On the Dynamics of Innovative Strategic Alliances in Korea

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Abstract

The purpose of this study is to model the formation and success of innovative strategic alliances and international joint-ventures, in particular, for Korea. Especially for such high risky market entries it is argued that incorporating a suitable treatment of irreversibility, uncertainty and flexibility related to a multinational enterprise (MNE) entry decision gives further insights to the expansion, dissolvement, and optimal timing of joint ventures in Korea.

Keywords Foreign direct investment, multinational enterprise, sequential investments, Korean economy, international joint venture, real options.

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1 Introduction

The decision on how to enter a foreign market has become crucial to an internationalizing firm. Besides all other market entry modes and a perceived decline in 2001, worldwide foreign direct investment (FDI) continues to grow stressing the importance of equity based entry strategies.The turmoil caused by the Asian crises and their aftermath created a very volatile environment in this region. The increased uncertainty affected foreign portfolio investments and foreign direct investment, respectively. Although Korea's inward FDI for 2004 was 13 billion US$, inward FDIs' annual average volatility (1997-2004) accounts for 41%. If one subtracts long term loans from this figure, the remaining components seem to be even more volatile. During the same period annual average volatility of the acquisition of newly issued stocks was 44 percent while the annual average volatility of acquiring outstanding stocks resulted to 76 percent. Not only are these facts underscoring the importance of volatile indicator in foreign direct investment theory but also highlight the sequential nature of foreign investors divestment/investment pattern. Among the main investors are the USA, Japan, and Germany.

Another interesting fact about Korea's inward FDI is that only a relatively small number of industries, i.e. chemical, IT and electronics, food and transportation, accounted for the major shares of inward FDI over the years. While the importance has declined for the chemical industry recently, the amount of the remaining industries mentioned has risen steadily.[1] Facts about the type of entry and their annual distribution are rare, however. As Hong (1998) reports, the number of new strategic alliances in Korea was 256 in 1996. However, only 82 were on a national level. Thus, roughly two-third of the strategic alliances were initiated with at least one foreign partner.[2] Excluding the number of joint sales, OEM and tech-imports from the data, Hong (1998) reports 27 alliances due to joint R&D activity and 34 alliances due to an equity joint venture. These stylized facts highlight the importance of foreign direct investment in innovative sectors in form of JV. However, the overall successes of such high tech alliances suffer from high sunk costs and the fear of knowledge dissipation.

In this context, uncertainty puts a premium on flexibility which results in the fact, that multinational enterprises (MNEs) often prefer the formation of collaborate ventures, e.g. equity ventures or strategic alliances when entering a foreign market for the first time.

So far, however, models of the multinational enterprise have been too static and thus fail to take proper account of uncertainty that is created by the volatility in the international business environment (e.g. Marjit et al. (1995)). Consequently, flexibility was identified as the hallmark of modeling the multinational firm (e.g. Buckley and Casson (1998)). Given this context, real options theory has recently generated significant interest in the international business field (e.g. Kogut and Kulatilaka (1994), Buckley and Tse (1996), and Gilroy and Lukas (2005)). In brief, real option theory suggests to view FDI as a platform in the expansion abroad indicating that the initial investments carry a high option value due to possible new subsequent investment opportunities.

It is clear that this fact is most obvious for international joint ventures. Possible project interdependencies within an international joint ventures (IJV) allow for strategic flexibility calling for an interpretation of IJVs as platform investments (e.g. Kogut (1991)). Thus, although unprofitable from a stand-alone perspective, the value of a joint-venture can be much higher due to the flexibility to acquire later stakes of the venture in the future. Consequently, the termination of an IJV does not indicate its failure but the exploitation of its flexibility. Lately, this idea has become a building block for empirical research (see e.g. Reuer and Leiblein (2000) or Reuer and Tong (2005)). In addition, the modeling of immanent real options in the IJV context was further extended by several authors (e.g. Chi and McGuire (1996), Pennings and Sleuwaegen (2004) and Lukas (2005)).

The remainder of the paper is organized as follows. First, we will present the model: a two-phase market entry situation where each phase is connected to some sort of sunk cost and the flexibility to decide whether to initiate the phase or not. The first phase serves as a platform, i.e. an important prerequisite to further expand a MNEs presence in the new market. After this phase of close collaboration, the second phase is linked to two options. The first is to expand the foreign commitment by acquiring the remaining shares and transform the market entry into a merger. The counterpart option is to dissolve the venture by selling out the partner. Against the recent background of international joint-ventures within Korea, the results are discussed and implications on a broader level are deduced.

2 The Model

The analysis presented exemplifies the common situation facing typical equity-based international joint ventures between two private enterprises. International joint ventures (IJV) permit enterprises to integrate complementary resources encompassing firm-specific knowledge such as marketing or technological expertise or an amalgamation of various expertises. As commonly observed at a practical level, however, we assume that only a subset of total existing overall knowledge is exchanged freely among the participating IJV firms which is sufficient to fulfill some agreed upon objective such as a specific R&D collaboration. In addition, it is pointed out that one firm is a foreigner to the new market, namely the multinational enterprise (MNE) which has chosen a local partner in Korea.

The choice of which entry strategy an enterprise chooses has no influence upon the profit rates of other enterprises. Moreover, the value of the chosen FDI mode $v(t)$ is ex ante unknown and follows a geometric Brownian motion. Assuming a perfect capital market, the existence of a unique martingale measure Q can be used to modify the stochastic differential equation, which results in:

$$\frac{dv}{v} = (r-\delta)dt + \sigma dz^Q, \tag{1}$$

where $(r-\delta)$ is the growth rate of the project value, σ^2 designates the variance of dv/v, r is the risk-free interest rate, and dz^Q indicates a Wiener process with non-zero drift.

The original equity stake the MNE shareholder has invested is ϵ, which generates a portfolio of two exclusive strategic options.[3] The interval of time necessary for the partners to become acquainted with each other is $[t_1, t_2]$. At the end of this time span, the MNE has to decide whether it prefers to continue collaboration with the host partner by exercising the right to convert the IJV into a cross-border merger, i.e. by acquiring at a later date the remaining shares $(1-\epsilon)$. On the other hand, offsetting such a strategy, the MNE might find it more favorable to prematurely divest the growth option and dissolve the IJV later by selling its own share ϵ to the local partner.[4] We denote the optimal threshold separating both of these strategies by ξ.

The option value F, the optimal trigger points v_U^*, v_L^* (representing the actual timing of the subsequent investment/divestment) and ξ may be solved for recursively (See Lukas (2005).) From Dixit and Pindyck (1994) as well as Merton (1973) the results for a perpetual call option, and a perpetual put option respectively, are commonly known. Thus, they are just summarized briefly.

Under the assumption of a perpetual time to maturity and corresponding boundary conditions the flexibility value for a perpetual call option results to:

$$C(v) = \left[(1-\epsilon)\frac{1}{\beta_1}\left[\frac{1}{(1-\epsilon)}\frac{\beta_1}{\beta_1-1}I\right]^{(1-\beta_1)}\right]v^{\beta_1} \quad \text{for} \quad v < v_U^* \tag{2}$$

with I designating the cost for acquiring the rest of the equity stake $(1-\epsilon)$ and $\beta_1 = \frac{1}{2} - \frac{(r-\delta)}{\sigma^2} + \left(\left[\frac{(r-\delta)}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}\right)^{1/2}$ as a constant.[5] If $v \geq v_U^*$ the usual NPV criterion applies which generates a value of $(1-\epsilon)v - I$ for the investment. In such a case, there is no premium on flexibility to be observed.

From this, the optimal trigger value v_U^* for the M&A strategy can be deduced which results to:

$$v_U^* = \frac{1}{(1-\epsilon)}\frac{\beta_1}{\beta_1-1}I. \tag{3}$$

In contrast, if the MNE terminates the IJV it will obtain a perpetual put option. Upon exercising the second stage, the MNE forsakes the existing project with value ϵv and attains subsequently its abandonment value κ (see e.g. Chi (2000)). The respective strategic flexibility value is thus:

$$P(v) = \left[-\frac{1}{\beta_2}\epsilon\left(\frac{\beta_2\kappa}{(\beta_2-1)\epsilon}\right)^{1-\beta_2}\right]v^{\beta_2} \quad \text{for} \quad v > v_L^* \tag{4}$$

whereby $\beta_2 = \frac{1}{2} - \frac{(r-\delta)}{\sigma^2} - \left(\left[\frac{(r-\delta)}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}\right)^{1/2}$ is again a constant. Like for the call option, no premium for flexibility is observed for project values below v_L^*. Consequently, the project has a value of $\kappa - \epsilon v$ if $v \leq v_L^*$.

The corresponding optimal threshold value v_L^* for initiating a divestment strategy results to:

$$v_L^* = \frac{\beta_2}{\beta_2 - 1}\frac{\kappa}{\epsilon}. \tag{5}$$

Consequently, the value of the chooser option is determined by:

$$F = e^{-r(t_2-t_1)} E^Q \left[\max\{P(v), C(v)\}\right], \tag{6}$$

with $E^Q(\ldots)$ as the expectations operator under the martingale measure Q. This results in solving the following integral:

$$\begin{aligned} F &= e^{-r(t_2-t_1)} \left[\int_{-\infty}^{v_L^*} (\kappa - \epsilon v) d\Phi(v) \right. \qquad (7) \\ &+ \left. \int_{v_L^*}^{\xi} BV^{\beta_2} d\Phi(v) + \int_{\xi}^{v_U^*} AV^{\beta_1} d\Phi(V) + \int_{v_U^*}^{\infty} ((1-\epsilon)v - I) d\Phi(v) \right], \end{aligned}$$

where $d\Phi(v)$ denotes the implied probability measure. In order to derive a closed form solution for the complex chooser option one has to determine the aforementioned optimal threshold ξ. Thus, ξ is determined by the intersection of $P(\xi)$ and $C(\xi)$.[6] From $A\xi^{\beta_1} = B\xi^{\beta_2}$ we get:

$$\xi^\gamma = \frac{-\frac{\epsilon}{\beta_2}(v_L^*)^{1-\beta_2}}{((1-\epsilon)v_U^* - I)(v_U^*)^{-\beta_1}}, \tag{8}$$

with $\gamma = \beta_1 - \beta_2$.

Solving equation (7) results in:

$$\begin{aligned} F &= \kappa e^{-rT} N(d_3) - \epsilon v_{t_1} e^{-\delta T} N(d_4) + B v_{t_1}^{\beta_2} N(d_7) - B v_1^{\beta_2} N(d_8) \qquad (9) \\ &+ A v_{t_1}^{\beta_1} N(d_5) - A v_{t_1}^{\beta_1} N(d_6) + (1-\epsilon) v_{t_1} e^{-\delta T} N(d_1) - I e^{-rT} N(d_2), \end{aligned}$$

with v_{t_1} as the value of the overall IJV at time t_1, $N(\ldots)$ as the cumulative normal distribution and

$$
\begin{aligned}
\mathrm{d}_1 &= \frac{\ln\left(\frac{v_{t_1}}{v_U^*}\right)+(r-\delta+\frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}}, &\quad \mathrm{d}_2 &= \frac{\ln\left(\frac{v_{t_1}}{v_U^*}\right)+(r-\delta-\frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}},\\
\mathrm{d}_3 &= \frac{\ln\left(\frac{v_L^*}{v_{t_1}}\right)-(r-\delta-\frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}}, &\quad \mathrm{d}_4 &= \frac{\ln\left(\frac{v_L^*}{v_{t_1}}\right)-(r-\delta+\frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}},\\
\mathrm{d}_5 &= \frac{\beta_1\ln\left(\frac{v_U^*}{v_{t_1}}\right)-(r-\frac{1}{2}\beta_1^2\sigma^2)T}{\sigma\beta_1\sqrt{T}}, &\quad \mathrm{d}_6 &= \frac{\beta_1\ln\left(\frac{\xi}{v_{t_1}}\right)-(r-\frac{1}{2}\beta_1^2\sigma^2)T}{\sigma\beta_1\sqrt{T}},\\
\mathrm{d}_7 &= \frac{\beta_2\ln\left(\frac{\xi}{v_{t_1}}\right)-(r-\frac{1}{2}\beta_2^2\sigma^2)T}{\sigma\beta_2\sqrt{T}}, &\quad \mathrm{d}_8 &= \frac{\beta_2\ln\left(\frac{v_L^*}{v_{t_1}}\right)-(r-\frac{1}{2}\beta_2^2\sigma^2)T}{\sigma\beta_2\sqrt{T}}.
\end{aligned}
$$

3 Results and Simulations

Presuming in the following the respective values $I = 1$, $r = 0.03$, $\delta = 0.03$, $\sigma = 0.3$, and $\kappa = 0.8$, we now briefly summarize our results and the comparative-static analysis. The value of the international joint venture's flexibility F is composed of the option value to stop the IJV (i.e. the first to fourth term) and the growth option value reflecting the value of the subsequent cross-border merger strategy (i.e. the remaining terms). As the calculations suggest, F increases with the size of initial equity share, uncertainty, and value of the IJV. In contrast, it decreases for high initial costs and time to maturity (i.e. $T = (t_2 - t_1)$). Figure 1 below graphically summarizes these results.

==========[INSERT FIGURE 1 HERE]===========

From the standard literature, the comparative-static outcomes for the respective trigger values v_L^* and v_U^* are familiar. The threshold value v_U^* becomes larger and so does the propensity to wait with turning the IJV into a merger, the higher the costs of acquiring the remaining shares I are, and the higher the aggregate investment uncertainty is. Furthermore, the trigger value is additionally dependent upon the size of the equity share ϵ so that v_U^* increases as ϵ increases. The situation reverses for the trigger value of the divestment stage. Low uncertainty levels correlate with a high threshold value v_L^*. The magnitude of this effect is further enhanced the lower the initial equity share ϵ or the greater the recovery value κ is.

The chooser option is a path dependent derivative. Consequently, conjectures regarding the kind of termination the MNE chooses at time t_2 can only be inferred in combination with the threshold ξ. As mentioned above, at t_2 the MNE selects a strategy that offers the maximum return. Given v_{t2} is greater than ξ, the MNE will continue its present strategy of collaboration until the above mentioned threshold v_U^* is attained turning it into a merger. In situations where v_{t2} is less than ξ, the MNE will further collaborate while at the same time opt out to dissolve the IJV. It can now be stated that the optimal threshold ξ may be characterized by two distinctive trends with respect to its dependence on project uncertainty. When a MNE has majority possession of an IJV, the threshold increases the greater the level of aggregate uncertainty given. As a result, there is a noticeable trend toward sell out due to the fact that a MNE will require a higher project value to compensate for the corresponding risks of implementing the merger strategy option.

In the case of a minority IJV, however, ξ is inversely dependent on project uncertainty. As such, the likelihood for a subsequent merger increases as project uncertainty levels rise. Moreover, in situations where the threshold ξ has (not yet) been reached, the propensity to commence (sell off) the investment is even faster the lower the uncertainty σ is (this follows from the fact that only small upward (downward) movements of $v(t)$ are necessary to attain the respective threshold value). A decrease in abandonment value κ diminishes both trends. The dependence of ξ on uncertainty with regard to ϵ is illustrated below in Figure 2.

==========[INSERT FIGURE 2 HERE]===========

In order to derive implications on the dynamics of Korean IJVs we choose the IT industry as a reference. This sector leads Korea's industrial R&D activities by accounting for roughly half of Korea's R&D expenditures.[7] In addition, this sector faces growing foreign direct investment trends. From 1997 on the relevance of IT driven FDI inflow has risen from 5.4% incipiently to 42.3% in 2001.[8]

However, unlike for financial securities, there are neither written contracts nor financial markets for real options in general. To simulate the dynamics of the model, one has to look for proxies that represent trend and substitutes or twin assets that capture the surrounding uncertainty of $v(t)$'s dynamics. As the risk-free interest rate is concerned, it is comfortable to refer to a treasury bond with equivalent maturity as the option right. We will use Korea's 10 year Treasury bond yield as of October 2005 which results to 5.54 percent.[9]

In addition, we collected data on announced international innovative joint venture in Korea for the IT industry which was compiled from several sources.[10] In order to compare the results, we also collected data on international joint ventures for a more mature industry, i.e. the chemical sector. While the majority of IJV data were mostly limited with respect to initial equity stake or location base, 43 international joint ventures have been identified in Korea with utilizable data. From the data we derived the mean equity stake for both industries ($\epsilon_{IT} = 0.52$, $\epsilon_{CH} = 0.53$) and an average cooperation time frame (min. 6 years). In order to take account for the uncertainty in a sector, we choose the 5 year mean of the historical volatility derived from the Korea Composite Stock Price Index (KOSPI) IT industry ($\sigma = 37\%$) and Chemical industry ($\sigma = 26\%$) sub indices, respectively.[11][12] The minimum cooperation period for companies in both industries was fixed to 7 years while the simulated time horizon was 24 years. Costs for the stages were set to be proportional to the initial stake in the venture. Furthermore, we treat the IT sector to be more concentrated while the Chemical sector is assumed to be more competitive.[13] The results of the simulations are given in figure three.

==========[INSERT FIGURE 3 HERE]===========

For the Korean chemical industry the simulation results are as follows. After the collaboration period, there is a 89 percent chance that the joint venture will decide to continue and secure FDI flows to Korea in the future. Thus, the chance for divestment is 11 percent. With respect to what will be realized at the end of the given time frame, 9 percent of the simulation ended with divestment while for 90 percent of the simulation the joint venture is still operating. This implies the fact that possible M&A, although occurred with a 1 percent chance can be neglected. In this context, the corresponding thresholds were not reached in the given period. With respect to the timing of divestment and merger, respectively one can note that there is a great chance that the joint venture will end right after the fixed cooperation period ends while M&A is possible at the end of the forecasted time frame.

As international joint ventures in the Korean IT industry are concerned, the picture is quite different. Although there is an almost 60 percent chance that the joint venture will decide to continue cooperating divestment is much more realistic than for the chemical industry.

In this context, there is a fear of FDI divestment flows out of Korea in the future. At the end of the forecasted time horizon, there is still a perceived chance of 40 percent that the divestment takes place as prognosted. On the opposite, there is a 51 percent of chance that the partners are still in a stable joint venture. Interesting, though, that roughly 9 percent of the simulation forecast an acquisition strategy. Like for the chemical industry joint ventures in the IT sector tend to end just after the collaboration period. On the contrary, however, a M&A strategy tend to occur on average 4 years after the fixed cooperation period, i.e. in year 11.

4 Summary

The expansion of multinational enterprises into Korea is a path dependent process which is reflected in the fact that the observed internalization processes happened not only to be a unidirectional path. Therefore, strategic reorientation, divestment or withdrawal must be considered as serious strategies, too. Analyzing Korea's IT and Chemical Industry, the model presented here depicts the influence of foreign investor's subsequent investment/divestment options on FDI patterns. The results show the new complementary insight, that the choice of investing in the first stage is not only driven by the growth option, as commonly modeled in the literature, but also driven by the flexibility to dissolve the venture. Implications for governmental policies in order to attract and stabilize FDI flows can be deduced from the model. Moreover, the study provides new opportunities for further in-depth Korean empirical research under an option framework.

Notes

[1]See Jung-Soo (2002).

[2]Since the 1990s, South Korean firms have strengthened strategic technological alliances with foreign firms mainly in response to the upward pressure on technology protectionism. Illustrative of such activities is the case of LG.Philips LCD, which is a joint venture between LG Electronics Inc. and the Netherland-based Philips Electronics N.V. Together with their core competitor Samsung Electronics both companies took up 22.0 percent and 19.7 percent each of the global LCD market in 2004.

[3]Thus, the venture will be an equity joint venture if $0.05 < \epsilon < 1$ (see e.g. Gomes-Casseres (1987)).

[4]The last step may be justified, because a subsequent innovation renders an existing partner's technology obsolete or due to misappropriation risk. Consequently, the venture is abandoned for the sake of a new venture or for withdrawal from the foreign market.

[5]It is assumed that the acquisition price is fixed right from the start. For a justification of this assumption refer to e.g. Chi and McGuire (1996).

[6]If there is not such a perpetual lifespan assumed, ξ has to be determined iteratively, i.e. using Newton-Raphson or quadratic methods instead. See e.g. Nelken (1993).

[7]See KISDI (2005).

[8]See KISDI (2002).

[9]See e.g. Clark (1997) who used a 30 year STRIP instrument.

[10]The Korean government established a Foreign Investment Promotion Act in 1998 which lowered the restriction on equity transactions significantly. Thus, we only accounted for international joint ventures initiated after 1998.

[11]Indices are a reasonable proxy in real option valuation since they comprise market and industry specific risk.

[12]See Miller et al. (2004) for an option approach to value a Korean IT-infrastructure project. In this context, the authors use a cash flow volatility of 60%.

[13]Consequently, we assume $\delta_{IT} > \delta_{CH}$.

References

Buckley, A. and Tse, K. (1996). Real operating options and foreign direct investment: A synthetic approach. *European Management Journal*, 14(3):304–314.

Buckley, P. and Casson, M. (1998). Models of the multinational enterprise. *Journal of International Business Studies*, 29(1):21–44.

Chi, T. and McGuire, D. J. (1996). Collaborative ventures and value of learning: Integrating the transaction cost and strategic option perspectives on the choice of market entry modes. *Journal of International Business Studies*, 27(2):285–307.

Chi, T. (2000). Option to acquire or divest a joint venture. *Strategic Management Journal*, 21:665–687.

Clark, E. (1997). Valuing political risk. *Journal of International Money and Finance*, 16(3):477–490.

Dixit, A. K. and Pindyck, R. S. (1994). *Investment under Uncertainty*. Princeton University Press, Princeton, NJ.

Gilroy, B. M. and Lukas, E. (forthcoming). The choice between greenfield investment and cross-border acquisition: A real option approach. *The Quarterly Review of Economics and Finance*.

Gomes-Casseres, B. (1987). Joint venture instability: Is it a problem? *Columbia Journal of World Business*, 22(2):97–102.

Hennart, J.-F., Kim, D.-J., and Zeng, M. (1998). The impact of joint ventures on the longevity of Japanese stakes in the U.S. manufacturing affiliates. *Organization Science*, 9(3):382–395.

Hong, Y.S. (1998). Technology-related FDI climate in Korea. *KIEP Working Paper* No. 98-14, Korea Institute for International Economic Policy.

Jung-Soo, Seo and Jong-Soon, Kang and Deok-Ki Kim (2002). Intra-Industry Foreign Direct Investment and Intra-Industry Trade in Korea. *Pacific Economic Papers*, July, No. 329.

Kogut, B. and Kulatilaka, N. (1994). Operating flexibility, global manufacturing, and the option value of a multinational network. *Management Science*, 40(1):123–139.

Kogut, B. (1991). Joint ventures and the option to expand and acquire. *Management Science*, 37(1):19–33.

Korea Information Strategy Development Institute (KISDI) (2002). IT industry outlook for Korea 2003, KISDI.

Korea Information Strategy Development Institute (KISDI) (2005). IT industry outlook for Korea 2005, KISDI.

Leung, W. F. (1997). The duration of international joint ventures and foreign wholly-owned subsidiaries. *Applied Economics*, 29:1255–1269.

Lukas, E. (2005). Sequential international joint ventures and the option to choose. *Working Paper Series* No. 83, University of Paderborn, Germany.

Marjit, S. and Broll, U. and Mallick, I. (1995). A theory of overseas joint ventures. *Economics Letters*, 47(3-4):367–370.

Merton, R. C. (1973). Theory of rational option pricing. *Bell Journal of Economics and Management Science*, 4:141–183.

Miller, L. and Choi, S. H. and Park, C.S. (2004). Using an option approach to evaluate Korean information technology infrastructure. *The Engineering Economist* 49(3):199–219.

Nelken, I. (1993). Square deals. *RISK*, 6(4):56–59.

Pennings, E. and Sleuwaegen, L. (2004). The choice and timing of foreign market entry under uncertainty. *Economic Modelling*, 21:1101–1115.

Reuer, J. J. and Leiblein, M. J. (2000). Downside risk implications of multinationality and international joint ventures. *Academy of Management Journal*, 43(2):203–214.

Reuer, J. J. and Tong, T.W. (2005). Real option in international joint ventures. *Journal of Management*, 31(3):403–423.

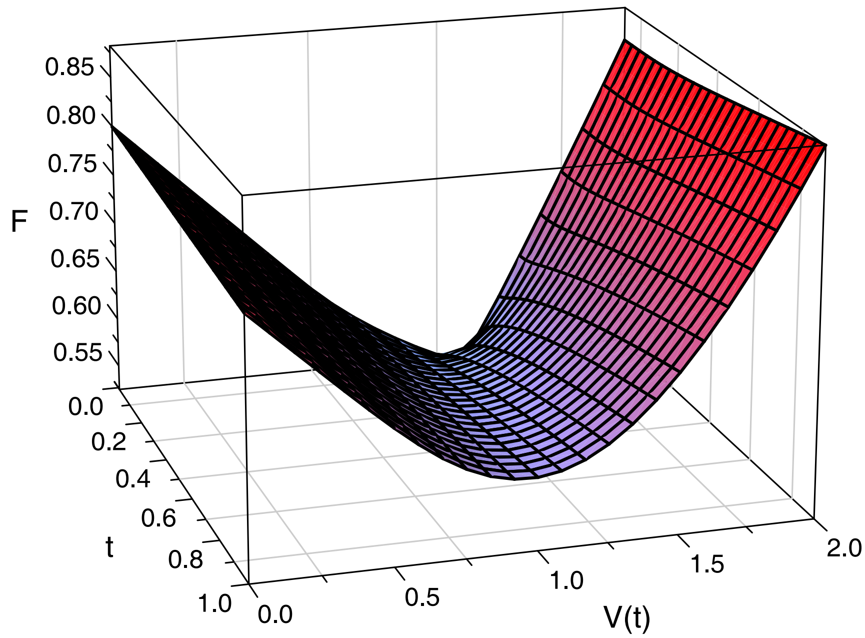

Figure 1: Value of acquisition/divesture option F with respect to V and time of joint collaboration T.

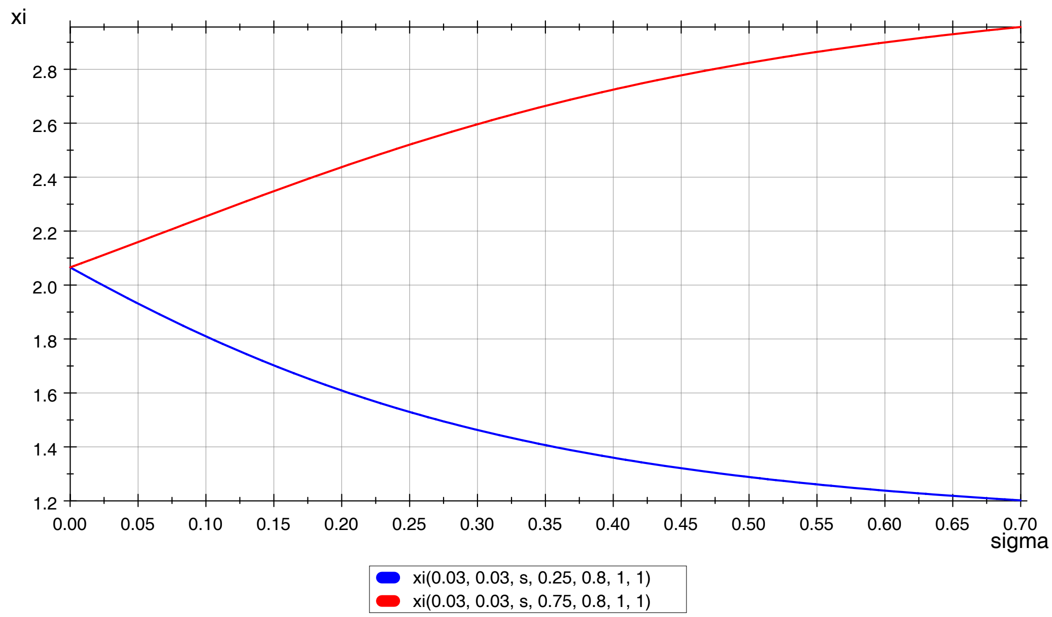

Figure 2: Influence of uncertainty σ and equity share ϵ on ξ.

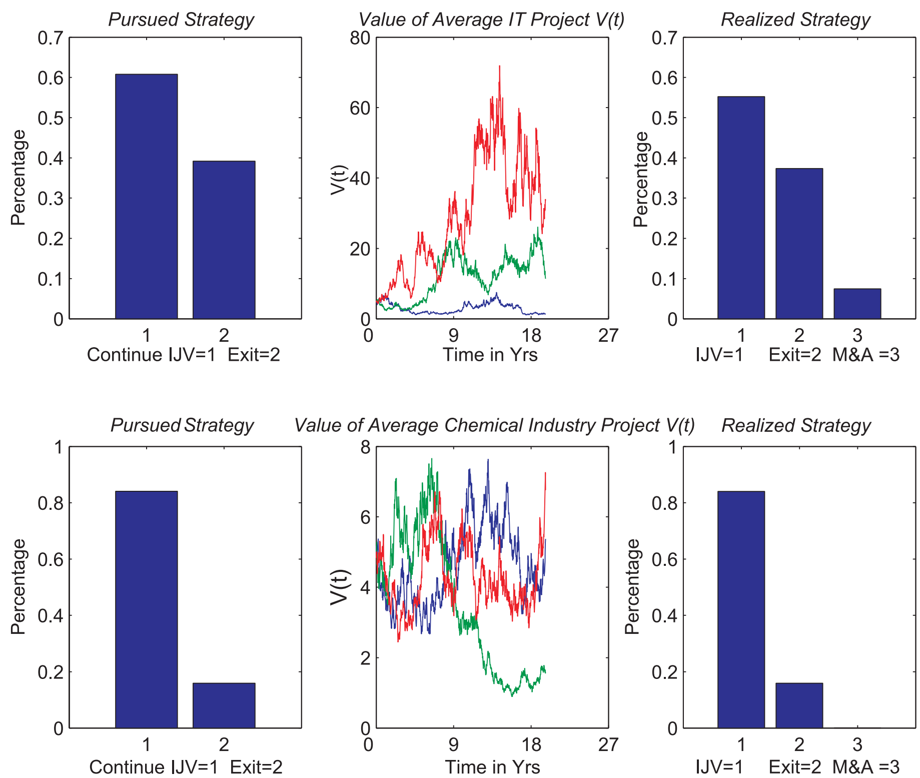

Figure 3: Simulation results for the IT and chemical industry in Korea.