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New Product Development Process Valuation using Compound Options with Type-2 Fuzzy Numbers

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Abstract—**Introducing new products is a key factor for the success and survival of companies. Managers need to examine every possibility that can occur during the life span of their new product and focus on the right strategy. Even then, launching a new product is highly risky due to uncertainties of the market and competitors. Traditional discounted cash flow models have some major disadvantages, and they underestimate the value of investments. This study presents a proposal of real option evaluation through fuzzy logic for a new product development project in a retail banking market with Type-2 fuzzy sets. A multi-stage new product development is used to have a better understanding of the long term success of the project. Compound options with the solution method based on Black-Scholes method in a fuzzy form is offered also in this study. This technique is mostly suitable for managerial flexibility decisions. In this paper different from the literature compound options and Type-2 fuzzy numbers are combined to cope with uncertainties of the practice. Finally, a numerical analysis is presented to demonstrate the compound option pricing under fuzzy environment. The chosen bank is a Netherland origin multinational bank who got into the Turkish market in the last decade and the product of the project is a saving account that supports the bank's vision. The main challenge for this bank is the adjustment of this new market and its vagueness.**

Index Terms—**Real Options, Type-2 Fuzzy Sets, Multi-Stage Project Evaluation, New Product Development, Compound Options.**

I. Introduction

CAPITAL investment decision-making is crucial for long-term success of the corporations [1]. Introducing new products is critical for survival of companies and making of a decision to invest is a multi-stage interactive process which includes certain stages such as; idea generation, business analysis, testing, commercialisation, and improvement. Especially for retail banking, it is highly risky due to the amount of money, reputation and credibility.

Retail banking refers to the customer-oriented services offered by commercial banks. These services include saving accounts, mortgages, loans and investment products. Most commercial bank's goal is to reach a wider consumer base. Launching new products to the target audience serves this purpose if they have right marketing strategy and timing.

Managers need to intensify proper strategy, though during the lifecycle of any new product they had to explore every possibility that should arise in the future. Even so, market uncertainties and rivals' moves riskify launching of a new product. Once new product is on the market, customer experiences and feedbacks are great ways to develop new ideas and going further. The Bank (hereafter) considers releasing a new saving account, which support their vision. This new product offers a high interest rate for customers; it requires the use of their deposit accounts and credit cards. Fluctuation in the market, entrance of new competitors and similar products make it hard to see the profit of the product, and to decide the strategy.

These uncertainties are inadequate to be represented by crisp values and traditional methods are inadequate to solve real life problems. Our study touches a field that very few academicians have explored. Practitioners excessively used the net present value (NPV) to evaluate project investments. Given that, the real world is characterised by change, uncertainty and competitive interactions, these methods are ineligible to have the best perspective. Traditional models have some major disadvantages, and they underestimate the value of investments.

While these traditional techniques make implicit assumptions, the real options theory focus on managerial flexibility and uncertainty of real world management decisions. Many aspects of investment decision-making problems are similar to real options. Businesses usually have the option to make an investment but they are not obliged to do so but they can defer, expand, abandon, or put-on-hold a project. This flexibility of real options does add significant value to potential projects and this value grows as the volatility of potential project cash flows grow [2]. It reflects synergies that NPV misses [3].

Real asset investment's NPV = Estimated cash flows' NPV + option values.

In the literature, there is an extensive diversity of assessment models that approach to find the worth of an investment. Copeland and Antikarov [2] present a computer based model that helps evaluating real options. Dixit and Pindyck [4] study switch options to reach optimal solution and the others give several examples on the topic. Common features in capital investment projects are uncertainty, irreversibility and flexibility. Real options theory has been used in many industries, and various application fields. New product introduction constitute 36.2 % of researches (Table I) [5]. This application area is well suited to real option approach with the lack of information on the market and on competitors. Vagueness and high risk are the main properties of new product development projects and also by the reason that it requires high investment cost at the beginning of the project.

As real options and fuzzy logic have been widely used to provide framework to deal with uncertain project parameters or to handle the lack of certainty in data. Distinct from the crisp parameters used in real options theory, real options' fuzzy evaluations approve fuzzy parameters and practitioners

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TABLE I
APPLICATION FIELDS OF REAL OPTIONS [5]

Application fields	Used by
New product introduction	36.2 %
Research & Development	27.8 %
Mergers and acquisitions	22.1 %
Foreign investment	9.6 %
Other	4.3 %

can detect objectively real options embedded in projects.

Various real option assessment methods come into view in the literature to declare assessment problems under ambiguity. Thavaneswaran et. al. presented a volatility model with fuzzy sets theory [6]. Nowak and Romaniuk presented a technique grounded on stochastic examination for option pricing using fuzzy sets [7]. Quadratic adaptive fuzzy numbers based Black-Scholes model is introduced by Thiagarajah et al. [8]. Hsien-Chung Wu [9] considered volatility, interest rate and stock price in fuzzy form to generate the pricing boundaries of the European call and put options using Black-Scholes formula. In this manner, Lee and Lee [10] used a fuzzy approach to evaluate RFID investments. They chose Black-Scholes' method to accomplish supply chain decisions with real options embedded inside.

A fuzzified adaptation of the Black-Scholes technique is utilized by Cherubini [11]. Black-Scholes method was also used by Benaroch and Kauffman to evaluate projects for an electronic banking network in New England [12]. Ghaziri et al. presented artificial intelligence as a way to price options and used fuzzy logic [13]. Carlsson and Fuller studied real options with fuzzy logic where present values of costs and expected cash flows were represented by trapezoidal fuzzy numbers [14]. In their paper they tried to find the optimal exercise time of the option and how long an investment can be postponed. Li, Qu and Feng used a two stages investment decision making model with real options techniques. They tried to estimate the flexible and optimal investment value in present market risk. This approach provided great support for short-term investment decision-making [15]. Collan et al. introduced a technique that evaluates and analyzes real options, costs and revenues those are also presented as fuzzy numbers to estimate expected future pay-off [16].

In real world, a capital investment project can be split into many stages. This segmentation reduces risks of the project. Childs and Triantis presented a model of dynamic R&D investment which underlines the interactions across projects in their study[17]. In the real market, due to market fluctuations and human errors, information cannot be collected precisely. The literature on option pricing under the fuzzy environment studies the European option and based on the Black-Scholes formula. For example, Yoshida used fuzzy logic in a stochastic model for European options [18]. Wu (2007) transformed the Black-Scholes formula to a fuzzy model by using interest rate, volatility, and stock price as fuzzy numbers [9].

The structure of a compound option is an option on another. The exercise payoff of a compound option includes the value of the other option. This type of combined options has more than one expiration date and strike price.

Type-1 fuzzy set is an extension of the concept of an ordinary set. Whereupon Type-2 fuzzy set is an extension of Type-1 fuzzy set that has grade of membership which is itself fuzzy also. In Type-2 fuzzy set the membership function is three-dimensional, and the third one is for coping with new degrees of freedom. In vague computing Type-2 fuzzy sets are expedient in conditions where it is hard to establish the precise membership function for a fuzzy set. Type-2 fuzzy set provides an occasion to model levels of vagueness which traditional fuzzy set logic (Type-1) strive for. In literature, there exists various types of Type-2 fuzzy membership functions, i.e. gaussian, triangular, trapezoidal, etc. Additionally Type-2 fuzzy set has been used with the problems such as clustering to provide a simple tool that allows resolution of uncertainty in complex problems.

This study presents a proposal of real option evaluations through Type-2 fuzzy logic. The technique is performed in a multi-stage approach because of managerial reasons of the bank and upper-lower bounds are traced for a better understanding of the possibilities. Finally, a numerical analysis presents the compound option pricing under fuzzy environment. Project will be divided into two stages in order to observe the success of the new product. And the essential variable of options, volatility, is decided as the main uncertainty of the project.

This paper is formed of five sections and organized as follows. In the following section, Type-2 fuzzy sets are explained in detail. In section 3, compound real options theory with Type-2 fuzzy numbers will be presented. A real case application in banking sector will be introduced in section four. Then, finally in section 5, we will conclude the study with findings of our approach and suggest future research directions.

II. TYPE-2 FUZZY SETS

Fuzzy set was first introduced by Zadeh to deal with vagueness of data and information processing [19]. In this logic, each component is mapped to [0,1] by membership function.

$$\mu_{\tilde{A}}: X \rightarrow [0,1] \tag{1}$$

where [0,1] presents real numbers between 0 and 1 (including 0 and 1). It is defined that a fuzzy set i.e. a type-n fuzzy set, with n=1,2,3,..., $(n-1)$, n if its membership function line up over fuzzy set of type n-1.

While for type-1 fuzzy sets, membership functions are definite and ranges over [0, 1], for Type-2 fuzzy sets, membership functions those are themselves vague and fuzzy. Type-2 fuzzy sets were acquainted by Zadeh also, as an extension of type-1 fuzzy sets [20]. To model vagueness and impreciseness in a better style Type-2 fuzzy sets are utilized. On purpose to expand the fuzziness, a Type-2 fuzzy set $\tilde{\tilde{A}}$ denoted by Mendel et al. [21] might be used. $\tilde{\tilde{A}}$ called Type-2 fuzzy set in the universal oration X might be displayed by a Type-2 membership function shown $\mu_{\tilde{\tilde{A}}}$, as below:

$$\tilde{\tilde{A}} = \left\{ \left((x,u), \mu_{\tilde{\tilde{A}}}(x,u) \right) | \forall x \in X, \forall u \in J_x \subseteq [0,1] \right\} \tag{2}$$

where J_x denotes an interval in $[0,1]$. The Type-2 fuzzy set $\tilde{\tilde{A}}$ also can be interpreted as follows:

$$\tilde{\tilde{A}} = \int_{x \in X} \int_{u \in J_x} \mu_{\tilde{\tilde{A}}}(x,u)/(x,u) \tag{3}$$

where $0 \leq \mu_{\tilde{\tilde{A}}}(x,u) \leq 1$ and $\int\int$ states the union over all admissible x and u. And additionally they called $\tilde{\tilde{A}}$ as an interval Type-2 fuzzy set if all $\mu_{\tilde{\tilde{A}}}(x,u) = 1$. In Fig. 1, representation of an interval Type-2 fuzzy set with a membership function is presented.

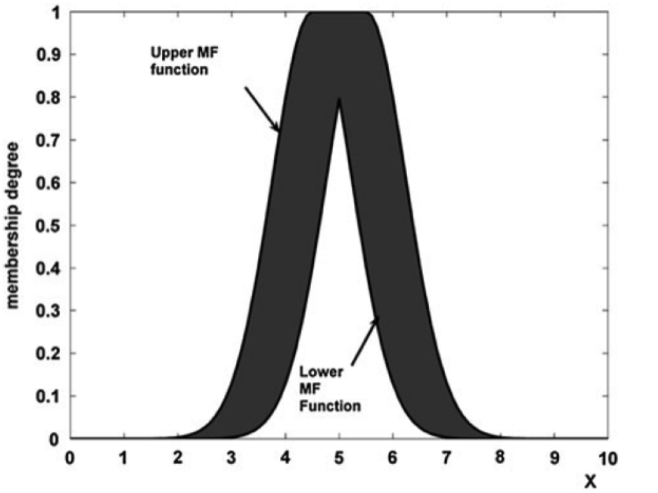

Fig. 1. Interval type-2 membership function

Liang and Mendel [22] introduced a new concept that allows the characterisation of a Type-2 fuzzy set with an upper and lower membership functions. Cited two functions are themselves type-1 fuzzy set membership functions. In addition, the interspace between these superior and inferior type-1 fuzzy functions indicates the footprint of uncertainty (FOU). This interval is used to describe a Type-2 fuzzy set.

In this work, interval Type-2 fuzzy sets are utilised as shown in Mendel's study [21] those are called to deal with uncertainty of real world problems. Interval representation of fuzzy sets is easy to use and implement.

Type-2 fuzzy number (FN) $\tilde{\tilde{A}}$ can be illustrated as follows;

$$\tilde{\tilde{A}} = \left\{ f\left(\tilde{A}_U\right), f\left(\tilde{A}_L\right) \right\} \tag{4}$$

where $\tilde{A}_U$ and $\tilde{A}_L$ are type-1 fuzzy sets and the Type-2 fuzzy interval number is represented by $\tilde{\tilde{A}}$, $f\left(\tilde{A}_U\right)$ and $f\left(\tilde{A}_L\right)$ signify the membership values of the elements in the upper and in the lower membership functions $\tilde{A}_U$ and $\tilde{A}_L$, respectively, where $\tilde{A}_U \in [0,1]$ and $\tilde{A}_L \in [0,1]$.

There exists many uncertainties in an investment project, especially for a new product development in a retail banking market. Identification of the problem and choice of the type of fuzzy system which best suits the problem are highly important before making a decision.

III. Compound Real Options with Type-2 FNs

There are many stages in a new product development project and the decision maker has to determine whether to exercise the option or to postpone it. This process can be explained by compound options. These options accept other options as underlying assets. A compound option has several expiration dates and several strike prices. Let K_i be the present value of investment cost (strike price) for stages $i = 1, 2, \ldots, n$ and S be the present value of the project return (price of the underlying asset) after market introduction.

In this work, we will refer two call options with two expiration dates. If an investor purchases an option at time $T = 0$, on the first expiration date T_1, the option holder has the right to purchase a new option with the strike price K_1. And the second option offers the investor the right to purchase the underlying asset with the strike price K_2 at time T_2.

The pricing formula for compound option any time can be extended into a Type-2 fuzzy number form as with the process given at the next paragraphs.

In the real financial market, somewhat parameters like the volatility and interest rate from time to time cannot be registered or gathered implicitly due to market fluctuations and human errors. Owing to the imprecise information and the fluctuation of the financial market occasionally it is almost impossible to assume that the volatility σ is constant. So we replace σ by fuzzy number $\tilde{\tilde{\sigma}}$ to get the formula for this compound option under fuzzy environment. Here r is the risk-free interest rate, $N(y)$ is the standard normal distribution function, $M(y,z,\rho)$ is the bivariate cumulative normal distribution function with y and z as upper and lower integral limits and ρ as the correlation coefficient between the two variables.

Suppose the volatility be fuzzy number, S^* is the unique solution of the equation;

$$xN\left(d^* + \tilde{\tilde{\sigma}}\sqrt{T_2 - T_1}\right) - K_2 e^{-r(T_2-T_1)} N\left(d^*\right) = K_1 \tag{5}$$

where

$$d^* = \frac{\ln\left(x/K_2\right) + \left(r - (1/2)\,\sigma^2\right)(T_1 - T_2)}{\sigma\sqrt{T_1 - T_2}} \tag{6}$$

$$\tilde{\tilde{\sigma}} = [\tilde{\sigma}_H, \tilde{\sigma}_L] \tag{7}$$

with $\tilde{\sigma}_H$ and $\tilde{\sigma}_L$ are the higher and lower values of $\tilde{\tilde{\sigma}}$, respectively.

Under fuzzy environment, the call option value $\tilde{\tilde{C}}$ is a Type-2 fuzzy number.

The compound option price $\tilde{\tilde{C}}$ is;

$$\begin{aligned}\tilde{\tilde{C}} = SM\left(\tilde{\tilde{d}}_1, \tilde{\tilde{d}}_2, \rho\right) - K_2 e^{-rT_2} M\left(\tilde{\tilde{d}}_3, \tilde{\tilde{d}}_4, \rho\right)\\ -K_1 e^{rT_1} N\left(\tilde{\tilde{d}}_3\right)\end{aligned} \tag{8}$$

where

$$\tilde{\tilde{d}}_1 = \frac{\ln\left(S/S^*\right) + (r + (1/2)\tilde{\tilde{\sigma}}^2)T_1}{\left(\sigma\sqrt{(T_1)}\right)} \tag{9}$$

$$\tilde{\tilde{d}}_2 = \frac{\ln\left(S/K_2\right) + (r + (1/2)\tilde{\tilde{\sigma}}^2)T_2}{\left(\sigma\sqrt{(T_2)}\right)} \tag{10}$$

$$\tilde{\tilde{d}}_3 = d_1 - \tilde{\tilde{\sigma}}\sqrt{T_1} \tag{11}$$

$$\tilde{\tilde{d}}_4 = d_2 - \tilde{\tilde{\sigma}}\sqrt{T_2} \tag{12}$$

$$\rho = \sqrt{\frac{T_1}{T_2}} \tag{13}$$

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The fuzzy set of $\tilde{\tilde{C}}$ may be denoted as $\tilde{\tilde{C}} = \left[\tilde{C}_H, \tilde{C}_L\right]$ and $\tilde{C}_H$ and $\tilde{C}_L$ can be calculated as in the following equations.

$$\begin{aligned} \tilde{\tilde{C}} = \Big[& SM\left(\tilde{d}_1^H, \tilde{d}_2^H, \rho\right) - K_2 e^{-rT_2} M\left(\tilde{d}_3^H, \tilde{d}_4^H, \rho\right) \\ & -K_1 e^{rT_1} N\left(\tilde{d}_3^H\right), \\ & SM\left(\tilde{d}_1^L, \tilde{d}_2^L, \rho\right) - K_2 e^{-rT_2} M\left(\tilde{d}_3^L, \tilde{d}_4^L, \rho\right) \\ & -K_1 e^{rT_1} N\left(\tilde{d}_3^L\right) \Big] \end{aligned} \tag{14}$$

where $\tilde{\tilde{d}}_1 = [\tilde{d}_1^H, \tilde{d}_1^L]$, $\tilde{\tilde{d}}_2 = [\tilde{d}_2^H, \tilde{d}_2^L]$, $\tilde{\tilde{d}}_3 = [\tilde{d}_3^H, \tilde{d}_3^L]$, and $\tilde{\tilde{d}}_4 = [\tilde{d}_4^H, \tilde{d}_4^L]$ and they can be computed as below:

$$\tilde{d}_1^H = \frac{\ln(S/S^*) + (r + (1/2)[\tilde{\sigma}_H]^2)T_1}{\tilde{\sigma}_H \sqrt{(T_1)}} \tag{15}$$

$$\tilde{d}_1^L = \frac{\ln(S/S^*) + (r + (1/2)[\tilde{\sigma}_L]^2)T_1}{\tilde{\sigma}_L \sqrt{(T_1)}} \tag{16}$$

$$\tilde{d}_2^H = \frac{\ln(S/K_2) + (r + (1/2)[\tilde{\sigma}_H]^2)T_1}{\tilde{\sigma}_H \sqrt{(T_1)}} \tag{17}$$

$$\tilde{d}_2^L = \frac{\ln(S/K_2) + (r + (1/2)[\tilde{\sigma}_L]^2)T_1}{\tilde{\sigma}_L \sqrt{(T_1)}} \tag{18}$$

$$\tilde{d}_3^H = \tilde{d}_1^H - \tilde{\sigma}_H \sqrt{T_1} \tag{19}$$

$$\tilde{d}_3^L = \tilde{d}_1^L - \tilde{\sigma}_L \sqrt{T_1} \tag{20}$$

$$\tilde{d}_4^H = \tilde{d}_2^H - \tilde{\sigma}_H \sqrt{T_2} \tag{21}$$

$$\tilde{d}_4^L = \tilde{d}_2^L - \tilde{\sigma}_L \sqrt{T_2} \tag{22}$$

IV. Application in Banking Industry

For retail banking reaching more customers and being the main bank that people prefer for their daily routine like payments, savings and transfers are more important. To achieve their goals, banks can offer advantageous products or services.

The Bank considers launching a new product, a saving account that offers the customers extra bonus when they spend with their debit cards. Its extra interest rate is triple the normal saving accounts which can lead the decision maker quit the project if they calculate the present value of the project with traditional discount methods.

Managers have this product to launch in their five year plan. This period of time is for them to observe the market and its needs then take an action when their profit is high. It also gives us the flexibility to choose the best year with optimum profit in next five years.

Given that financial markets, in nature, can be described with words instability and uncertainty, predicting customer reactions to this new product from today is very hard. Lots of variables cause these fluctuations and uncertainty; movements in foreign currency, probable new competitors or similar products, changes in interest rates and orientation to real estates. That's the reason why we will take the benefit of Type-2 fuzzy interval method for probable income distribution.

When firms enter new businesses, make new investments or launches new products, they have their option to enter the business in stages. This way at each stage they can decide whether to go on to the next stage or not. The bank considers adding other features to this saving account after testing stage if they succeed. This brings again customers interest to the new product. Risks of new product development by traditional methods and real options are depicted in Fig. 2.

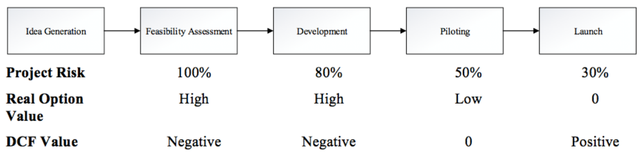

Fig. 2. New Product Development Phases with expected risk and project values

After those stages the best time to launch the product with the highest net present value is found and the intervals of profit between the high and low volatility of the market are estimated. Real options remind financial options however they are written on real assets, so decision steps are like financial options as represented in Fig. 3.

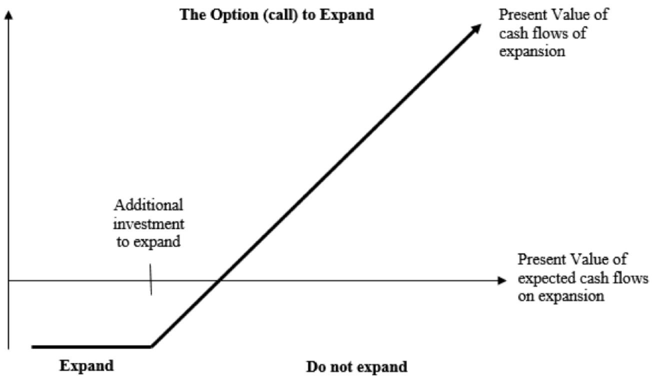

Fig. 3. Decision logic of the project

A. *Background and Gathered Data*

The Bank chosen in this project is a global financial institution, active in over 40 countries in Europe, North and South America, Asia and Australia, offering banking, investment, life insurance and retirement services. Its focus is people and trust. Its strengths are multi-channel distribution strategy and high customer satisfaction levels, as well as offering appealing and easy to understand products.

On July 7, 2008, The Bank started to provide world-class financial services to its individuals and corporate customers with the motto "Your money is valuable here". The Bank operates with the priority of providing the customers with the right solutions at the right time. The Bank's Deposit Products Marketing Department considers launching a new product, a saving account that accrues high overnight interest, in five years. This account will be closed to deposit but free to withdraw money and no account management fee will be collected from. The only way to save money in this account will be spending money with debit card or giving automatic bill prescription and gain the disposition part. The challenge with this account is the high level of interest rate which is almost triple the regular saving accounts. Main idea behind this product for this bank is to become the primary bank for more customers in the next five years.

Introducing new products on the market is extremely important for continuing success of businesses. New product introduction carries significant risk. Yet, without this cycle, failure of companies is inevitable. They are presented to the market after a sequence of stages, beginning with the initial product idea and ending with the release on the market as depicted in Fig. 4. First of all, information for the product concept is collected, analysed and developed. To minimize the level of risk in an uncertain market, it is decided to launch this product on the market in stages where the first stage includes idea generation, feasibility evaluation, development, piloting, and launching and the second stage includes improvement.

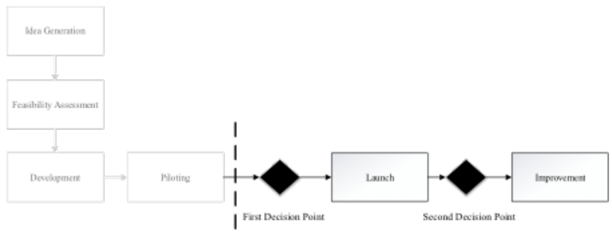

Fig. 4. Decision points of the project

B. Implementation

As a first step, discounted cash flow of this implementation is created from data obtained from the bank as seen on Table II. Launching a new product to a market require initial investment. IT investment in banking necessitates high primary investment costs and sustained long-run investments, yet has significant ambiguity and risk in forthcoming cash flow. In retail banking market, early investment include IT development, maintain, marketing, promotion and stuff education costs.

At the next step, fluctuations are determined. Possible changes in the market, interest rates, similar products, entrance of new competitors could affect the expected profit. And profit directly depends on the number of customers which is normally distributed. With a Type-2 fuzzy interval perspective, we can say that this distribution could be high or a low distribution due to the vagueness quoted above.

By this manner, some numerical demonstration of compound option pricing under fuzzy environment is made. We assume by the expertise of the department leader $\tilde{\tilde{\sigma}} = [\tilde{\sigma}_H, \tilde{\sigma}_L] = [0.3, 0.2]$, where $\tilde{\sigma}_H$ is the high standard deviation and $\tilde{\sigma}_L$ is the low standard deviation, first expiration date of the initial investment option $T_1 = 5$, second expiration date of the improvement option $T_2 = 6$, PV of the project return $S = 4,151,101.05$ TL, the first stage investment cost $K_1 = 4,774,500.00$ TL, the second stage investment cost $K_2 = 2,625,500.00$ TL, and risk-free interest rate $r_f = 0.08$.

This means that the option price can easily be computed by the equations given in the previous section and will lie in the closed interval $\tilde{\tilde{C}} = [\tilde{C}_H, \tilde{C}_L] = [4,922,588.72, 3.545.594.03]$ with standard deviations $\tilde{\sigma}_H$ and $\tilde{\sigma}_L$, respectively. This interval provides reference for business investors. If the market conditions support this interval and investor is satisfied with the expected return on the project then decision maker can exercise the option which means invest into the project immediately neverthless the traditional NPV result is on the negative direction.

C. Discussions

Our study of new product development in a retail banking market suggests strategic decision-making and uses real options method in order to make an investment under uncertainty. The most convenient option embedded in the assessment of new product development is a strategic expansion option because the capital input is more or less irreversible and the output is subject to uncertainty. A learning process including real options analysis supports multi-stage decision making.

The major difficulty in valuing this investment by using real option valuation methods was that there were often no straight market data about the underlying asset value and no archive information to make inference of significant entries. The expected value of the project were specified grounded on practitioners' experience and wisdom of the investment. Though the worth of underlying asset is so difficult to anticipate with the lack of market information this approach is also problematic in part. Finally, it is assumed that the risk-free rate is known and constant.

A comparison of binomial lattice technique with multi-stage real option valuation made in Semercioglu and Tolga's study [23] and compound option method with Black-Sholes formula has to be made in this study. In cited study one can easily notify that The Bank should invest in the project at the fourth year and the second year for the best case. However in that study we found exercise the option this year. Nearly the same result but in compound real options solution method it is swiftly reachable result than binomial tree solution technique. Valuing each option individually and summing these separate option values can overstate the value of a project. This is because; there is a consideration of best option choice at the right time. Project value is measured optimistically. Second of all, closed form of Black-Scholes formula reacts on the exercise of both options in the project. It cannot properly capture the value investment and it's hard to track the life time of those options. Although binomial tree gives more flexibility when the corporation needs fast and right results it is better to use Black-Scholes technique.

V. Conclusions and Future Research

In an uncertain and dynamic global market, managerial flexibility has become essential for companies to take advantage of future investment opportunities. The main focus of this study, in contrast to others in the literature, is to model uncertain information and evaluate the new product development.

Success in new product development still remains critical challenge for growing companies. These types of investments allow companies to gain more customers and to enter other markets in the future. The option to expand, in our new

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TABLE II
CASH FLOW OF THE PROJECT IN FIVE YEARS

	T = 0	T = 1	T = 2	T = 3	T = 4	T = 5	T = 6
Initial Investment	-4,250,000.00					-3,250,000.00	-1,000,000.00
Maintain Cost		-24,500.00	-24,500.00	-24,500.00	-24,500.00	-24,500.00	-25,500.00
Marketing Cost		-500,000.00	-500,000.00	-500,000.00	-500,000.00	-500,000.00	-500,000.00
Promotion Cost		-1,000,000.00	-1,000,000.00	-1,000,000.00	-1,000,000.00	-1,000,000.00	-1,100,000.00
Average Income		2,520,000.00	2,520,000.00	2,520,000.00	2,520,000.00	2,520,000.00	3,400,000.00
Total		995,500.00	995,500.00	995,500.00	995,500.00	995,500.00	1,674,500.00
PV		4,151,101.05 TL					5,982,439.69 TL
NPV	-98,898.05					3,732,439.69	

product development case, is used to rationalize taking investments that have a negative net present value. Under uncertainty, it is cautious to stage an investment. Staging investment gives decision makers flexibility whether to continue to the next stage or to abandon midway. Multi-stage investments may have great option values that can verify making strategic investments despite having a negative cash flow.

This study has presented a Type-2 fuzzy compound option valuation application to evaluate new product development project assessment with real options in an uncertain environment. Compound options are options that are written on others, which mean that compound options take standard options as their underlying assets. They are used to hedge risky investments. Considering the uncertainty and vagueness of the real market, a fuzzy pricing formula is introduced for compound option using volatility as fuzzy variable. The project has divided into two phases so that managers could observe the success of the product launch and decide whether to continue with additional features or to abandon for good. And with the vagueness contained in financial markets, the work is represented with Type-2 fuzzy numbers to provide reliable results at the end.

Our findings support the argument that decision makers either implicitly or explicitly use real options. The consequences in this project have shown that, even with negative cash flow, some projects could have benefits for companies with the real options approach. And the Type-2 fuzzy interval method ensures to predict possible outcomes when exercising these options. Actualize the project and consider to launch this new product immediately is a powerful result of this study. At the second stage, implementing new features is appropriate in any time until the end of the lifetime of the project. Our results suggest that the options concept could prove to be a fruitful approach to retail banking new product development project.

Real options have been combined with many theories in recent year years. As a future work, multi criteria decision making methods and real options can be examined together to value components of the project. It may provide the decision maker to discover real options' advantages.

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REFERENCES

[1] L. E. Brandão, J. S. Dyer, and W. J. Hahn, "Using binomial decision trees to solve real-option valuation problems," *Decision Analysis*, vol. 2, no. 2, pp. 69–88, 2005.

[2] T. E. Copeland, V. Antikarov, and T. E. Copeland, *Real options: a practitioner's guide*. Texere New York, 2001.

[3] A. Galli, M. Armstrong, and B. Jehl, "Comparing three methods for evaluating oil projects: Option pricing, decision trees, and monte carlo simulations," in *SPE hydrocarbon economics and evaluation symposium*, 1999, pp. 91–99.

[4] A. K. Dixit and R. S. Pindyck, *Investment under uncertainty*. Princeton university press, 1994.

[5] D. M. Lander and G. E. Pinches, "Challenges to the practical implementation of modeling and valuing real options," *The quarterly review of economics and finance*, vol. 38, no. 3, pp. 537–567, 1998.

[6] A. Thavaneswaran, S. S. Appadoo, and A. Paseka, "Weighted possibilistic moments of fuzzy numbers with applications to garch modeling and option pricing," *Mathematical and Computer Modelling*, vol. 49, no. 1, pp. 352–368, 2009.

[7] P. Nowak and M. Romaniuk, "Computing option price for levy process with fuzzy parameters," *European Journal of Operational Research*, vol. 201, no. 1, pp. 206–210, 2010.

[8] K. Thiagarajah and A. Thavaneswaran, "Fuzzy random-coefficient volatility models with financial applications," *The Journal of Risk Finance*, vol. 7, no. 5, pp. 503–524, 2006.

[9] H.-C. Wu, "Using fuzzy sets theory and black–scholes formula to generate pricing boundaries of european options," *Applied Mathematics and Computation*, vol. 185, no. 1, pp. 136–146, 2007.

[10] Y.-C. Lee and S.-S. Lee, "The valuation of rfid investment using fuzzy real option," *Expert Systems with Applications*, vol. 38, no. 10, pp. 12 195–12 201, 2011.

[11] U. Cherubini, "Fuzzy measures and asset prices: accounting for information ambiguity," *Applied Mathematical Finance*, vol. 4, no. 3, pp. 135–149, 1997.

[12] M. Benaroch and R. J. Kauffman, "A case for using real options pricing analysis to evaluate information technology project investments," *Information Systems Research*, vol. 10, no. 1, pp. 70–86, 1999.

[13] H. Ghaziri, S. Elfakhani, and J. Assi, "Neural networks approach to pricing options," *Neural Network World*, vol. 10, no. 1, pp. 271–277, 2000.

[14] C. Carlsson and R. Fullér, "A fuzzy approach to real option valuation," *Fuzzy sets and systems*, vol. 139, no. 2, pp. 297–312, 2003.

[15] H. Li, X. Qu, and J. Feng, "Definition of optimal proportion of phased investment: A real options approach," Working Paper, School of Management, Dalian University of Technology, Dalian, China, Tech. Rep., 2000.

[16] M. Collan, R. Fullér, and J. Mezei, "A fuzzy pay-off method for real option valuation," *Advances in Decision Sciences*, vol. 2009, 2009.

[17] P. D. Childs and A. J. Triantis, "Dynamic r&d investment policies," *Management Science*, vol. 45, no. 10, pp. 1359–1377, 1999.

[18] Y. Yoshida, "The valuation of european options in uncertain environment," *European Journal of Operational Research*, vol. 145, no. 1, pp. 221–229, 2003.

[19] L. A. Zadeh, "Fuzzy sets," *Information and control*, vol. 8, no. 3, pp. 338–353, 1965.

[20] ——, "The concept of a linguistic variable and its application to approximate reasoning," in *Learning systems and intelligent robots*. Springer, 1974, pp. 1–10.

[21] J. M. Mendel, R. I. John, and F. Liu, "Interval type-2 fuzzy logic systems made simple," *IEEE Transactions on Fuzzy Systems*, vol. 14, no. 6, pp. 808–821, 2006.

[22] Q. Liang and J. M. Mendel, "Interval type-2 fuzzy logic systems: theory and design," *IEEE Transactions on Fuzzy systems*, vol. 8, no. 5, pp. 535–550, 2000.

[23] N. Semercioglu and A. Ç. Tolga, "A multi-stage new product development using fuzzy type-2 sets in a real option valuation," in *Fuzzy Systems (FUZZ-IEEE), 2015 IEEE International Conference on*. IEEE, 2015, pp. 1–7.

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