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COMPARISON BETWEEN PORTFOLIOS OF REAL OPTIONS AND PORTFOLIOS OF FINANCIAL OPTIONS

Summary: The article aims to compare portfolios of financial and real options. First of all, a definition and classification of real options is presented. Secondary, the theory of Markowitz portfolio is introduced and compared with the theory of portfolio of real options. This analysis results in showing the differences between real and financial options.

Keywords: portfolio of options, real options analysis, financial option analysis.

1. Introduction

The world changes offer a lot of possibilities when it comes to new investments. Therefore, an investment can alter because of the market situation; for instance, it can be expanded, differed or abandoned. These different decision opportunities imply that one investment provides plenty of scenarios. These decision alternatives regarding an investment are called real options. Options can be valued by means of portfolio analysis which is also implied for financial assets. The article presents how portfolios of real options differ from financial portfolios and how they can be managed. First of all, the definition of real options is presented and a simple classification of basic options is provided. Secondly, after the theory of traditional financial portfolio analysis is explained, the introduction of the real option portfolio follows. The aim of this paper is to present the differences between financial and real options. This work can be seen as a support for the approach of real option valuation of projects.

2. Real options definition and classification

The definition of "real options" was formulated by Myers in 1977. According to him, "real options" are "opportunities to purchase real assets on possibly favorable terms" [Myers 1977, p. 163]. A more precise definition was coined by Sick, who

defines a real option as "the flexibility a manager has for making decisions about real assets" [Sick 1995 p. 631]. When buying an option a right, but not an obligation to make certain decisions regarding the real asset is acquired. In other words, a real option is a right – not an obligation – to take an action (e.g. abandoning, expanding or contracting a project or even deferring a decision) on a project at a predetermined price on or before a predetermined date [Kodukula, Papudesu 2006, p. 3]. The right that an action can be taken is called flexibility [Copeland, Koller, Murrin 2000, p. 396]. The flexibility which is embedded in a project can make it more attractive and more likely to accept.

The options can be classified into five categories:

- **Option to abandon (abandonment option):** This option implies that an investment (project) can be sold or abandoned. From the financial point of view, it can be compared to American put. If the investment did not occur to be successful at the end of the first period, management may have abandoned the project and realize the expected liquidation value. The expected liquidation value of the investment may be identified as the exercise price of the put. When the present value of the investment falls below the liquidation value, the act of abandoning the project is equivalent to exercising the put. Moreover, an investment that offers a possibility to abandonment is worth more than the same project without this possibility.
- **Option to defer (deferral option):** The option to defer an investment to develop is the same as an American call option on the stock. This option refers to defer the investment in order to start it when appropriate market conditions arise. The expected development cost may be thought of as the exercise price of the call.
- **Option to expand or contract:** Like option to defer, the option to expand the scale of a project is equivalent to an American call option on the stock. The expansion option gives decision makers the right, but not the obligation, to make additional investments if the project occurs to be more successful than it was anticipated at the beginning. In contrary to the option to expand, the option to contract enables to reduce the scale of operations and save costs if the underlying asset develops below expectations.
- **Option to extend or shorten:** It is possible to extend the life of a project by paying a certain amount of money (an exercise price). On the other hand, it is possible to shorten the life of an asset. The option to extend is a call, while the option to shorten is a put.
- **Option to scope up or scope down:** Scope is the number of activities that the project is consisted of. This option gives the opportunity to switch among given alternatives at a decision point in the future. Scope is similar to diversification. The reason for that is the fact that sometimes (at a higher exercise cost) it is better to have the possibility to choose among a wide range of alternatives. Buying the scope up option is a call.

3. Financial portfolio theory

Management's goal is to maximize shareholder value. Considering the portfolio analysis, the goal is to develop a portfolio in order to maximize its return at whatever risk the investor regards as appropriate. Not only do the high expected returns of the assets determine which asset should be chosen to the portfolio, but also the correlation between them in the portfolio counts as well.

In the 1950s portfolio theory was discovered and developed by Harry Markowitz, who formed the foundation of modern finance [Norstad 1999, p. 2]. In the financial portfolio analysis the concept of diversification is of significant importance. Diversification is crucial for the creation of an efficient investment because it gives the opportunity to reduce the variability of returns around the expected return. Markowitz diversification may be defined as a combination of assets that are less than perfectly correlated in order to reduce portfolio risk without sacrificing portfolio returns [Francis 1991, p. 234]. Diversification should be increased as long as marginal benefits exceed marginal costs [Statmen 1987, p. 354].

From Markowiz's theories the definition of "efficient portfolio" can be derived. "Efficient portfolio" is any asset or combination of assets that has the maximum expected return in its risk class or the minimum risk at its level of expected return [Francis 1991, p. 236]. The group of efficient portfolios is called the efficient set of portfolios. The efficient set of portfolios determines the "efficient frontier". The efficient frontier is the locus of points in risk-return space having the maximum return at each risk class (see Figure 1). The portfolios on efficient frontier are better than all other investments. In other words, the theory of efficient portfolio assumes that at a given level of risk, only the largest returns will be chosen by a rational investor. If a portfolio is efficient, then there is no possibility to construct a portfolio with the same, or a better level, of expected return and a lower volatility. This means that such a portfolio cannot further be diversified to increase the expected rate of return without accepting a greater amount of risk.

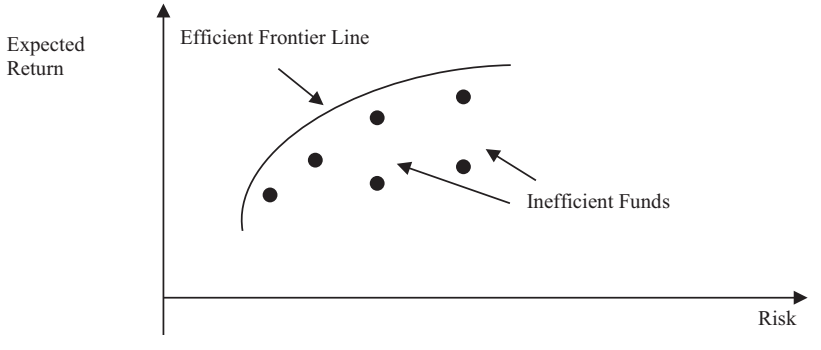

Figure 1. Portfolios along the efficient frontier are called optimal portfolios

Source: [Schulmerich 2012, p. 2].

The approach of Markowitz, who established a relationship between risk and expected return in a portfolio context, identifies the optimal portfolio configuration for an investor in a one-period decision problem with the objective to optimally allocate a given amount of money to a portfolio of risky assets. This approach is called "mean-variance analysis". The key notion of the mean-variance approach is the concept of diversification. Diversification can reduce risk without affecting expected portfolio return. The conclusion is that the individual risk of an asset is not as important as its contribution to the risk of the entire portfolio. The risk for a well diversified portfolio is captured by covariance, the correlation of the individual asset with the overall portfolio [Francis 1991, p. 232].

4. Portfolios of real options

Companies create investment programs which are based on current investment opportunities. Such a program can be defined as a portfolio. Neftci refers to a portfolio as "a particular combination of assets in question" [Neftci 2000, p. 17]. According to Rainer Brosch, "portfolios of real options are combinations of multiple risky assets and multiple real options written on these assets subject to constrains" [Brosch 2008, p. 12]. Constraints mentioned in the definition can refer to constrained resources, e.g. funds or uncertain market conditions.

The basic real option portfolios presented in the literature are: switching options, compound options and rainbow options. Most common are portfolios of real options which consist of switching options [Kodukula, Papudesu 2006, p. 187]. The option to switch project operations is a portfolio of options that includes both calls and puts. A switching option gives the flexibility of being able to switch resources, assets or technology in the future [Mun 2003, p. 178]. Moreover, a project with operations that can be turned on and off or switched between two different locations is more valuable than the same project without the opportunity to switch. When a project is shut down, restarting operations is the same as an American call option. Closing down operations when unfavorable conditions arrive is equivalent to an American put option. Exercise price of the call (or put) will be the cost of restarting (or shutting down) operations. An example of this kind of option may be a flexible manufacturing system with the ability to produce two products.

Compound options can be considered as options on options. Exercising one option generates another; therefore, the value of one option relies on the value of another one and the relation between them [Rogowski (Ed.) 2008, pp. 91–92]. A good example of this option is an investment from which distinct stages of development can be distinguished. A research program can be created as a sequence of real options, each depended on those that precede it. Other examples are: new product launches, exploration of oil fields. A compound option can be either sequential or parallel (simultaneous). A sequential option is considered as a situation when exercising option gives the opportunity to create another one. For instance, acquiring a license

gives the possibility to start the production. Considering a parallel option, both options are available at the same time [Kodukula, Papudesu 2006, p. 146].

In the case of multiple sources of uncertainty, real options are called rainbow options, and due to that they can use different volatility factors. An example of a rainbow option can be an exploration of natural resources like oil reserves. Technological and market uncertainty can be determined as two sources of uncertainty in most research and development (R&D) programs. Market uncertainty can be described as the evolution of the product's price from a value that is relatively well known today, to less certain values that are affected by the market conditions as well as other uncertain influences in the future. Therefore, market uncertainty increases with time. On the other hand, technological uncertainty is reduced over time by constant research until the knowledge about a product and capabilities are acquired.

Most of the literature focuses on the interactions between the options, for example, compound options, rainbow options or synergies between projects, while according to R. Brosch a more systematic approach to portfolio of real options which would include budget constraints, has been lacking so far. R. Brosch provides a theory that within a portfolio projects can be interdependent for direct and indirect reasons. Direct qualitative interactions derive from an investment plan or result from interactions with investment already undertaken and still generating cash flows. Direct qualitative interactions do not result from stochastic relationships, but from physical properties of the projects. This is why they cannot be avoided with the usage of diversification. The following types of projects can be a good example: substitutive, complementary or synergies (positive or negative) projects. On the other hand, indirect qualitative interactions constraints have their origin beyond the investment plan. They are called indirect because of the fact that they are not connected to investment opportunities. On the contrary, these constraints refer to investment decisions [Brosch 2008, pp. 34–35].

5. Financial portfolios vs. portfolios of real options

There are several differences in financial and real options portfolios. The main are: additive and non-additive character, passive and active attitude towards risk, static and dynamic view. When it comes to the financial portfolio perspective, a set of underlying assets is considered simultaneously. Two separate financial options, e.g. to buy stock of company A and company B are independent from one another. That is the reason why they can be treated separately while considering the portfolio view. It is essential to mention that such a portfolio will have an additive character. In contrast, real option interactions are much complex. According to R. Brosch, portfolio interactions on the real options level and on the real asset level can be distinguished (see Figure 2).

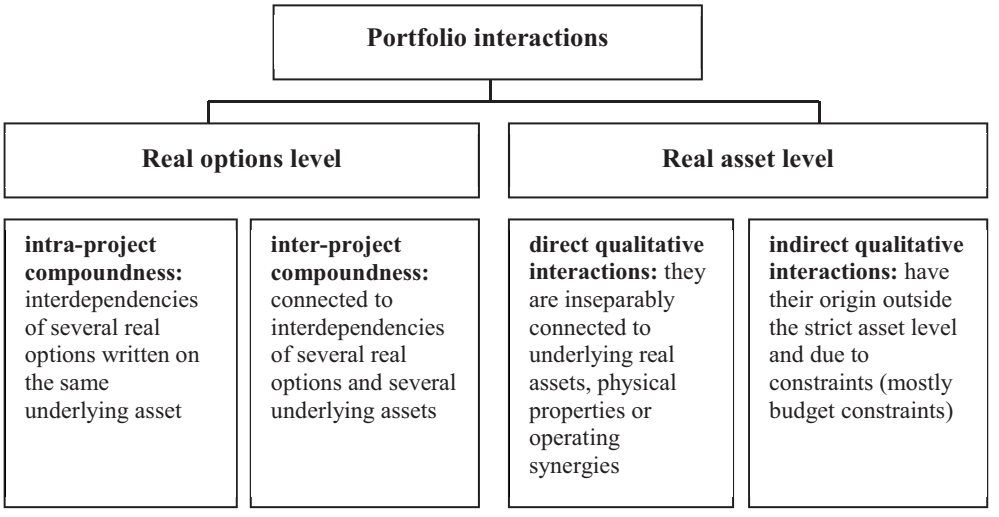

Figure 2. Portfolio interactions

Source: [Brosch 2008, pp. 34–35, 50–51].

Real options on the same underlying asset interact in an intrinsic way, which is the reason why they cannot be valued independently from one another, but should be modeled as a compound option. The value of portfolio of real options written on the same underlying asset does not equal the sum of the simple options it is composed of [Rogowski (Ed.) 2008, p. 92]. The reason for that is the fact that the options on the same underlying assets within a portfolio interact with one another. Interactions may have different forms: partial if there are simultaneously positive or negative synergies in projects or binary if projects are mutual exclusive or depend on one another [Brosch 2008, p. 52]. Valuation of these interacting real options must be conducted by the valuation of all the real options and underlying asset as a whole, which is similar in structure to valuing a compound option. The reason for that is the fact that options on the same real assets are linked through this asset. By exercising any option the underlying asset is affected and with it, all other options tied to it. A good example is the option to abandon: by exercising it, all subsequent options are gone. Moreover, the portfolio value depends on the order in which options are exercised. This indicates that when the number of options within a portfolio exceeds two an optimal order of option execution should be chosen by the management [Smith 2004, p. 2].

As mentioned previously, for the financial portfolio theory diversification is a core concept. However, considering the real options analysis this perspective is not valid because for real options the notion of risk is different from risk for financial options. The notion of risk for portfolios of real options differs from the understanding of risk (volatility) in the financial portfolio perspective. From the point

of view of real options, risk can be also positive because it can be an opportunity to earn more money. Moreover, when it comes to option pricing, total volatility is essential and option prices usually increase with higher volatility. Therefore, any risk's diversification of the portfolio and reduction of its volatility causes reduction of option values. The financial portfolio theory created by Markowitz [1952] has a passive attitude towards risk because it consists of diversifying the risk as many assets as possible. The approach of portfolio of real options refuses the passive perspective on risk for portfolios of real options. Real options can be exercised when market conditions are desirable, as a result, they can protect from undesirable movements [Copeland, Koller, Murrin 2000, p. 395]. By designing an optimal portfolio of real options, risk is managed actively by an optimal sequence of options which execute certain decisions. Due to that real options can be a resolution for uncertainty on the market. When the structure of possible portfolio configurations is to be determined, diversification is pertinent.

When it comes to real options, an asymmetry in return can be distinguished. Good results which are expected can be leveraged, the bad while predicted can be eliminated and the company can adjust the project to the market conditions. Moreover, the symmetry involved in real options fundamentally affects the distribution of returns. Therefore, it cannot be described sufficiently by mean-variance analysis.

The Markowitz portfolio selection problem is a static model, because it considers a single-period decision problem. This concept can be the foundation of the analysis of portfolios of real options [Rogowski (Ed.) 2008, p. 27]. However, some assumptions like perfect capital markets are restrictive for the problem of constructing a real options portfolio. First of all, options being asymmetric contracts cannot be analyzed with the use of mean-variance perspective. On the contrary, a portfolio of real options has a dynamic character, because a dynamic interaction between the elements of the portfolio occurs. This portfolio perspective on real options is a fundamental way to handle correlation between decisions over time in a proper way.

6. Conclusion

Although the analysis of portfolios of real options in literature is limited, the concept of real option's portfolios seems to be crucial for investment valuation. Nowadays the decision problems are characterized by compounders and interactions which are caused by special features of the decision problem, such as the parallel or sequential development of some projects, for example, strategies of R&D projects. To sum up, the main differences between the portfolios of financial and real options are: static and dynamic view, additive and non-additive character, different attitude towards risk. In spite of the mentioned differences between the both kind of options, the same valuation methods are applied to them.

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PORÓWNANIE PORTFELA OPCJI FINANSOWYCH I OPCJI REALNYCH (RZECZOWYCH)

Streszczenie: Artykuł ma na celu porównanie portfeli opcji finansowych i rzeczowych. Na początku została przedstawiona definicja i klasyfikacja opcji realnych. Następnie, po przedstawieniu klasycznej teorii portfela finansowego Markowitza, omówiono założenia portfela opcji realnych. Zaprezentowanie wyżej wymienionych zagadnień dało podstawę do określenia najbardziej charakterystycznych różnic między portfelem opcji realnych i finansowych oraz reakcji w nim zachodzących.

Słowa kluczowe: opcje finansowe, opcje realne, portfel opcji.