Patent Evaluation with a Numerical Real Option Method

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Outline

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   - Patent Application Program as A Compound Real Option
2. Numerical Patent Analysis with The Fuzzy Pay-Off Method
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   - The Fuzzy Pay-Off Method

What is a patent?

Definition

(a simplified version) A patent can be defined as a set of exclusive rights, usually granted by national governments, to make exclusive use of a new, non-obvious invention for a predetermined (limited) period of time in return for publication of the underlying invention.

Patent application

Patents do not come into existence as instantaneously as some other IPRs such as copyright. Some form of patent application process has to be gone through, in which application is made to a patent office and following examination and perhaps negotiation as to the scope of the claims allowable is very much likely to be involved. A further complication is that patent application procedures differ by country,

Patent systems

A patent system consists of patent application process and patent exploitation in the post-grant phase. Most patent systems have four major decision types confronting applicants and patentees:

- Whether to file a patent application.
- Whether to continue with the ongoing patent application at a few decision points.
- Whether to maintain any patent granted in effect or abandon it.
- How to exploit the patent once granted.

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Patent systems (cont.)

We simplify the problem to a more general case:

- Whether to file a patent application.
- We will choose to continue with the ongoing patent application at all decision points.
- Whether to commercialize the patent (patent exploitation).
- We want to maintain the patent granted in effect for n years.

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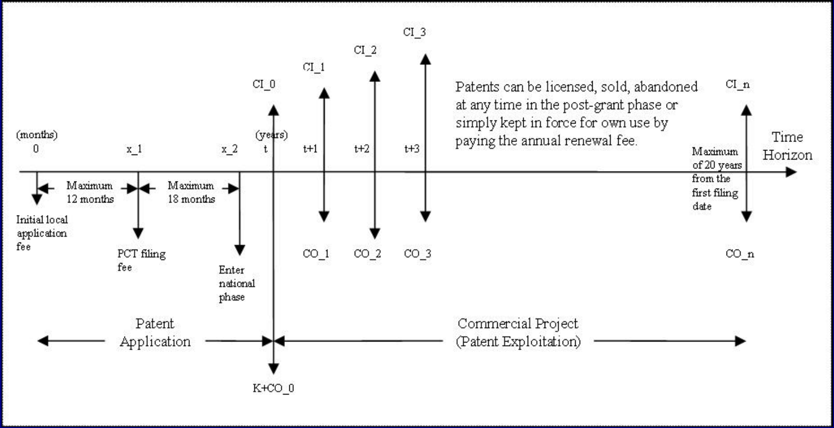
Patent application and patent exploitation



Analysis as a compound real option

Investing in patent application derives strategic value from generating the opportunity to commercialize later under the right circumstances, but implies no obligation to do so. In other words, patent application program resembles a compound real option.

Analysis as a compound real option (cont.)

To be specific, patent application program resembles a compound real option as follows:

- The first (call) option is the one to conduct patent application, whose underlying asset is the subsequent commercialization project with the corresponding strike price being the present value (as of $T = 0$) of the capital outlays for the application program I_0.
- The opportunity to invest in the follow-on commercialization project can be treated as the second (call) option with time to maturity of t years, whose underlying asset and exercise price is the present value (as of $T = 0$) of the commercial project's expected future profits and the one-off investment of K respectively.

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Fuzzy sets

A *fuzzy subset* A of a non-empty set X can be defined as a set of ordered pairs, each with the first element from X, and the second element from the interval $[0, 1]$, with exactly one ordered pair present for each element of X. This defines a mapping,

$$\mu_A \colon X \to [0, 1],$$

between elements of the set X and values in the interval $[0, 1]$.The value zero is used to represent complete non-membership, the value one is used to represent complete membership, and values in between are used to represent intermediate degrees of membership.

Fuzzy numbers

A fuzzy number A is a fuzzy set of the real line with a normal, (fuzzy) convex and continuous membership function of bounded support.Fuzzy numbers can be considered as possibility distributions.

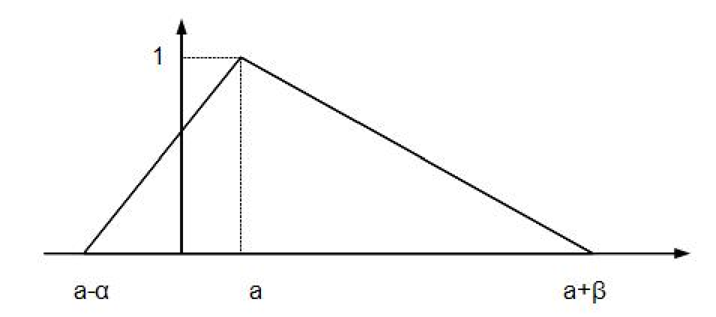
Definition

A fuzzy set A is called triangular fuzzy number with peak (or center) a, left width $\alpha > 0$ and right width $\beta > 0$ if its membership function has the following form

$$A(t) = \begin{cases} 1 - \dfrac{a-t}{\alpha} & \text{if } a - \alpha \leq t \leq a \\ 1 - \dfrac{t-a}{\beta} & \text{if } a \leq t \leq a + \beta \\ 0 & \text{otherwise} \end{cases}$$

and we use the notation $A = (a, \alpha, \beta)$.

Triangular fuzzy number



A triangular fuzzy number (with center *a*) can be seen as a fuzzy quantity

"x is approximately equal to a given real number a".

Definition

A fuzzy set A is called trapezoidal fuzzy number with tolerance interval $[a, b]$, left width α and right width β if its membership function has the following form

$$A(t) = \begin{cases} 1 - \dfrac{a-t}{\alpha} & \text{if } a - \alpha \leq t \leq a \\ 1 & \text{if } a \leq t \leq b \\ 1 - \dfrac{t-b}{\beta} & \text{if } a \leq t \leq b + \beta \\ 0 & \text{otherwise} \end{cases}$$

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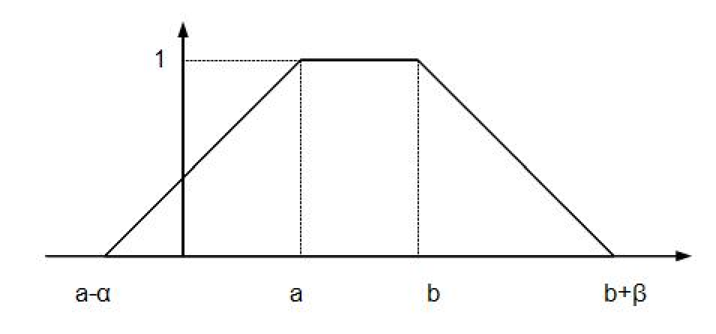
Trapezoidal fuzzy number



A trapezoidal fuzzy number (with core $[a, b]$) can be seen as fuzzy quantity

"x is approximately in a given interval $[a, b]$ of real numbers".

Why we use fuzzy numbers

- To estimate future cash flows and discount rates we usually employ educated guesses, based on expected values or other statistical techniques, which is consistent with the use of fuzzy numbers.
- When we replace non-fuzzy numbers (crisp, single) that are commonly used in financial models, with fuzzy numbers, we can construct models that include the inaccuracy of human perception.
- These models are more in line with reality, as they do not simplify uncertain distribution-like observations to a single point estimate that conveys the sensation of no-uncertainty.
- The most used fuzzy numbers are trapezoidal and triangular fuzzy numbers, because they make many operations possible and are intuitively understandable and interpretable.

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Fuzzy pay-off method

Fuzzy Pay-Off Method for Real Option Valuation is a new method for valuing real options, created in 2008. It is based on the use of fuzzy logic and fuzzy numbers for the creation of the pay-off distribution of a possible project (real option). The structure of the method is similar to the probability theory based Datar-Mathews method.

The main observations

The main observations of the fuzzy pay-off model are the following:

- The fuzzy NPV of a project is (equal to) the pay-off distribution of a project value that is calculated with fuzzy numbers
- The mean value of the positive values of the fuzzy NPV is the possibilistic mean value of the positive fuzzy NPV values.
- Real option value calculated from the fuzzy NPV is the possibilistic mean value of the positive fuzzy NPV values multiplied with the positive area of the fuzzy NPV over the total area of the fuzzy NPV.

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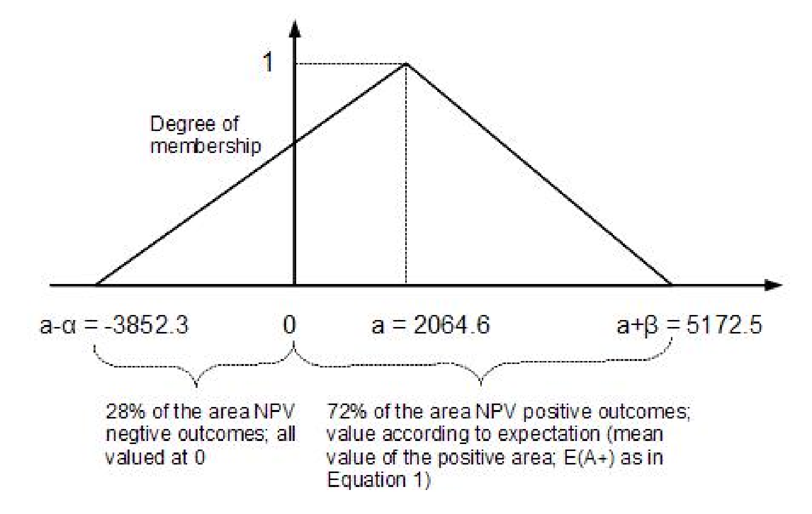
Definition

We calculate the real option value from the fuzzy NPV as follows

$$ROV = \frac{\int_0^\infty A(x)dx}{\int_{-\infty}^\infty A(x)dx} \times E(A_+), \tag{1}$$

where A stands for the fuzzy NPV (the pay-off distribution), $E(A_+)$ denotes the fuzzy mean value of the positive side of the NPV, and $\int_{-\infty}^\infty A(x)dx$ and $\int_0^\infty A(x)dx$ compute the area of the whole fuzzy NPV and the area of the positive part of the fuzzy NPV, respectively.

Example


1
Degree of membership
a-α = -3852.3
0
a = 2064.6
a+β = 5172.5
28% of the area NPV negtive outcomes; all valued at 0
72% of the area NPV positive outcomes; value according to expectation (mean value of the positive area; E(A+) as in Equation 1)