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The Role of Flexibility Manufacturing System via Real Option in the Market: A Review

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Abstract : *In our globalization era economic situations are increasingly intense to majorities of manufacturing companies need to consider with manufacturing flexibility via real option. In this paper we illustrated different types of option pricing papers and real option papers related to flexibility manufacturing in order to present which types are considered and which way to use. Furthermore, we also show real option papers to flexibility manufacturing system types according to the Sethi and Sethi's framework. Also, in this article we conclude with advises for some possible future research directions.*

Keywords: *Manufacturing flexibility; Manufacturing flexibility system; Real options; discrete parts manufacturing; Sethi and Sethi's framework*

I. Introduction

Jens Bengsston [1] presented in his research work that flexibility manufacturing system and real options from industrial engineering/production management perspective. He says that flexibility types not considered via real option and also real option without any responsibility flexibility manufacturing types are discussed and identified. Since Black and Scholes [2] and Merton [3] presented their research work on option pricing theory many application areas, e.g. valuing complex security of financial and valuing companies, have been found. Capital budgeting is another part which theory of option pricing has become much and much used, at least by many academics. Many authors see e.g. Trigeorgis [4], have used this theory of option pricing to deal with special features and dilemmas associated with valuation of project contains flexibility which have resulted in a number of many papers concerning valuation of so-called real option. In this paper we will examine some of literature related to theory of option pricing applied on valuation of flexible manufacturing, also real options manufacturing. We will review some of related papers to manufacturing flexibility from industrial engineering or production management perspective. Such as, Sethi and Sethi's [5] survey on flexibility manufacturing system is used. Sethi and Sethi proceed from Brown et al. [6] however a number of manufacturing flexibility types are added and the viewed of Sethi and Sethi very occasionally deviates from that of Browne et al. Gupta and Goyal [7] claim that the definitions of flexibility in Browne et al. are the most comprehensive and use their framework in a survey to classify the literature on manufacturing flexibility. Olhager and West [8] refer to Sethi and Sethi as a literature review on manufacturing flexibility, which covers and systematize the flexibility types linked to flexible manufacturing systems. Thus, the Sethi and Sethi framework based on Browne et al. should be appropriate as a point of departure for a review on and classification of manufacturing flexibility and real options.

II. Pricing Theory

Introduction to option pricing theory

When we talk about option pricing majorities know that, the most commonly used models today are the Black-Scholes[2] model. Theoretically, their value of pricing options have margins error from other assets, because, the price of a company's common shares. Time also plays a large role in option pricing theory, because calculations involve time periods of several years and more. What options are granted to employees of the company have been exported, compared to non-trade requires a different valuation methods. A financial market is a mathematical model was the Black-Scholes formula derived. In 1973 the formula was introduced by three economists led to fast growth in options trading. This formula is used in almost all global hedging markets by sole traders and buyers to determine price of European option, a type of financial security. These type of European options can only be exercised at expiration. The formula has been demonstrated to yield prices very approachable to the discovered market prices. The aims of this part is to present introduction to the foundation of option pricing and some option related concepts that are of importance to the following text. A more thorough introduction can be found in J.C.Hull [9]. The value of call option, and value of put option, at the data of exercise are written as function of the exercise price, *K*, and value of the underlining asset by time, S_t and expressed as in expression below.

For a call: $\max(S_t - K, 0)$

For a put: $\max(K - S_t, 0)$

Where:

S_t-is the price of the underlying at time *t*

K-is strike price

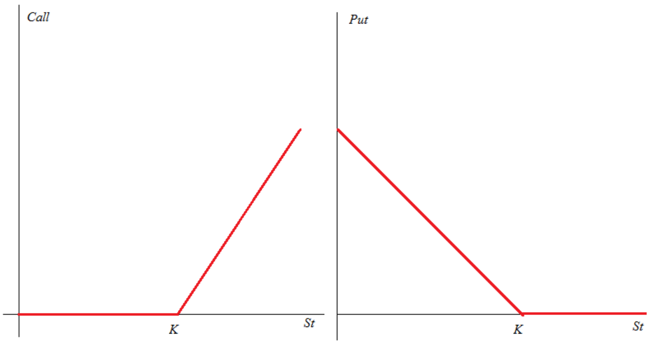

Fig. 1. Payoff from a call and a put option.

The model of stock price behavior used by Black-Scholes[2] and Merton[3]. That means the percentage (%) changes is distributed in the stock price in a short time. Define:

μ : Expected return on stock

σ : Volatility of the stock price

The mean of return in the time Δt is $\mu \Delta t$ and the standard deviation of the return is $\sigma\sqrt{\Delta t}$, so that,

$$\frac{\Delta S}{S} \sim \phi(\mu \Delta t, \sigma^2 \Delta t)$$

Where ΔS the change in stock is price S in time Δt , and $\phi(m, \nu)$ a normal distribution with mean *m* and variance ν .

The model existence that

$$\ln S_T - \ln S_0 \sim \phi[(\mu - \frac{\sigma^2}{2})T, \sigma^2 T]$$

it follows that

$$\ln \frac{S_T}{S_0} \sim \phi[(\mu - \frac{\sigma^2}{2})T, \sigma^2 T]$$

and

$$\ln S_T \sim \phi[\ln S_0 + (\mu - \frac{\sigma^2}{2})T, \sigma^2 T]$$

Where S_T the stock price is at a time *T* and S_0 is the stock price at the time = 0. Equation (6) shows that $\ln S_T$ normally distributed, so that S_T has a lognormal distribution. The mean of $\ln S_T$ is $\ln S_0 + (\mu - \frac{\sigma^2}{2})T$ and the standard deviation equals to $\sigma\sqrt{T}$.

Real option introductions

Our Merton and Black, Scholes and shows their research work, option pricing theory found brand new directions of applications. Differ from financial pricing options theory is appropriate to options established through real opportunities. In this research flexibility manufacturing system is considered and flexibility claims, only has chance however, no obligations. By that means, flexibility can be clarified as different types of options, apart from the pay offs in case of real options and flexibility, is more difficult than the payoff from put

options and call option. In whatever way, in many cases, put and call options can be combined to present required payoff [1]. The traditional approach valuing a potential capital investment as is known as the "net present value" (NPV) approach. The NPV of a project is the present value of its expected future incremental cash flow. Discount quantity used to determine present value is a "risk-adjusted" discount rate, chosen to reflect the risk of the project. Riskiness of project increases, discount is also increases.
Short example: company invest cost is $200 million last 4 years, the expected cash flow per year $50 million, if risk adjusted discount rate 12%, then NPV of investment is:

$$-200+50e^{-0.12x1}+50e^{-0.12x2}+50e^{-0.12x3}+50e^{-0.12x4}=-50.4$$

If NPV is negative, as we just calculated means that project will reduce the value of company its shareholders and should not be undertaken.

If NPV is positive would indicated that the project should be undertaken because it will increase shareholders wealth.

Commonly using involves the capital asset pricing models steps as follows:

- Take the sample of companies main line of business is the same as that of the project being contemplated
- Calculate the bates of the companies and average them to obtain a proxy beta for the project
- Set the required rate of return equals to the risk-free rate plus the proxy beta times excess return of the market portfolio over risk-free rate

One problem with traditional NPV approach is that many projects contain embedded options.

III. Flexibility And Real Options

Components flexibility via real options

According to the Sethi and Sethi's [5] framework, here, we carefully define several different kinds of flexibilities that are reported. These are *machine, material handling, operation* flexibilities. Sethi define these as follows:

- *Machine flexibility* (of a machine) refers to the various types of operations that the machine can perform without requiring a prohibitive effort in switching from one operation to another. In assembly systems, the term machine refers usually to an assembly robot. Types of operations that we have in mind are drilling holes up to ¼ diameter, grinding case-hardened steel to specified tolerances, assembling parts of certain shapes and sizes, etc. Note that we allow these operations to include the specification of the input material, such as its hardness or ductility. With regards to the prohibitive effort, it is usually expressed in terms of time and cost. It would certainly rule out redesigning the machine completely. On the other hand, it might not exclude changing the tools in the tool magazine. The motivation for our definition lies in how useful the definition is in assessing the contribution of the given machine toward the manufacturing flexibility of a system, not yet fully specified and subject to major changes in the long run, of which the machine will become an element. Such an assessment may enable us, for example, to make an informed decision to buy or not to buy the machine
- *Flexibility of a material handling* system is its ability to move different part types efficiently for proper positioning and processing through the manufacturing facility it serves. The definition covers loading and unloading of parts, transporting them from machine to machine, and eventually storing them under varying conditions of the manufacturing facility. define the ability of the material handling system in terms of physical location of each group of machines, the linkages between each pair of groups and between each pair of machines within each group, and the times for every possible move between machines. From these it is possible to define the set of all possible material paths that can be supported in the factory. Peter emphasizes buffer sizes, the ability to accommodate different parts of different shapes and sizes, and the readjustment of paths in case of expansion. The definition also subsumes the pallet fixture flexibility defined by Newman. This flexibility determines the degree of freedom available to part loading schedules.
- *Operation flexibility* of a part refers to its ability to be produced in different ways. Operation flexibility is a property of the part, and means that the part can be produced with alternate process plans, where a process plan means a sequence of operations required to produce the part. An alternative process plan may be obtained by either an interchange or a substitution of certain operations by others. Thus, a part that permits operations to be performed in alternate orders or using different operations (i.e., slurry versus wire brush deburr) in an interchangeable fashion would possess operation flexibility. A process will be considered to have operation flexibility if parts that are being produced in the system possess operation flexibility and if the material handling system is able to deliver parts to machines in different possible orders. The definition of the operation flexibility of a process is consistent with Browne et al. (1984), Maier (1982), and Chatterjee et al. (1987).

The model Kulatilaka [10] present that the value of flexibility within a stochastic dynamic model. Monahan and Smunt [1984] took a similar approach in their study of the flexibility manufacturing system investment decision. They develop a discrete time stochastic dynamic programming model where interest rates and "levels of technology" are assumed to be exogenous and evolving stochastically over time. The proportion of production using flexibility manufacturing system is then chosen so that discounted costs are minimized.

System level of flexibility via real options

Sethi and Sethi's[5] difine 5 flexibility types at this system level, such as: product, process, volume, routing, and expansion flexibility.

- *Product flexibility* is the ease with which new parts can be added or substituted for existing parts. In other words, product flexibility is the ease with which the part mix currently being produced can be changed inexpensively and rapidly. It should be kept in mind that the addition of new parts will invariably involve some setup. This distinguishes product flexibility from process flexibility. What is required for product flexibility is that the setup does not involve inordinate amounts of time and cost. We should also emphasize that the new parts in the definition above cannot be arbitrary; for further clarification, on production flexibility. It is important to note that in Lim's (1987) survey of FMSs in the United Kingdom, 11 out of 12 reporting companies considered flexibility in manufacturing to mean product flexibility.

  In Stulz[17] calculated analytical formulas the European option on the maximum of two risky assets with fixed exercise price is evaluated. Johnson[19] extend Stulz to include several risky assets, i.e. there are several mutually exclusive products that can be produced. Triantis[16] develop two models that evaluate a product flexible manufacturing system under somewhat different circumstances. Kamrad and Ernst[20] consider valuation of multiproduct agreements where demand, delivery schedule, and output prices are known.
- *Process flexibility* of a manufacturing system relates to the set of part types that the system can produce without major setups. This definition is similar to the one in Browne et al. (1984). Another preferred term is mix flexibility used by Gerwin (1982) and Carter (1986). Buzacott (1982) uses the term job flexibility, which relates to the ability of the system to cope with changes in jobs to be processed by the system; Rempp (1982) and Behrbohm (1985) use the term Einsatzflexibilitaet; Freist et al. (1984), Kegg (1984), and Melcher and Booth (1987) use the term part mix flexibility; and Yamashina et al. (1986) call it variant flexibility. Falkner (1986) considers a system to be process-flexible if the manufacturing costs are relatively stable over widely ranging product mixes. The use of the term short-term flexibility by Warnecke and Steinhilper (1982) emphasizes the set of parts that can be produced in the short run.

  Margrabe [12] considers the general option to exchange one risky asset for another. McDonald and Siegel [13] extend Margrabe to include dividends in the case of European options and Carr [14] considers the American exchange option with dividends. Triantis and Hodder [15] develop a model, which evaluates investments in process flexible equipment where profit margins are uncertain, switching between products is free of charge and production decisions are taken at pre-set points in time. The assumption concerning switching cost can also be relaxed to include this cost, see Triantis [15], but adds a great deal of complexity. Triantis [15] also develops a model under perfect competition, no switching cost and when the marginal profit contribution is uncertain. Andreou [16] evaluates a process flexible manufacturing system producing two different products without any switching cost.
- *Routing flexibility* of a manufacturing system is its ability to produce a part by alternate routes through the system. Alternate routes may use different machines, different operations, or different sequences of operations. Typically, these different machines (e.g., lathe and milling machines or two brands of grinders) are those capable of essentially the same processes. It should be noted that routing flexibility is different from operation flexibility in the sense that the former is the property of a system while the latter is that of a part. Even a part with a single specified operations sequence, i.e., no operation flexibility, may still be processed using different routes through the system. It is also different from the material handling flexibility, which is the property of a specific component of the system. Thus, with the existing material handling subsystem, only some of the routes, by which it is possible to produce a part under a universal subsystem, may be feasible.
- *Volume flexibility* of a manufacturing system is its ability to be operated profitably at different overall output levels. Note that only feasible output levels are under consideration here. This definition is similar to the ones in Browne et al. (1984), Gerwin (1982), Maier (1982), Behrbohm (1985), Freist et al. (1984), and Kegg (1984). It is also similar to the demand flexibility of Son and Park (1987). Volume flexibility has some degree of interchangeability with Slack's (1987) delivery flexibility--the ability to change planned or assumed delivery dates. Bengtsson [21] considers the value of having the option to hire personnel on short contracts when demand of a product or aggregated demand is uncertain, i.e. one source of uncertainty is considered.
- *Expansion flexibility* of a manufacturing system is the ease with which its capacity and capability can be increased when needed. The capacity is in terms of output rate per unit time, whereas capability refers to such characteristics as quality, the technological state, other types of flexibilities, etc. Note that in contrast

with volume flexibility, expansion flexibility is concerned with capacity, i.e., the maximum feasible output level. Expansion flexibility makes it easier to replace or add machinery by providing for such possibilities in the original design. Ease in this connection refers to the overall effort needed for the expansion. It would include the direct cost, the indirect cost of interruption in production because of the expansion, and the speed with which the expansion can be accomplished. Trigeorgis [4] considers the option to expand when an investment decision is made and where the underlying value of the project is uncertain. Pindyck [22] does not explicitly address the problem of valuing expansion flexibility. He and Pindyck [23] use the same approach as Pindyck [22] but extend the analysis to include flexible capacity and compare this to the situation when only dedicated equipment is used.

IV. Sethi And Sethi's Framework

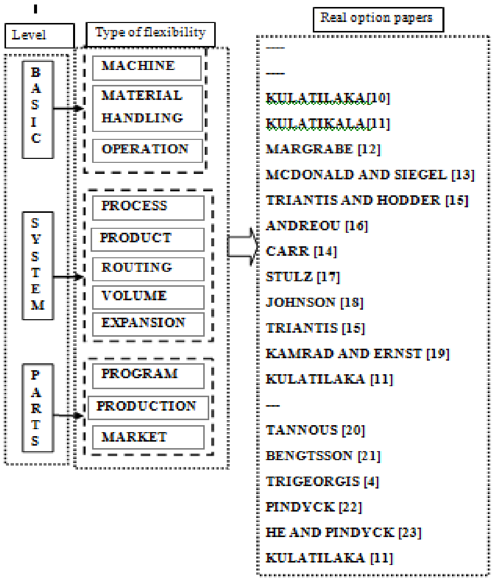

Table 1. Flexibility types to Sethi and Sethi's framework

V. Conclusion

In this paper, flexibility in terms of real options is investigated from an industrial engineering and product management perspective. Then, Option pricing theory has wide applicability in corporate finance and we have explored a wide range of these applications. We began with a discussion of some of the measurement issues that make the pricing of real options more difficult than the pricing of options on financial assets.

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