time is assumed to follow a known distribution. Duration estimate obtained from parametric duration models typically yields plots more consistent with a theoretical survival curve. If the investigator is comfortable with underlying distributional assumption, then parameters can be estimated that completely specify the survival and hazard functions. This simplicity and completeness are the main appeals of using a parametric approach. The different parametric models place different restrictions on the shape of the hazard function. The exponential distribution has hazard function that is constant, whereas the Weibull model can have hazards that are constant, monotonic increasing or monotonic decreasing. By contrast, the log-logistic exhibit non-monotonic hazard rates, initially increasing and then decreasing.

In this paper, we used log-logistic hazard function which is defined as (3) since the data does not exhibit monotonic hazard rate and log-logistic model is found to be more stationary in residual distributions than other duration models in this analysis. In addition, the likelihood-ratio chi-square statistic can not reject the null hypothesis, that is to say log-logistic model fits the data better than any other parametric models.

$$(3)\quad \lambda(t) = \lambda\alpha(t)^{\alpha-1}/[1+\lambda t^{\alpha}], \qquad S(t) = 1/[1+\lambda t^{\alpha}]$$

The parameters λ and α of this model can be estimated by maximum likelihood. If $\alpha \le 1$, then the hazard decreases over time. If $\alpha > 1$, however, the hazard increases to a maximum point and then decreases over time. The log-logistic model is a proportional odds model. A proportional odds model is a model in which the odds ratio is assumed to remain constant over time. The survival odds is the odds of surviving beyond time t (that is, S(t)/(1-S(t))). This is the probability of not getting the event by time t divided by the probability of getting the event by time t. The failure odds is the odds of getting the event by time t (that is, (1-S(t))/S(t)), which is the reciprocal of the survival odds. The log of the failure odds is expressed as (4). In other words, the log odds of failure is a linear function of the log of time with slope α and intercept $\ln(\lambda)$. This is a useful result enabling a graphical evaluation for the appropriateness of the log-logistic distribution.

$$(4)\quad \begin{aligned} \log(\text{failure odds}) &= \ln(\lambda t^{\alpha}) \\ &= \ln(\lambda) + \alpha[\ln(t)] \end{aligned}$$

For this log-logistic distribution, it is convenient to formulate the log-likelihood function in terms of $f(t) = \lambda(t)S(t)$ so that

$$(5)\quad \ln L = \sum_{uncensored} \ln \lambda(t|\theta) \; + \; \sum_{all} \ln S(t|\theta)$$

Inference about the parameters can be done in the usual way. Either the BHHH estimator or actual second derivatives can be used to estimate asymptotic standard errors for the estimates. The transformation $\omega = \alpha(\ln t + \ln \lambda)$ for this distribution greatly facilitates maximum likelihood estimation.

4. Results and Discussions

The results of the duration analysis are used to find the important factors affecting the time to IPO and verify the hypotheses about technology strategies. Table 4 presents the results of the regression analysis with the time to IPO, that is *time to IPO* as the dependent variable. The negative signs of Log-logistic model mean that if the hazard is high, then events occur quickly and duration times for IPO are short.

For the variables in incubation stage, the significant negative sign of *CEO's experience in industrial field* means that CEO's experience in related industry is helpful to lead the firm to an IPO early. Meanwhile, the negative sign of *CEO's experience in research field* is not statistically significant. These results imply that the hypothesis 1 may not be rejected and the founder's business experience in related industries helps expedite IPO of a venture company more than the founder's research experience.

For technology strategy, the timing of technology acquisition is very important to lead the firm to an IPO. From the result of significantly positive sign of *time to first technology,* it is known that the faster the timing of the first technology acquisition, the shorter the time to an IPO. These results imply that the hypothesis 2-1 may not be rejected. Contrary to hypothesis 2-2, *first source of technology* is not statistically significant, which means that the first sourcing type is not important. Consequently, the timing of technology acquisition is very important in incubation stage and venture companies who are quick to acquire technologies regardless of the sources of technology can expedite IPO faster.

Table 4
Results of the duration analysis

Variables			*Time to IPO* (Log-Logistic Model)		
Constant			5.3222*** (0.1287)	4.8160*** (0.3091)	4.6986*** (0.3055)
Variables in incubation stage	CEO's experience	*CEO's experience in research field*	-0.0510 (0.0411)	-0.0553 (0.0420)	-0.0540 (0.0417)
		CEO's experience in industrial field	-0.0731* (0.0413)	-0.0852** (0.0410)	-0.0905** (0.0402)
	Technology Sourcing	*Log(Time to first technology)*	0.0626*** (0.0167)	0.0600*** (0.0171)	0.0600*** (0.0170)
		First source of technology	0.0047 (0.0297)	0.0055 (0.0291)	0.0156 (0.0288)
Variables in growing stage	Venture Capital	*Equity share of CEO*	-0.0001 (0.0012)	-0.0002 (0.0012)	-0.0001 (0.0012)
		Equity share of venture capital	0.0022 (0.0020)	0.0022 (0.0020)	0.0018 (0.0019)
	Technology Sourcing	*Share of technology near IPO*	-0.0023*** (0.0007)	-0.0021*** (0.0007)	-0.0022*** (0.0007)
		Source of technology near IPO	-0.0662 (0.0433)	-0.0709* (0.0426)	-0.0756* (0.0424)
	Diversity of products	*Product*	0.0095** (0.0043)	0.0119*** (0.0041)	0.0299** (0.0144)
		(Product)^2	–	–	-0.0006 (0.0007)
Control variables	R&D Activity	*Log(Patent application)*	0.0146 (0.0173)	0.0106 (0.0186)	0.0093 (0.0186)
		R&D expenditure to sales	0.00010 (0.0015)	0.0010 (0.0027)	0.0011 (0.0308)
	Firm Characteristics	*Log(Sales)*	–	0.0339 (0.0306)	0.0328 (0.0308)
		Sales growth	–	0.0245 (0.0276)	0.0172 (0.0271)
		Log(Profit)	–	0.0158 (0.0126)	0.0201 (0.0125)
		Setup year	-0.4290*** (0.0202)	-0.4341*** (0.0229)	-0.4259*** (0.0232)
	Stock Market Environment	*IPO market index*	-0.0095** (0.0043)	-0.0074** (0.0031)	-0.0074** (0.0031)
Log likelihood			-1.53	2.29	4.16
Sample				165	

notes: standard errors in parentheses.
*** 1% level significancy ** 5% level significancy * 10% level significancy

For the variables in growing stage, *equity share of venture capital* variable representing the role of venture capitalist is not statistically significant. This is due to the low average equity share (around 10 percent) of venture capitalist as it is shown in Table 2. In addition, it is not permitted by Korean government that the investment of venture capitalist with the purpose of taking over management right[i]. Consequently, the role of venture capitalist is weak for IPOs in Korea, which means that the hypothesis 3 is not yet effective in Korea.

For technology strategy, the more technology are acquired near IPO, the earlier the start-up go public, which is verified in the result of significantly negative sign of

share of technology near IPO. This result implies that venture companies who are centralized in technology innovation during growing stage can expedite IPO faster (Hypothesis 4-1).

For technology sourcing, the internal development becomes more important when it is near IPO. This fact is derived from the result *source of technology near IPO* is significantly negative, which means that the hypothesis 4-2 may not be rejected. In addition, it is found that broad manufactured goods have positive influence on the time to an IPO from the result of positive sign of *product* variable. Therefore, the strategy of concentrating on several core goods makes IT start-ups go public fast. If the second order polynomial of *product* variable is introduced, the result shows that there is inverted u-shaped relation, while it is not significant.

Table 5
Comparison of the ratio of venture companies that pursue both internal development and outsourcing in parallel

The ratio of venture companies that pursue both internal development and outsourcing in parallel (%)			
For last 3 years before IPO	For first 3 years after IPO		
Total	Total	Bottom 33 percentile [a)]	Top 33 percentile [b)]
37.8	56.8	53.1	69.4

notes: [a), b)] In terms of sales growth before and after IPO which is calculated by the ratio of the first 3-year average real sales after IPO to the last 3-year average real sales before IPO.

To test the hypothesis 5 for maturing stage, technology sourcing and the sales growth are examined before and behind the IPO. The result is displayed in Table 5. The ratio of venture companies that pursue both internal development and outsourcing in parallel was no more that 37.8 percent for last three years before IPO, while the ratio is increased up to 56.8 percent after IPO. In addition, this ratio of high ranked ventures in terms of sales growth surpasses that of low ranked ventures, with the top 33 percent of sales growth before and after IPO reporting an average ratio of 53.1 percent and the bottom 33 percent 69.4 percent. Though the other factors affect sustainable growth, this result shows that venture companies are pursuing both internal development and technology outsourcing in parallel in order to achieve sustainable growth after IPO.

5. Concluding remarks

Though the three-staged growth model is not a new one, this study reconstructs the growth model from the viewpoint of technology strategy and sheds light on the question, which is better, make or buy? According to transaction cost theory and property right theory, these two technology strategies, make or buy, have advantage and disadvantage respectively. In other words, they are in complementary relations and effective strategy may vary by growth stage.

In incubation stage, key is how quickly a venture company can acquire technologies and turn them into products. Thus, the founder's technology development experience in related industries is useful and an effective technology

strategy during this stage would be to introduce technologies from outside since founder's research experience and the technology outsourcing strategy may shorten the time to development. However, these two factors are not verified to be important from the viewpoint of growth or performance. That is, it is said that the development of product with marketability as well as the development of technology with novelty is important since external source of technology, for example technology transfer from university does demand time to convert it into product with marketability. Consequently, during the incubation stage, venture companies who are quick to acquire technologies regardless of the sources of technology and turn them into products with marketability can get good performance.

In growing stage, key is to enhance production efficiency and to save cost. Thus, it is important to develop capabilities for internal R&D during this stage since this internal capability can make venture companies improve product quality, save production cost and innovate their production process by internalizing and furthering technologies acquired during the incubation stage. The development of internal capabilities gets more important when the main technologies come from external sources during incubation stage. In addition, venture companies should avoid developing too many products though they need to pursue product differentiation and new product development for the entry of competitors. Consequently, venture companies should focus on developing internal technology development capabilities in their specialty areas to get a good performance.

In maturing stage, key is to develop new products and to standardize technologies in order to maintain growth rate. Contrary to the growing stage, one of the key reasons for failure during this stage is companies' ignorance of the importance of developing follow-up products as they are too much focused on single product. To overcome this limitation, companies need to step up their absorptive capacity by maintaining technology development capability accumulated during the growing stage and diversify products by actively introducing technologies from outside. Consequently, venture companies should pursue both internal technology development and technology outsourcing in parallel in order to achieve sustainable growth.

This study has several limitations. As IT venture companies are analyzed in this study, it is difficult to extend and generalize the proposed technology strategy by growth stage into other industries. Nevertheless, this study is worthwhile since most of new stock market is IT-oriented market and IT industry in one of the most developed high tech industries. The detailed analysis on the differences among other industries will be conducted in the future. Another limitation is that the analysis is done with only private venture companies which do not go public. Though the comparison of non-IPO case with IPO case may be more desirable, it is difficult to get a reliable data from private venture companies. In addition, it gets more important how quickly venture companies go public though going public or not is important. In spite of these limitations, this study gives some important implications for start-ups who want to go public through the Korean new stock market.

Consequently, entrepreneurs may have three-staged technology strategy. In the incubation stage, they should acquire technologies as quickly as possible regardless of the sources of technology. Then, they should enlarge the capability of internal R&D to internalize and further technologies acquired during the incubation stage. In order to achieve sustainable growth after IPO, they should pursue both internal technology development and outsourcing in parallel. This three-staged technology strategy lays stress on the successive combination of internal and external sourcing from the complementary aspect instead of considering them as substitutes.

Footnote

[i] Government prevented the venture capitalists from investing over 50% of equity share or capital. However, this regulation was removed in 2005.

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