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Selecting the Most Economic Project under Uncertainty Using Bootstrap Technique and Fuzzy Simulation

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Abstract

This article, by leaving pre-determined membership function of a fuzzy set which is a basic assumption for such subject, will try to propose a hybrid technique to select the most economic project among alternative projects in fuzziness interest rates condition. In this way, net present worth (NPW) would be the economic indicator. This article tries to challenge the assumption of large sample sizes availability for membership function determination and shows that some other techniques may have less accuracy. To give a robust solution, bootstrapping and fuzzy simulation is suggested and a numerical example is given and analyzed.

Keywords

Net present worth (NPW), Fuzzy interest rate, Bootstrap technique, Economical project selection, Fuzzy simulation.

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Introduction

Accurate project selection is the most important financial success factor for individuals and organizations (Cleland & Ireland, 2002). Not only they have to prevent failures, but also selecting the best among alternative projects and manage them simultaneously to get their desirable results is vital to make them sustainable in such a competitive environment. Investment risks embedded in many realistic issues such as research and development (R&D) and developing new products (DNP), would result in a decision to survive or die.

Under uncertainty and risk, the reality of lack of reliable information can't be hidden or ignored (Carlsson et al., 2007). In fast changing environments and industries that face to new products design, R&D investments, high technologies and integrated information systems (Chen et al., 2009), accurate data and information would not be in touch. In other words, information uncertainty and vagueness is a challenging issue which has dependencies on fuzziness and shortage of available data and advices.

Organized activities have to be adopted due to manager's strategies. Although strategy evaluations are based on different criteria, one of the most important existing constraints to achieve them would be limited budget (Allen, 1991). These limitations make them to choose among investment alternatives in their operation cycles; so there is always some glance at financial issues such as needed budget or resulting benefits (Biafore, 2007).

Project portfolio selection can be divided into three main categories: risk analysis, ranking by scoring methods and financial evaluation (Lawson et al., 2006). Financial evaluation of project portfolio has been used many years to help decision makers and many models and methods have been proposed (Zhang et al., 2011). Scoring and ranking is used with many methods such as multi criteria decision making techniques (e.g. AHP (Al-Harbi, 2001), TOPSIS (Mahmoodzadeh et al., 2007), PROMETHE. Risk considerations have got increasing attentions during recent years (Alessandri et al., 2004; Armaneri et al., 2005).

In order to financially evaluate economical projects, it's needed to examine beneficiary due to their cash flows. Proper tools for monitoring and evaluating such projects are net present worth (Armaneri et al., 2010; Huang, 2007; Zhang et al., 2011), internal rate of return (IRR) and payback period (Martino, 1931). NPW and IRR are the most common techniques used by banks and large-sized organizations to compare projects. Selection between NPW and IRR is discussed in numerous ways and shown that better can be chosen due to many different factors and situations (Osborne, 2010).

To calculate NPW, interest rate must be determined as one of the needed inputs. Interest rates can be fixed by governments or economical socials (Blakely & Leigh, 2002), otherwise, by many different factors and situations, it can be undefined and changeable (Nawalkha et al., 2005).

To deal with financial evaluation, many methods have been used. The most interesting method is categorized in (Carlson et al., 2007). Fuzzy zero-one integer programming (Wang & Hwang, 2007) and (Huang, 2007), Fuzzy DEA (Zuojun et al., 2011), fuzzy AHP, fuzzy ANP (Ebrahimnejad et al., 2011) and fuzzy variance (Tsao, 2012) have got great attentions, while many hybrid algorithms (Chiang & Che, 2010), (Huang, 2007), (Zhang et al., 2011), (Ebrahimnejad et al., 2011) tries to combine these methods to get more accurate and reliable results. Using simulation, as one of the main methods, has been studied in different ways. Some hybrid methods have used it after the transformation of fuzzy numbers to probability distributions (Armaneri et al., 2005), some used Monte-Carlo simulation to get sample sizes (Shakhsi-Niaei et al., 2011) and others have used fuzzy simulation directly (Huang, 2007). All these methods can be applied if essential assumptions such as distribution adoption and data accuracy have been guaranteed.

A traditional solution to manage the risk of having inaccurate information would be to take large sample sizes. In such a way, statistical methods and probabilistic distributions for estimation and hypothesis testing can be applied as well (Montgomery & Runger, 2010). The easiest way is to get a weighted mean to estimate the interest rate. Although it has good performance in some places, some researches have shown the reality that in asymmetric curves and in small sample sizes, the performance can be quite worse and result in many errors (Wilcox, 2010). To handle such problems, some other estimation solutions have been given (Wilcox, 2005), which will be presented in the following sections.

Before fuzzy theory introduction by (Zadeh, 1968), the only way to face vagueness was probabilistic approach which was done by frequency and expected value definitions (Choobineh, 1989).

After fuzzy theory evaluation and showing its vast applications, the use of fuzzy sets in investment has been greatly considered (Klir, 1995). Vagueness and uncertainty in many investments made decision makers to face risk not only as a quality indicator but also as a quantity indicator in decision models. In order to get better result from fuzzy theory, input accuracy is very important (liao & Ho, 2010).

Fuzzy interest rates have been applied in net present worth and future worth (Buckley, 1987), long period property pricing (Sanchez & Gomez, 2004), interest rate forecasting (Bargielaa et al., 2007), insurance value pricing (Ostaszewski, 1993), scrap value and many others. This article will attempt to compare alternative projects based on NPW which will try to complete researches (Buckley, 1987).

The presented method, by ignoring such assumptions which have been used greatly by some like Armaneri, Yalç and Eski, will try to show good robustness in different situations. It means that such method may have worse result in comparison to some others but will have so better performance in situations that others do worse and guarantees the performance reliability. One of the most important issues is membership function determining. Although it is common to suppose their values predetermined and deterministic, the reality shows that membership function and its values have embedded probability ambiguity and fuzziness (Voloshyn et al., 2002). Different methods such as numerical methods (Xuejin, 2009), statistical methods (Stamelos & Angelis, 2001), artificial intelligence techniques (Hong et al., 2011), (Wang, 1994), analytical approaches (Tiryaki & Ahlatcioglu, 2009) and many others have been developed to determine the probability and vagueness. Although some studies have used options to determine the accuracy and reliability of in hand information (Huang, 2007), but they are consuming more money and time in a competitive situation which may lead to lose market share (Armaneri et al., 2005).

Many robust techniques have been proposed to deal with hypothesis testing in different situations and statistics (Huber, 2004). One of the most updated and applied to improve sample mean performance is bootstrapping techniques. These techniques show robustness in dealing with non-asymmetric and non-normal distributions while no large sample sizes are available (Wilcox, 2010).

In this article, the use of both bootstrapping and fuzzy simulation techniques in fuzzy situations has been applied. The proposed method will attempt to manage explicit estimations and lack of professional opinions. Usual financial models used by organizations ignore uncertainty (Carleton, 1973). This may happen because of complexity of uncertain problems and can lead to suppose unrealistic assumptions. This method will consider such an important issue and believes that fuzzy sets can help quantitative methods to consider and model uncertainty in planning and managing foregoing complexity.

The following sections are organized in this order: Section 2 provides an overlook on fuzzy simulation technique and parameter estimation situations. Section 3 describes the way hybrid technique was proposed. Section 4 illustrates a numerical example and Section 5 shows the results and makes conclusion.

Fuzzy Simulation

Simulation is the process of designing real world models and doing experiments by means of these models that can be used as a powerful tool for analyzing and understanding the behavior of a system and evaluates the performance of the alternatives through a descent understanding of it (Pritsker & Reilly, 1999).

Simulation deals with model design and experimentation of a system to achieve at least one of these objectives:

- system performance recognition;
- System performance differentiation under various situations.

In simulation, all natural uncertainties are usually considered in stochastic sense. However, in practice this does not always correspond to the nature of uncertainties that often appear as the effects of subjective estimations. Fuzzy set theory provides new tools to represent uncertainty. Several studies concerning the use of fuzzy set theory in modeling and managing production environment have emerged (Guiffrida & Nagi, 1998).

As many probabilistic distributions are unknown, or have uncertainties, answers to if-then problems would cost so. In these situations, fuzzy simulation would be a better choice over discrete-event simulation if such data were in hand. In other words, if probabilistic distributions have embedded uncertainties to describe model's behavior, fuzzy estimation can be a good choice (Buckley 2005).

Fuzzy simulation has been applied in different aspects of knowledge. Some of these studies are at (Jowers et al., 2007; Medaglia et al., 2002; Zhang et al., 2007). For example, (Jowers et al., 2007) used crisp discrete event simulation to estimate the fuzzy numbers which are used to describe system behavior. These fuzzy numbers are regarded as fuzzy parameters of the stochastic system.

Fuzzy Parameter Estimation

Suppose we have the results of a random sample to estimate the value of a parameter. We would construct a set of confidence intervals for it and then put these together to get a fuzzy number. This method of building fuzzy number from a set of confidence intervals is discussed in details in (Azadeha et al., 2010), (Buckley, 2005; Jowers et al., 2007).

As described before, giving a deterministic or probabilistic distribution to a parameter may have low accuracy for some real situations. Fuzzy estimation can make some others in some other conditions. For α-percent parameter confidence intervals estimation, a fuzzy number for that parameter can be achieved by summing these confidence intervals. In fact, calculated intervals with $(1-\alpha)$-percent confidence level are α-percent fuzzy cuts. Being a parameter in a $(1-\alpha)$-percent confidence interval can be interpreted as a confidence level for measuring closeness to the real parameter in fuzzy concept. In simulation, α-cuts can be obtained by this formulation:

$$\bar{R}[\alpha] = \{ R |\ R = SIM\ (\lambda, \mu, \sigma^2) \quad (1)$$

$$S = \lambda \in \lambda[\alpha], \mu \in \mu[\alpha] \quad (2)$$

In formula (1), $\overline{R}[\alpha]$ is lower and upper level for α-percent cut of a fuzzy number like$\overline{R}$. SIM function can produce lower and higher limits by giving different inputs. By making an α-cut, the calculated interval can be used for interval simulation. For the resulted α, R simulation can be obtained by:

$$R[\alpha]=[r_1(\alpha), r_2(\alpha)] \quad (3)$$

$$r_1(\alpha)= \min \{ R |\ R = SIM\ (\lambda, \mu, S) \quad (4)$$

$$r_2(\alpha)= \max \{ R |\ R = SIM\ (\lambda, \mu, S) \quad (5)$$

α-Cuts which results in estimated lower and higher limits will be used in system simulation and calculation of output interval estimation. By summing the calculated interval estimations, by the means of different α-cuts, fuzzy output will be achievable.

Bootstrap Technique

In statistics, bootstrapping is a computer-based method for assigning measures of accuracy to sample estimates (Efron & Tibshirani, 1993). This technique allows estimation of the sample distribution of almost any statistic using only very simple methods (Chernick & Michael, 2007). Generally, it falls in the broader class of resampling methods. Bootstrapping is the practice of estimating properties of an estimator such as its variance by measuring those properties when sampling from an approximating distribution. One standard choice for an approximating distribution is the empirical distribution of the observed data. In the case where a set of observations can be assumed to be from an independent and identically distributed population, this can be implemented by constructing a number of resamples of the observed dataset (and of equal size to the observed dataset), each of which is obtained by random sampling with replacement from the original dataset.

(Adèr et al., 2008) recommend the bootstrap procedure for the following situations:

- When the theoretical distribution of a statistic of interest is complicated or unknown. Since the bootstrapping procedure is distribution-independent it provides an indirect method to assess the properties of the distribution underlying the sample and the parameters of interest that are derived from this distribution.
- When the sample size is insufficient for straightforward statistical inference. If the underlying distribution is well-known, bootstrapping provides a way to account for the distortions caused by the specific sample that may not be fully representative of the population.
- When power calculations have to be performed, and a small pilot sample is available. Most power and sample size calculations are heavily dependent on the standard deviation of the statistic of interest. If the estimate used is incorrect, the required sample size will also be wrong. One method to get an impression of the variation of the statistic is to use a small pilot sample and perform bootstrapping on it to get impression of the variance.

In this paper, the interest rate is an uncertain variable which its theoretical distribution is unknown. So based on above, we can use bootstrap method to find properties of it.

Research Method

This research has considered situations in which for special reasons, exact calculation of interest rate is not available or for various reasons such as lack of sufficient data, the estimated value is not reliable. In fact, for reasons like no accessible sufficient data, knowledge weakness and many others, there is no exact value for interest rate. In these situations, fuzzy logic can be useful and evaluation can be based on fuzzy value. After achieving fuzzy value, net present worth calculation is possible by the use of fuzzy mathematics. For instance a calculative method to find fuzzy NPV is presented at Kriengkorakot and Pianthong (2006). While in many articles calculation of fuzzy interest using fuzzy mathematics has been done (Huang, 2007; Chiu & Park, 1994), fuzzy value of interest rate is assumed to be determined. This research omits this hypothesis and tries to estimate with the use of bootstrapping technique, to calculate interest rates confidence interval values, to sum the fuzzy confidence intervals and net fuzzy interest rate. Then it calculates net present worth by simulation. In the next section, description of every step is presented by a numerical example. The structure of proposed framework is represented in Figure 1.

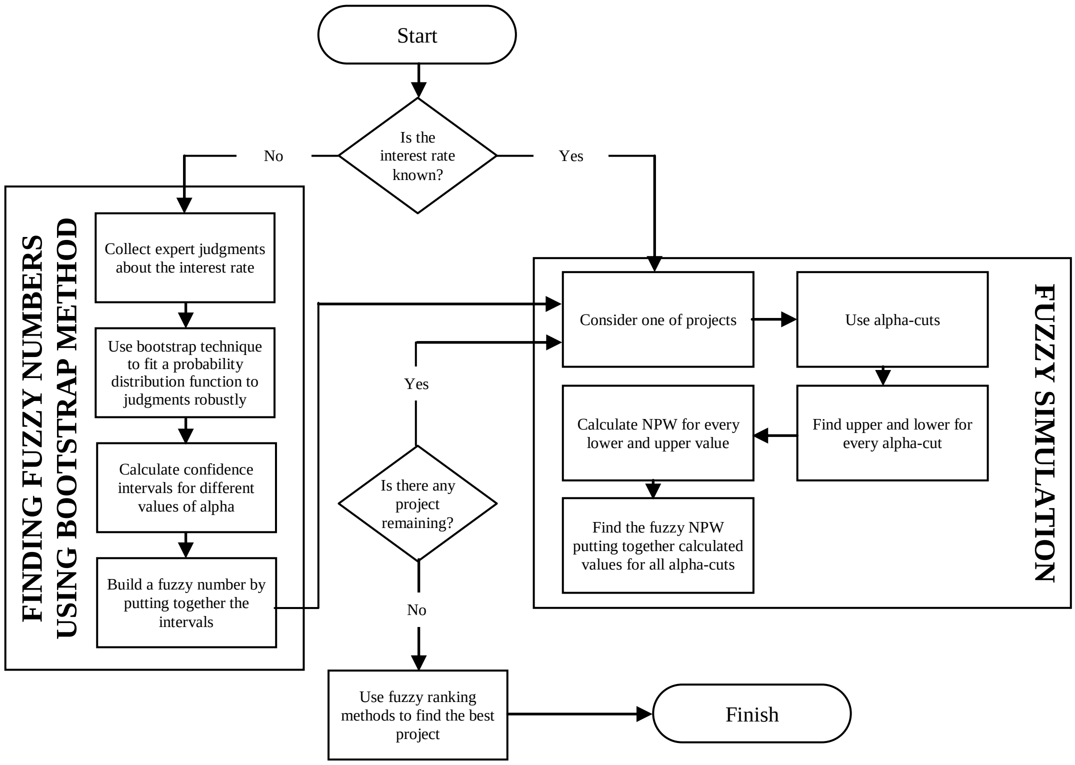

Figure 1. The structure of proposed framework

Numerical Example

Assume situations in which by gaining market historical information and experts' opinions, these values are obtained:

Table 1. Experts' opinion about possible values for interest rates

0.9	0.1	0.13	0.12	0.19	0.11	0.95	0.14	0.17	0.105

By bootstrapping, one thousand samples are generated. According to these samples, various interval estimations have been calculated:

Table 2. Obtained interest rates by bootstrapping

alpha	L-B	U-B	alpha	L-B	U-B
99%	0.099242	0.150758	50%	0.118255	0.131745
95%	0.1054	0.1446	45%	0.119022	0.130978
90%	0.108551	0.141449	40%	0.119756	0.130244
85%	0.110605	0.139395	35%	0.120462	0.129538
80%	0.112184	0.137816	30%	0.121147	0.128853
75%	0.113497	0.136503	25%	0.121814	0.128186
70%	0.114636	0.135364	20%	0.122467	0.127533
65%	0.115654	0.134346	15%	0.123109	0.126891
60%	0.116584	0.133416	10%	0.123743	0.126257
55%	0.117446	0.132554	5%	0.124373	0.125627
-	-	-	0%	0.125	0.125

Simulation Execution

Using available lower and higher limits for interest rate value, net present worth can be obtained. For any α values, higher and lower limits in Table 2 can be put in Formula 1 and harvest net present worth. By summing them, fuzzy value will be obtained showing its NPW. These projects and their cash flows are available:

Table 3. Two projects and their cash flows

Time	0	1	2	3	4	5	6
Project 1	-10000	2000	2500	2700	2800	2900	3100
Time	0	1	2	3	4	5	6
Project 2	-9000	1950	2050	2750	3000	3000	3150

As described before, higher and lower limits will be calculated by different α-cuts. Net present worth formula will be in this order:

Each cash inflow/outflow is discounted back to its present value (PV). Then they are summed. Therefore, NPV is the sum of all terms,

$$\sum \frac{R_t}{(1+i)^t} \qquad (6)$$

Where:

T: is the time of the cash flow

I: is the discount rate

$R_{t:}$ is the net cash flow (the amount of cash, inflow minus outflow) at time *t.*

For example, calculation of the first project higher and lower limits, by assuming$\alpha = 0.1$, will be derived by R_t from Table 3 values and Formula 1. Related *t* values will be taken from the table, too. Now through using Table 2 values and related$\alpha = 0.1$, interest rate lower limit is equal to 0.099242 and the higher limit is equal to 0.150758. By putting 0.099242 in Formula 1 and performing calculations, the first project lower limit for net present worth will be obtained. The higher limit can be gained by putting 0.150758 in that formula, too. Table 4 and Table 5 show the results of both projects calculations under different cuts.

Table 4. Lower and higher limits for first project net present worth for different cuts

Project 1					
α	LB	UB	α	LB	UB
0.01	13017.34	17687.86	0.5	14649.79	15871.61
0.05	13534.91	17087.2	0.55	14717.85	15800.66
0.1	13803.84	16784.49	0.6	14783.07	15732.98
0.15	13980.58	16588.91	0.65	14846.03	15667.97
0.2	14117.39	16439.32	0.7	14907.16	15605.13
0.25	14231.56	16315.67	0.75	14966.86	15544.04
0.3	14331.08	16208.74	0.8	15025.44	15484.35
0.35	14420.38	16113.47	0.85	15083.19	15425.75
0.4	14502.15	16026.79	0.9	15140.37	15367.98
0.45	14578.2	15946.64	0.95	15197.21	15310.79
-	-	-	1	15253.94	15253.94

Table 5. Lower and higher limits for second project net present worth for different cuts

Project 2					
α	LB	UB	α	LB	UB
0.01	14025.76	18779.24	0.5	15755.71	16857.75
0.05	14552.19	18167.56	0.55	15822.08	16788.86
0.1	14825.76	17859.34	0.6	15886.15	16722.69
0.15	15005.56	17660.21	0.65	15948.36	16658.72
0.2	15144.75	17507.91	0.7	16009.12	16596.54
0.25	15260.9	17382.02	0.75	16068.73	16535.78
0.3	15362.17	17273.16	0.8	16127.5	16476.15
0.35	15453.02	17176.18	0.85	16185.69	16417.35
0.4	15536.23	17087.93	0.9	16243.54	16359.14
0.45	15613.61	17006.35	0.95	16301.28	16301.28
-	-	-	1	15755.71	16857.75

As shown in these tables, net present worth of these projects are (17687.86, 15253.94, 13017.34) and (18779.24, 16301.28, 14025.76). Now by the means of ranking techniques, the comparison between these two projects is available where the greater value will be selected as the more economic project. Many ranking techniques have been proposed but this article will use the method developed by Lee and Li, (1988) in the concepts of developed mean and standard deviation based on probabilistic evaluations:

$\bar{X}_p(p1) = \frac{1}{4}(l + 2m + n) = \frac{1}{4}(13017.34 + 2 \times 15253.94 + 17687.86)$ =15303.19

$\bar{X}_p(p2) = \frac{1}{4}(l + 2m + n) = \frac{1}{4}(14025.76 + 2 \times 16301.28 + 18779.24)$ =16351.89

$\rightarrow \bar{X}_p(p2) > \bar{X}_p(p1)$ → NPWP2 > NPWP1

Note that in the above formulas, the shown fuzzy triangular values are in a (l,m,n) format. The net present worth of the second project is greater than the first one and it can be concluded that the second project is better.

Conclusion

According to embedded uncertainty in economic environments, two assumptive projects and their cash flows were presented. By assuming approximation values of interest rates, bootstrapping technique generates other samples and gave various internal estimations. By summation of the estimated intervals, the related fuzzy value is obtained. The next step will get such values to calculate higher and lower limits and NPW values. The calculated NPW is a fuzzy number and fuzzy ranking techniques are necessary to make decisions. While almost all the papers in related field have assumed the interest rate known, in this proposed method the interest rate is unknown. Therefore, via using bootstrap technique the interest rate is found. Also, the rest of work can be done by many procedures, but we have used fuzzy simulation to calculate fuzzy NPW since it is simpler and faster. The advantage of proposed method will be of better calculation speed, easiness, accuracy and comprehensibility. The main contributions of this article can be described as:

- In this article, the assumption of knowing the membership function of fuzzy inputs, repeated many times in other articles, is questioned. Interest rate of any project is a set of numerical data which shows no function or probability which is used vastly in other studies and we have no time or extra budget to evaluate these data.
- The new proposed hybrid technique gave robust results while it has been received less attention in the literature.

As a direction for future works, one can suppose cash flows and capital investment as a set of fuzzy numbers without knowing their membership functions. The other interesting way would be comparing all possible bootstrapping techniques and showing their performances under different situations and constraints.

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انتخاب اقتصادی‌ترین پروژه در شرایط عدم قطعیت با استفاده از روش بوت‌استرپ و شبیه‌سازی فازی

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چکیده

این مقاله روشی را پیشنهاد می‌دهد که اقتصادی‌ترین پروژه از بین گزینه‌ها در شرایطی که مقدار نرخ بهره غیرقطعی است، یافته شود. در این مقاله، فرض دانستن تابع عضویت مجموعه‌های فازی، که یک فرض پایه‌ای در این نوع مسائل است، کنار گذاشته شده است. برای ارزیابی گزینه‌ها از شاخص ارزش خالص فعلی (**NPW**) استفاده شده است. در این مقاله فرض در دست بودن تعداد کافی داده نیز کنار گذاشته شده است و با تعداد داده کم توابع عضویت فازی شناسایی شده‌اند. استفاده از روش بوت‌استرپ و شبیه‌سازی فازی نیز باعث رسیدن به جوابی استوار شده‌اند. روش پیشنهادی این مقاله با یک مثال عددی تشریح شده است.

واژگان کلیدی

ارزش خالص فعلی، نرخ بهره فازی، تکنیک بوت‌استرپ، انتخاب اقتصادی پروژه، شبیه‌سازی فازی.

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