Datu Buyung Agusdinata

ASSESSING THE ROBUSTNESS OF A REAL OPTIONS STRATEGY FOR ENERGY INVESTMENT USING EXPLORATORY MODELING AND ANALYSIS

Faculty of Technology Policy and Management, Delft University of Technology
Jaffalaan 5, 2628 BX Delft The Netherlands
E-mail: b.agusdinata@tbm.tudelft.nl

Overview

Real options analysis (ROA) has been proposed as a methodology that can take advantage of uncertainty in a positive way. Its attractiveness is based on the premise that, with options, one can maximize the upside potential of a project and, at the same time, minimize its downside effects. However, handling uncertainty quantitatively is still difficult for real options analysis [1]. On the one hand, it is problematic to find a replicating portfolio of stocks or commodities in the financial market that perfectly resembles the risk profile of a real asset. On the other, the subjective approach is completely detached from the financial market. In addition to this conceptual difficulty, there are also practical ones [2]. First, the nature of decisions on real assets differs from that on financial instruments. There are only a limited number of chances to make decisions. Second, the availability and accuracy of data is different. There are less empirical data on for example joint probabilities among input variables; and even if data are available, they are less accurate.

This paper demonstrates how the exploratory modeling and analysis (EMA) approach can be used to deal with the above issues. EMA is used in combination with options pricing and the decision tree method to analyze cash flow uncertainties of a real option strategy in an electricity infrastructure investment. For this purpose, a simple investment model in a natural-gas-fueled power plant is described. The model illustrates the creation of a real option by over-dimensioning a power plant investment.

The rest of the paper shows how the insights from the application of the EMA approach are used to assess the investment robustness. The paper shows first how the approach is performed. Then two major insights are demonstrated: (i) the pattern of regret values of the real option strategy and (ii) the robustness of the real option strategy across a wide range of future scenarios. These insights allow the decision maker to test the robustness of his real option strategy by finding the scenarios that will make the strategy fail.

Methods

This paper uses a methodological approach called exploratory modeling and analysis (EMA) to deal with uncertainty in ROA. EMA broadens the limited scope taken in traditional sensitivity analysis [3]. It involves exploring as broad a range of assumptions and circumstances as are plausible, given the resources available for performing the analysis. The approach involves exploring a wide spectrum of scenarios, alternative model structures, and value systems. In handling future scenarios, EMA is also different from the decision analytic method. In EMA, all parameters are considered non-stochastic. Instead of using probability distributions on the different scenarios, ranges of plausible values are used. EMA also uses minimization of regret as its decision rule, comparing the relative performance among decisions rather than absolute values. The exploration is carried out using multiple computational experiments. A single computational experiment is a computer run for one set of assumptions about the system model, the external scenario, and the value system. Hence, a computational experiment refers in fact to a plausible hypothesis about the system.

Uncertainty about the value of future variables such as the price of natural gas or electricity can be modeled in two ways. The first way is to use a portfolio of stocks or commodities in the financial market whose risk profile resembling one of the variables in question. For this type of uncertainty, the option pricing method (e.g. binomial method) is used as the basis for value calculation. The second way is to use a more subjective approach, in which the variable's values are determined by decision tree method. In this paper, the two ways of modeling uncertainties are combined.

How the future values of the external variables will unfold is modeled in a "funnel" of future scenarios. In a future of multiple periods, one unique manifestation in first period leads to multiple manifestations in the second period, each of which will then lead to multiple realizations in the third period, and so on until the last period is reached. In this paper, the 20 year service life of the plant is divided into two periods (i.e. Period 1 and Period 2).

Results

There are two major insights that are gained from applying the EMA approach:

(i) The pattern of regret values of the real option strategy

At the end of their service life, the NPV figures of two investments -- one including a real option -- are calculated. Fig.1 below shows the regret values for investment1 (i.e. the real option strategy) at the end of Period2. The scenario path is that in Period1 the price of natural gas is Up (i.e. calculated by binomial method), the price of electricity increases by 20%, and the demand for electricity by 5% (i.e. Up, 20%, 5%). The dashed line separates scenarios of successful and failed performance. There are 44 successful scenarios out of total of 50. Table 1 identifies the regret categories.

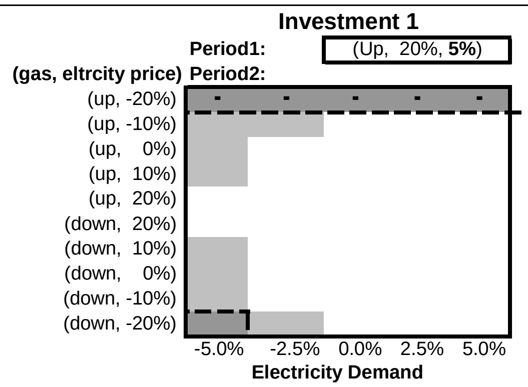

Fig.1 Pattern of regret values of the real option strategy

Table 1. Regret value categories

Category of regret	**Range of regret (in million US$)**	**Shade designation**
No regret	0 ≤ Regret ≤ 0.09	
Mild	0.1≤ Regret ≤ 14.9	
A lot	15 ≤ Regret ≤ 99.9	
Overwhelming	Regret ≥ 100	

- Note: Investment1 is a 563 MW power plant, in which an over dimensioning option is exercised. Its performances is compared with a 264 MW plant (i.e. Investment2, not shown here), resulting in regret values.
- The regret value is the difference in net present value (NPV) between Investment1 and Investment2 for the same scenario. An investment is considered successful if the NPV is positive with no or mild regret.

(ii)The robustness of performance of real option strategy across a wide funnel of future scenarios

Fig. 2 below shows the robustness of the real option strategy. The robustness score is calculated using equation1 (from [4]). The performances of the 50 scenarios at the end of period2 are collapsed into a robustness score. Next, using the categories of robustness given in table 2, the resulting scores are projected back to the scenarios at period1 that preceded them. For example, the robustness score of Investment1 in fig.1 results in robustness category I (indicated with a star in Fig. 2). As a whole, the real option strategy, by over-dimensioning, will be robust in the circumstances of high demand in period1. The boundaries between robust and non-robust performance are demarcated by the dashed lines.

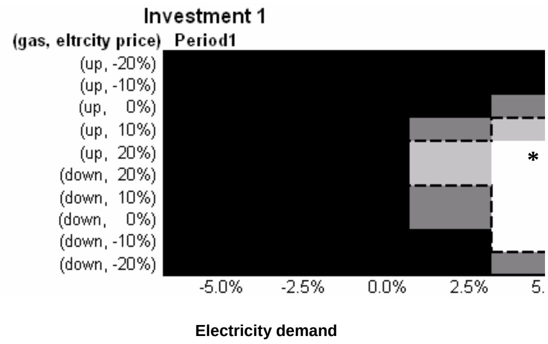

Fig.2 Pattern of performance robustness of the real option strategy

- Robustness score = $\frac{\text{no\_of \_successful scenarios}}{\text{total\_no\_of\_scenarios}}$ (1)

Table 2. Categories of performance robustness

	Robustness category	**Range of Robustness score**	**Shade designatio**
Robust performance	I	0.75 ≤ score ≤ 1	
	II	0.5 ≤ score < 0.75	
Non-robust performance	III	0.25 ≤ score < 0.5	
	IV	0 ≤ score < 0.25	

Conclusions

The paper demonstrates how the EMA approach can produce useful policy insights in cases in which the joint probabilities among input variables are unknown or disputable. Rather than pre-supposing best-guess relationships among the input variables, the EMA approach explores various plausible hypotheses about those relationships.

The two major insights are complementary. For one, the analysis of the pattern of performance robustness only indicates how many successful scenarios will be at the end of planning horizon without giving details about which scenario they are. For the other, the analysis of the pattern of regret values can track the successful or failure scenarios from the beginning until the end of the planning time horizon. The trace is based on a visual exploration, in which the emerging pattern of performance can be spotted and explained.

References

[1] Borison, A. *Real Options Analysis: Where are the Emperor's Clothes?* in *Real Options*. 2003. Washington D.C.

[2] Neufville, R.d., *Real Options: Dealing With Uncertainty In Systems Planning And Design.* Integrated Assessment Journal, 2003. **4** (Special Issue, No.1): p. 26-34.

[3] Bankes, S., *Exploratory modeling for policy analysis.* Operations Research, 1993. **41**(3): p. 435 - 449.

[4] Rosenhead, J., M. Elton, and S.K. Gupta, *Robustness and Optimality as Criteria for Strategic Decisions.* Operational Research Quarterly, 1972. **23**(4): p. 413-431.