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FLEXIBLE MANUFACTURING SYSTEM INVESTMENTS AND REAL OPTIONS

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Abstract: *In today´s dynamic and uncertain business environments it is necessary to have the ability to react to changes in market conditions. Companies have to learn how to operate effectively in a dynamic production environment it means to be able to respond on changes of product and process technologies. Flexible manufacturing systems have been considered to be essential for successful future of the company. The paper focuses on methodology for valuing flexibility of flexible manufacturing systems. An Illustrative example of the application of the real options methodology for switch operating modes is presented.*
Key words: *real options, flexible manufacturing systems, capital budgeting, production management*

1. INTRODUCTION

The main goal of this article is to show how to use real option theoretic approach to the modeling and analysis the uncertainty in flexible manufacturing systems.

This paper will be structured as follows. First, we look at the different levels of flexibility. Second, we introduce option pricing and analytical valuation framework for switching options. In intention of an illustrative example is to show the application of the options methodology in flexible manufacturing system and find optimal technology to use (X or Y) at each decison node. Finally, the concluding remarks are presented.

2. FLEXIBLE MANUFACTURING SYSTEMS EVALUATION – A REAL OPTIONS PERSPECTIVE

One of the problems challenging managers is deciding how much to spend for flexible manufacturing system.

2.2 Flexible manufacturing systems

According to Karsak and Ozogul (2002) a flexible manufacturing system FMS can be defined as a production system consisting of numerically controlled machine interconnected by a transport system. These machines and the transport system are under centralized computer control. In other words flexibility is ability of the system to respond to changes quickly and economically. Flexibility forms an important part of the company´s competitive strength. Flexibility is significant for the future investment decision-making of manufacturing systems that should adapt to the changing environment. Sethi and Sethi (1990) provide a comprehensive classification of flexibility in flexible manufacturing systems and define eleven types of flexibility as follows in Fig. 1.:

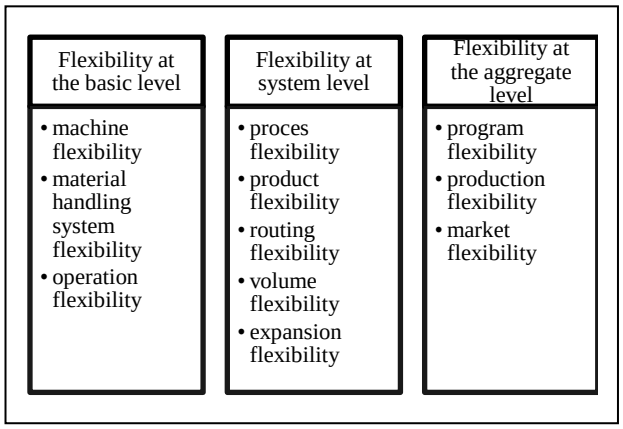

Fig. 1. Flexibility and real options

It is evident that companies have to determine the types of flexibility that are of highest concern to their competitive advantage.

2.1 Real options methodology

In recent decades a lot of financial analysis and economic valuation methods have been developed and succesfully applied in support in capital budgeting. Typical approaches to estimate costs and values associated with a project are based on discounted cash flows analysis, especially Net present value (NPV), Internal Rate of Return (IRR), Return On Investment (ROI).

Today´s competitive environment requires a decision support tool that takes into account risk and dynamic framework. Gerwin (1993) presented flexibility as an investment that generates options for a firm. The real-options-based valuation can be considered as suplement that fills the gaps that DCF cannot address. Copeland and Antikarov (2003) defined real options as the right, but not the obligation, to take an action at a predermined cost called the exercise price, for a pretermined period of time-the life of the option. Zmeskal (2007) considers real otpion metodology as one of the new conceptions used and verified in the corporate finance that presents the generalisation of well-known previous corporate finance approaches. The techniques for estimating the value of real options is based on the financial options metodology and applied on real assets. Comparing with traditional approaches, active measures in the future are considered in real projects managing. It means that decision makers can abandon project, change of the technological process, temporarily shut down production, etc. Zmeskal (2007).

This approach can be understood like a complement of traditional techniques. The Expanded (strategic) NPV can be viewed by Trigeorgies (1996) as a sum of the traditional NPV and option value.

3. MEASURING FLEXIBILITY IN INVESTMENT DECISIONS

Option pricing involve three step proces:

- Calculate potential future prices of the underlying asset at expiry - the binomial pricing model maps out the binomial tree for calculating possible prices of options. The binomial model is used for estimate the value of swiching options that give their owner the right between two modes of operation at a fixed cost presents Copeland (2003). It assumes that underlying security prices can only either increase by *u* or decrease by *d* with time until the option expires worthless.
- Estimate the value of the payoff of the option (V_N) at expiry for each of the potential underlying prices – it is the difference between the price (S_N) and the required investment (X):

$$V_N = \max(S_N - X, 0) \quad (1)$$

- Discount the payoffs back to today to determine the option price today. It means discounted product of probability for up movements (*p*) and additional cash payoff from switching from technology X to Y (S_u) plus product of probability of down movements *(1-p*) and additional cash payoff (S_d) by risk-free interest rate. The value of the option to switch $S_N(X \rightarrow Y)$ from X to Y is given by:

$$S_N(X \rightarrow Y) = \frac{pS_u(X \rightarrow Y) + (1-p)S_d(X \rightarrow Y)}{1+r} \quad (2)$$

The risk-neutral probability expresses formula:

$$p = \frac{1+r-d}{u-d} \quad (3)$$

4. ILLUSTRATIVE EXAMPLE OF MANUFACTURING FLEXIBILITY VALUATION

To illustrate the economics of switching options, consider a manufacturing company analyzing flexibility to switch between two alternative technology, X and Y. Suppose that machine with rigid technology X generate the cash flow = CZK 95 million, each period it is equally likely to grow by a factor of either u = 1,8 or d = 0,6 and the other with technology Y generate cash flow = CZK 75 million that increasing by u = 1,5 and falling to d = 0,8 of its earlier value. The present value of cash flow from each technogoly can be obtained by discounting the risk-free interest rate 8 %. The risk neutral probabilitiy is p = 0,4 for up movements and 1-p = 0,6 for down movements in each period. To simplify we suppose no switching costs. Flexibility values for every initial mode are put in Tab. 1.

Value / year	0	1	2	Flexible system X/Y
Technology X	95	95	95	290,9
Option (X-Y)	0	1,7	4,3	
Technology Y	75	75	75	290,9
Option (X-Y)	20	21,7	24,3	

Tab. 1. Value for each rigid machine (X and Y) and for the flexible system X/Y

Calculated results show the present value of each technology with flexible modes. To sumarizes the value of flexible system X/Y it is evident that cash flows in each period are higher of those from the two rigid technologies. The final result presents not only the correct valuation of flexible system that allows a manufacturing system to adapt to future production requirements but an optimal survey for execution of the switching options. The results also confirm that in absence of switching cost the expanded NPV that incorporates the value of the option to switch of both systems is equal.

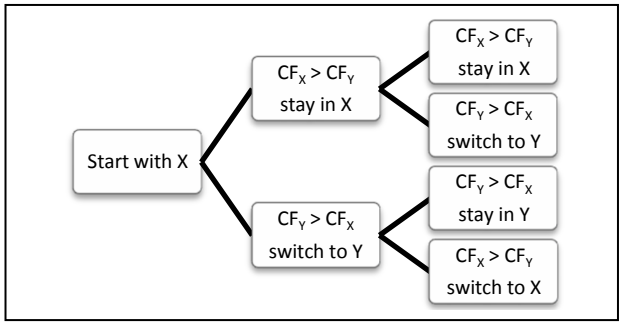

Fig. 2.The general optimal technology to use (X and Y) at each decision node

The optimal technology to use at each decision node is show above in Fig. 2. The decision tree captures the general way how to decide by switching between two rigid technologies.

5. CONCLUSION

Real options are valuable for manufacturing companies in the situations of high uncertainty where is necessary to operate with flexibility in investment decisions. The approach described in this paper provides a solution to integrate real options analysis into evaluation of flexible manufacturing systems. The purpose of the paper was to describe, explain and apply real option methodology in flexible manufacturing system. To show the general optiomal technology to use at each decision node was designed scheme of decision tree for accessibility of decision-making between switching of two technologies. On the basis of the results it was recommended to implement flexible system X/Y that allows management to switch between rigid technologies. Usefulness and motivation of model application of real options consists in doing more realistic decision-making, see Zmeskal (2007).

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