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Intellectual Asset Management in Manufacturing SMEs in China: Potential and challenges in the Die Industry

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Abstract

China has a large number of small and medium-sized enterprises (SMEs). However, in the international market competition, lack of innovative technology is the serious problem that Chinese SMEs are facing, because it is the main source of their weakness. Then technology is the strategic factor for improving the international competitiveness.

The purpose of the study is to formularize the business model for evaluating and managing technology strategically as intellectual assets, in order to improve the international competitive position of China's manufacturing SMEs.

When importing and developing technology, in order to value technology appropriately and make optimal investment decision, it is recently suggested to try to apply real options analysis. This study is pricing the value of patents by the Black-Scholes formula, to model how to make appropriate investment decisions at each stage of R&D process. Then the paper used numerical calculation to test the effectiveness of the approach.

Background

As the background of the study, China is a country which has a large number of small and-medium-sized enterprises (SMEs).On the other hand, in the international market competition, lack of innovative technology is the serious problem that Chinese SMEs are facing, and also means the weakness of them.

Then, how can the Chinese SMEs improve technological competitiveness under such research question?

Purpose and process of the study

Technology is the important element for improving the international competitiveness. The purpose of the study is to formularize the business model, by evaluating and managing technology strategically as intellectual assets, in order to improve the international competitive position of China's manufacturing SMEs.

I focus on manufacturing SMEs in die industry as a specific object of this study on the intellectual assets management, because the influence of die industry to manufacturing industry is very significant. For example, the quality of a mass production system depends on the precision of a die. Therefore, I am interesting in the technological management for standard improvement of the die precision.

As an example of a developed country, I compare Japan's case with that of China, to make clear the present problems of Chinese die SMEs. Then, I suggest an appropriate method to solve the problem, and build a model of evaluation and investment in technology development.

Analysis of present conditions

The result of present conditions is as follows.

1) The result of comparison between Japan and China in SMEs in die industry:

The number of China die SMEs is about 2 times of Japan, and the number of workers is about 5 times of Japan. Although the amount of production of China die SMEs is improved from about 1/4 of Japan in 2000 to about 1/2 in 2004, it is still staying in a low level. Comparing with the amount of export, the amount of import is bigger at China die SMEs. Depending on domestic supply only is not enough to meet demand. In addition, the situation is opposite in Japan. Then export from Japan becomes a large weight of the amount of Chinese import. So, in order to increase the amount of production in the country, and to decrease unfavorable balance of trade, it is necessary to improve the technology ability of SMEs, because of their very high weight in domestic industrial structure.

2) As a main cause of the present problem of China die SMEs, which I described above, there are three points should be considered. Firstly, on average, technology level is low. Secondly, the diffusion rate of new die technologies is slow. In addition, technology accumulating motivation of die SME's managers is cool. Rather than research and development investment which contributes to long-term development ability of company, most of the managers are more enthusiastic toward equipment investment, to earn short-term profits.

Because of lowness of such technological development ability, most of the products are at low or intermediate quality level. In particular, most of the large, precise, complex, and high-quality durable products are relying on imports by 75 percent.

Model building of technology evaluation / management for improvement of competitiveness of Chinese die SMEs

Considering the problems above of China's die SMEs, this study suggests that, China's die SMEs have to tackle with technology import and development more aggressively. And it also describes the necessity of management technique of evaluation and use of intellectual assets that can facilitate the realization of innovation in die, product, and production process.

When importing and developing technology, in order to evaluate technology appropriately and make optimal investment decision, it can be suggested to try to apply real options analysis. Hence this study is pricing the value of patents by the Black-Scholes formula, to model how to make appropriate investment decisions at each stage of research and development (R&D) process. Then the paper used numerical calculation to test the effectiveness of the approach.

Assumption

Considering investment in a die R&D projects, following tables show the conditions and assumptions.

Table 1: Assumptions (1) of die research and development projects

time	state	investment
The start of the first year	research	I_1
The start of the second year	development	I_2
The start of the third year	Factory construction	I_4

Table: 2 Assumptions (2) of die research and development projects

Till development state	Success probability	p
	Failure probability	1-p
Product's value	Increase	u
	Decrease	d
Risk-free rate		r
Cash flow	Precision Products	V_1
	Average Products	V_2
	Failure	0

Here, V_1, V_2 and 0 are showing each cash-flow which will generate permanently every year.

The location of this study

Previous studies In the conventional research (Copeland, T. & Antikarov, V., 2001), the model of real options application to technology R&D projects is as following Figure 1.

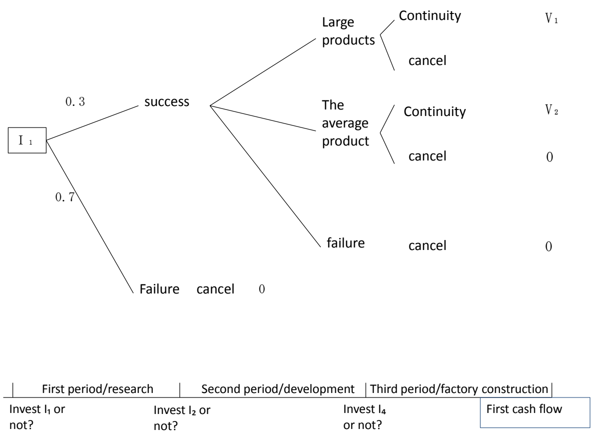

Figure 1.Application of financial option valuation to Real Options

Here, the pattern is just very simple pattern for checking whether the research is successful at the end of the first period. And there is also just one kind of option –cancel option used in the model.

Improved Study In this study, considering that the important element which impacts on the level of die quality is not only the level of technology, but also the level of skill, I changed the success results of research into 4 patterns. And I also increased the type of options used like out-license (put option), in-license (call option), technical improvements (expansion option), or the adoption of high-skilled experts (expansion option).

The model is as following Figure 2.

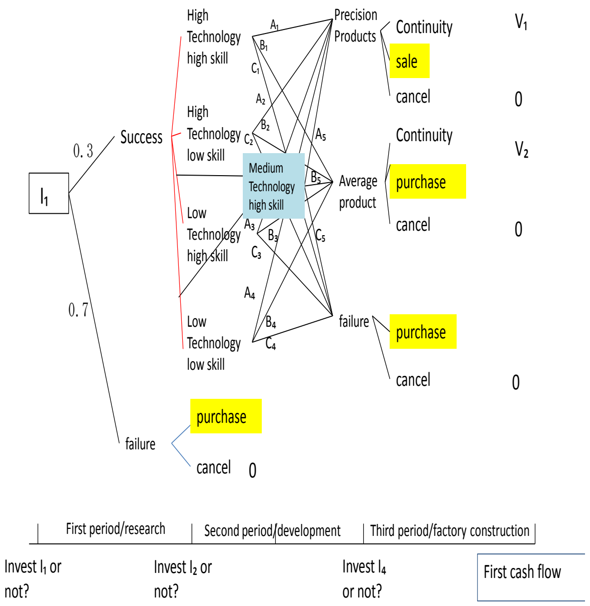

Figure2. Model of evaluation and investment in technology development

Here, I divided the technology level into high or low technology level at the end of the first period when research is succeed. Skills of the workers who develop dies are also divided into high or low skill. Suppose A and B as respectively the success rate of general and precision products, and C as the product failure rate. Based on each combination of different levels of technology and skills, it is divided into [high –technology, high-skill], [high-technology, low-skill, [low-technology, high skill], and [low-technology, low-skill]. Further A_i, B_i, and C_i here are variable from A_1, B_1, and C_1 to A_4, B_4, and C_4, under i=1,2…4.. It means that success rate of developing various dies is changeable and becomes a function of different combinations of technologies and skills. Therefore, outcomes of the function can also produce different failure rates. For example, when developing the precision die, the success rate of [high-technology, high-skill] is higher than the success rate of [high-technology, low–skill]. And the success or failure rate for developing average product is also variable depending on such technology and skill combinations.

Here, I propose a unique option as the combination of [medium-technology, high-skill].

In the case of such combination of [low-technology, high-skill] or [low-technology, low-skill], by one and a half years, by judging from the condition of developing, I added another options as additional R&D investment or hiring high-skill worker to improve respectively the technology level to medium technology, or the skill level to high skill. Here, the A_5 and B_5 are each success rate of developing the precision die and the average die. And C_5 is the failure rate. I_3 is an additional investment for improving technology level, and I_5 is the fixed cost to hire a high skill worker.

Here, sale and purchase refer to respectively out-license and in-license the technology, both of them are shown in the value of patent.

Putting the appropriate options into the four patterns according to their situations, four models will be built as follows.

Model 1 of evaluation and investment in technology development

This model is a model in case of [high-technology, high –skill] and can be shown like Figure 3.

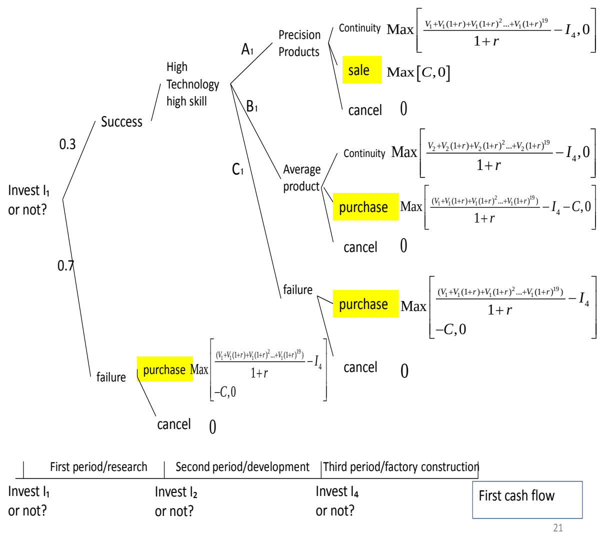

Figure3. Model 1 of evaluation and investment in technology development

In this type, in addition to an alternative as continuity I tried to involve two options of sale and purchasing of technologies, to improve the pre-committed NPV (net present value) as benchmark without options. In Figure 3, C means the value of patents. In considering the case of average quality products, a possibility of purchasing the partial technology can improve the situation from just capability to produce average quality product into capability to produce precision product. , Here, the value of patents C is assumed lower than normal, because of in-license of not complete technology set, but partial technology set.

More specific assumption of percentage numerical value will be explained in detail when proving the validity of the numerical model in later part.

Model 2 of evaluation and investment in technology development

This model is applied in case of [high-technology, low- skill].

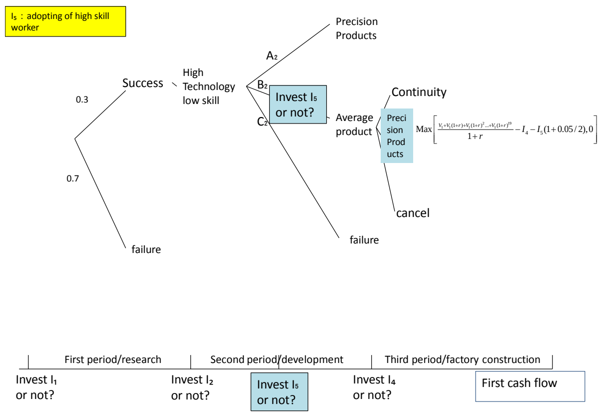

Figure4. Model 2 of evaluation and investment in technology development

The difference from the model 1 is the addition of another option by one and a half years. That is a choice of hiring high skill worker.

This option is assumed to possibly allow change the situation from just a capability to produce average quality product into more improved level to produce precision product.

Model 3 of evaluation and investment in technology development

This model is for a case of [low- technology, high skill].

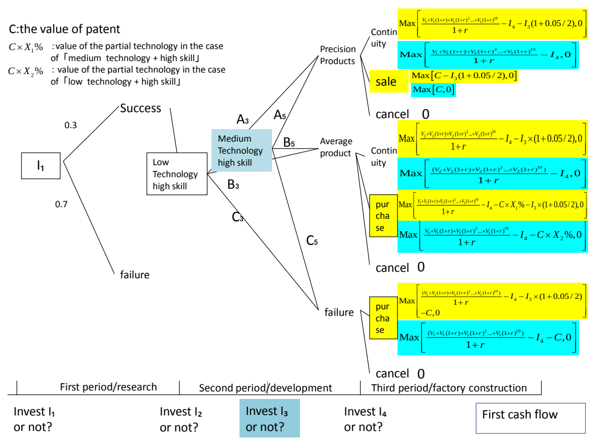

Figure5. Model 3 of evaluation and investment in technology development

The difference from the model 2 is, instead of the option adopting high skill worker, an added assumption of additional investment to improve the technology level from low to medium by one and a half years.

And, at the end of the second year, by purchasing partial technology, can change the situation from just capability to produce average quality product to capability to produce precision product. The value of the partial technology is calculated like $C \times X_1$ and $C \times X_2$ (weight of partial technology: $X_1 < 1$ 、$X_2 < 1$)。

The formula of the calculation of third stage will be increased one more than model 2.

Model 4 of evaluation and investment in technology development

This model is for a case of [low –technology, low- skill].

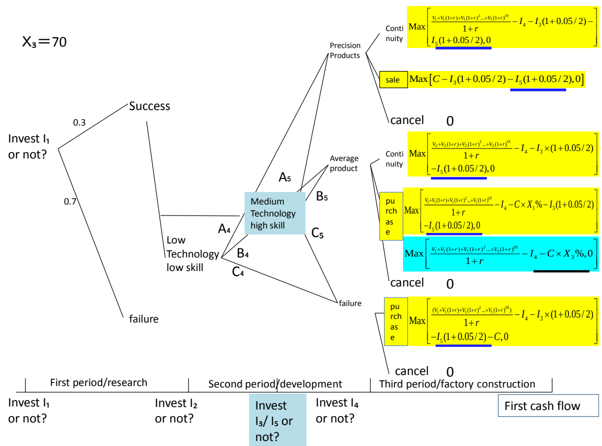

Figure6. Model 4 of evaluation and investment in technology development

The difference from the model 3 is, except the additional investment to improve the technology level from low to medium by one and a half years, an addition of hiring the high skill worker. Therefore there will be a new part in the formula of calculation marked by line in Figure 6.

Validity of the Model of evaluation and investment in technology development

Now use numerical calculation to test the effectiveness of the model.

Table 3: Assumptions (3) of die research and development projects

time	The start of the first year	The start of the second year	By one year and a half		The start of the third year
state	research	development	Improvement	Adopting	Factory construction
investment	2,000	8,000	2,000	500	10,000

(Value: 10 thousands Japanese yen)

Table: 4 Assumptions (4) of die research and development projects

Till development state		Product's value		Risk free rate	Cash flow		
Success probability	Failure probability	Increase	Decrease	5%	Precision Products	Consumer Products	Failure
0.3	0.7	1.1	0.90909		15,000	9,000	0

(Value: 10 thousands Japanese yen)

Here, firstly we start to calculate the success rate and the failure rate of each type of products of each pattern. And also we have to calculate the value of technology which is going to be sold and purchased.

Because of the learning of technical skill we can draw a logarithmic functional curve for worker's skill level like the figure below.

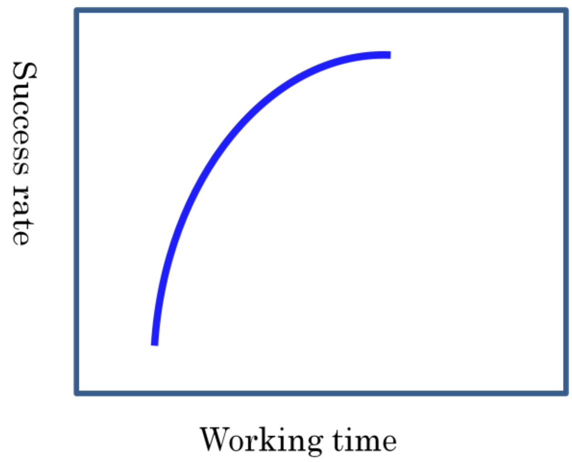

Figure7. Learning curve

The meaning of the curve is that the longer work time means the higher rate of success for developing products.

In the case of die treated in this paper, assumptions mean that the high skill worker has been working for 16years, and the low skill worker has been working for 4 years. According to the learning curve, when they develop the same quality product, the success rate of high skill worker becomes higher than that of the low skill worker.

Using the formula of learning curve I assume that we can calculate the success rate and failure rate of this case as follows:

$y(x) = cp^{a(x)}$, where y(x) = success rate of optional worker,

c= success rate of the worker who has been working 1year,

$a(x) = \log x / \log 2$ = the frequency number doubled from one year of any worker`s working time, as each step with working time like 1, 2, 4, 8 and so on.

P= learning rate of y(2x)/y(x)

Example

Assuming the success rate of worker who has been working 1 year is 0.1, and applying a temporary number of 160% learning curve, we will get the result as follows:

Table: 5 Success rates of workers

Working time x	$y(x)=cp^{a(x)}$	Success rate
Working time1year	$y(1)=0.1\times1.6^{0}$	= 0.1
Working time2 year	$y(2)=0.1\times1.6^{1}$	=0.16
Working time4 year	$y(4)=0.1\times1.6^{2}$	= 0.256
Working time8 year	$y(8)=0.1\times1.6^{3}$	=0.4096
Working time16 year	$y(16)=0.1\times1.6^{4}$	=0. 65536

A_1 = 0.65536

A_2 = 0.256

In the same way we can calculate B_1 and B_2,

B_1 = 0.33879491

B_2 = 0.285696

And we can calculate C_1 and C_2 as below.

(1−0. 256)×0. 384=0. 285696

1−0. 256−0. 285696=0. 458304

(1−0. 65536)×0. 98304=0. 33879491

1−0. 65536−0. 33879491=0. 00584509

C_1 = 0.00584509

C_2 = 0.458304

Repeat the similar calculations to calculate each success and failure rates. And put the result and value of patent (In this study the value of patent is calculated by Black –Scholes formula.) into each model to calculate each NPV (Net present value).

The changes of NPV is summarized by considering flexible decision making for R & D investments, with valuing licensed patent and involving real options like the table below:

Table 6 Changes of NPV with flexible decision making for R & D investments

	Pre-commit NPV	Value of patent calculated by BS Risk hedging by ROA	Value of flexibility		
High tech+ high skill	103,419.5	108,755.7	5,336.2		
High tech+ low skill	48,744.29	65,650.74	16,906.45 (42)	14,869.7468 87.95%	2,036.7032 12.05%
Low tech+ high skill	60,297.51	93,740.37	33,442.86 (43)	30,754.4 91.96%	2,688.46 8.04%
Low tech+ low skill	23,974.37	93,614.8571	69,640.4871(44)	68,581.3971 98.48%	1,059.09 1.52%

Conclusion

Among the four patterns in Table 5,, the change of NPV is the biggest at the case of [low-skill, low-technology], by flexible decision making for R & D investment with real options. In other words, the value of flexibility is the highest, and its 98.48% is come from the risk hedging effects by real options.

.In order to improve the technological competitiveness of Chinese manufacturing SMEs, firstly, it is necessary to evaluate the value of technology which to be in or out-licensed. Secondly, it was founded that NPV was improved, based on such flexibility to risky situations, as the options of technological improvements, recruitment of skilled workers, technology licensing, or the cancellation, or continuing of R & D projects.

Especially for China's die industry, as the level of technology is still low and talented people have not fully been considered seriously so far, so this type of real options analysis is possible to be useful to promote the technological innovation and investment.

References

Copeland, T. & Antikarov, V., *Real Options*, Texere, NY: USA, 2001.

Biography

My name is Ge Gen, I came from the Inner Mongolia of China. On July, 1997, I graduated from the Mongolian Language and Literature Department of Inner Mongolia University. From December, 1997 to August, 2007, I worked at the Huhhot Mongolia middle school, Inner Mongolia, China, as a Chinese teacher. From April, 2008 to March, 2010, I studied at Knowledge and Information Engineering Master's course of Toyohashi University of Technology. From April, 2010 to now, I am currently studying at Electronics and Information Engineering Doctor's course of Toyohashi University of Technology.