The Analysis of Managerial flexibility of Scale Expansion for Winery Plant Projects

Borliang Chen[1] and Wein-Quaeg Lia[2]

Abstract

High market risks are embedded in mega-scale projects. These risks include political instability, economic instability, social risks, technical risks, and other non-financial factors. All these risk factors will have directly impacted on financial feasibility of projects. Hence, it is necessary to conduct an elaborate financial analysis of projects at planning stage. A binominal option-pricing model is adopted for considering the managerial flexibility of scale expansion in the financial analysis of projects to increase the project value. Then, we conduct a financial analysis of winery plant projects with the option pricing model. Results show that the timing of investment may affect the option value of the project. The best time to invest for plant expansion depends on the variance of NPV of the project.

Keyword: binominal option pricing model, the real option.

INTRODUCTION

Options can be either call or put. A call is a financial instrument that gives its owner the right, but not the obligation, to purchase the underlying asset (stocks, stock indices, etc.) at a specified price (strike or exercise price) for a specified time. A put option gives its owner the right to sell the underlying at the strike price for a specified time. There are two kinds of options: the American option can be exercised at any time before or at the expiration; the European option can be exercised only at the expiration. We shall only deal with European options. The buyer of an option pays cash the option price to the seller (or writer) who assumes all the obligations of the contract (all the rights are of the buyer).

The term "real options" was coined by Stewart Myers in 1977. It referred to the application of option pricing theory to the valuation of non-financial or "real" investments with learning and flexibility, such as multi-stage R&D, modular manufacturing plant expansion and the like. (Myers, 1977) The topic attracted moderate, primarily academic, interest in the 1980's and 1990's, and a number of articles were published on theory and applications.

Beginning in the mid-1990's, interest in the concepts of value and the techniques of valuation increased substantially. Real options began to attract considerable attention from industry as a potentially important tool for valuation and strategy. Beginning in the oil and gas industry and extending to a range of other industries, management consultants and internal analysts began to apply real options intermittently, and in some cases regularly, to major corporate investment issues. An annual real options symposium for both academics and practitioners was first organized in 1996, and continues to this day. Several practitioner books on the topic, many simply titled *Real Options*, have appeared, and more are in the works. Most mainstream academic finance texts now mention real options prominently. Conferences on the topic, with

[1] *Associate Professor, Department of Civil and Hazard Mitigation Engineering, National United University. Miaoli, Taiwan 360*

[2] *Instructor, Department of Civil and Hazard Mitigation Engineering, National United University.*

both academic and industry participants, are held regularly. The increasing number of academic articles on real options is now matched by an increasing number of stories in such mainstream publications as *Business Week* and *USA Today*. All in all, real options has made a transition from a topic of modest academic interest to considerable, active academic and industry attention.

MODELING

Let a stand for the minimum number of upward moves that the stock must make over the next n periods for the call to finish in-the-money. Thus, a will be the smallest non-negative integer such that $u^a d^{n-a} S > K$. By taking the natural logarithm of both sides of this inequality, we could write a as the smallest non-negative integer greater than $\log(K/Sd^n)/\log(u/d)$. For all $j < a$,

$$\max[0, u^j d^{n-j} S - K] = 0, \text{ and for all } j \geq a,$$
$$\max[0, u^j d^{n-j} S - K] = u^j d^{n-j} S - K$$

Therefore,

$$C = \left[\sum_{j=a}^{n} \left(\frac{n!}{j!(n-j)!} \right) p^j (1-p)^{n-j} [u^j d^{n-j} S - K] \right] / r^n$$

By breaking up C into two terms, we can write

$$C = S \left[\sum_{j=a}^{n} \left(\frac{n!}{j!(n-j)!} \right) p^j (1-p)^{n-j} \left(\frac{u^j d^{n-j}}{r^n} \right) \right] - K r^{-n} \left[\sum_{j=a}^{n} \left(\frac{n!}{j!(n-j)!} \right) p^j (1-p)^{n-j} \right]$$

Now, the latter bracketed expression is the complementary binomial distribution function $\phi[a; n, p]$. The first bracketed expression can also be interpreted as a complementary binomial distribution function $\phi[a; n, p']$, where

$$p' \equiv (u/r)p \quad \text{and} \quad 1 - p' \equiv (d/r)(1-p)$$

p' is a probability, since $0 < p' < 1$. To see this, note that $p < (r/u)$ and

$$p^j (1-p)^{n-j} \left(\frac{u^j d^{n-j}}{r^n} \right) = \left[\frac{u}{r} p \right]^j = \left[\frac{d}{r} (1-p) \right]^{n-j} = p'^j (1-p')^{n-j}$$

The bi-nominal model (CRR model)

$$\mathrm{C} = S\Phi[a; n, p'] - K r^{-n} \Phi[a; n, p]$$

where

$$\mathrm{p} \equiv \frac{\mathrm{r} - \mathrm{d}}{\mathrm{u} - \mathrm{d}} \text{and } \mathrm{p}' \equiv \left(\frac{\mathrm{u}}{\mathrm{r}} \right) \mathrm{p}$$

$$\mathrm{a} \equiv \text{the smallest non} - \text{negative integer}$$

$$\mathrm{a} \geq \log \left(\frac{\mathrm{k}}{\mathrm{Sd}'} \right) / \log(\frac{\mathrm{u}}{\mathrm{d}})$$

If a>n, then c=0. With

$$\Phi[a; n, p'] = \sum_{j=a}^{n} \left[\frac{n!}{j!\,(n-j)!} p^j (1-p)^{n-j} \left(\frac{u^j d^{n-j}}{r^n} \right) \right]$$

$$\Phi[a; n, p] = \sum_{j=a}^{n} \left[\frac{n!}{j!\,(n-j)!} p^j (1-p)^{n-j} \right]$$

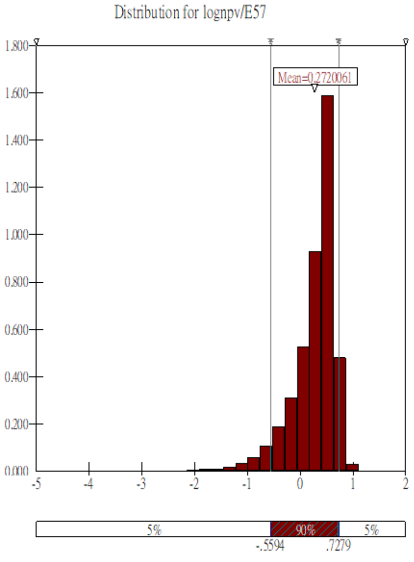
EMPIRICAL STUDY

We conduct a financial analysis of winery plant projects with the option pricing model. Results show that the timing of investment may affect the option value of the project.

Table 1: The profitability indices of three cases with various project scales

	Case 1: Base case	Case 2 Half scale	Case 3 Double scale
BC	822,512,100	543,020,590	1,288,619,360
NPV	337,253,368	244,927,206	518,792,148
IRR	15.32%	16.28%	15.03%
ADSCR	7.475	7.654	7.357
ATIE	49.085	50.046	49.197
AROA	19.698%	19.311%	20.482%
AROE	17.963%	17.559%	18.703%
SLR	2.26	2.30	2.29
Pay back year	17	14	17

In order to obtain the expected value of NPV and variance of NPV, we conduct the Monte Carlo simulation.



Name	lognpv
Cell	現金流!E57
Minimum	-4.012945
Mean	0.2720061
Maximum	1.106353
Std Dev	0.4299711
Variance	0.1848751
Skewness	-1.890618
Kurtosis	8.899336
Mode	0.4904036
Left X	-0.5594468
Left P	5%
Right X	0.7279125
Right P	95%
Diff. X	1.287359
Diff. P	90%
5th Perc.	-0.5594468
95th Perc.	0.7279125
#Errors	2859
Filter Min	
Filter Max	
#Filtered	0

Figure 1: A Monte Carlo simulation result of NPV for base case

Table 2: Monte Carlo simulation results for three cases with various project scale

	Case 1 Base case	Case 2 Half scale	Case 3 Double scale
σ	10.64%	10.25%	11.09%
T	38	38	38
N	38	38	38
r	1.03	1.03	1.03
u	1.112	1.108	1.117
d	0.899	0.903	0.895
p	0.534	0.620	0.607
1-p	0.466	0.380	0.393

There are six cases for consideration in calculation the option price, which are

Case A: project is to expand to full scale in year 2, and double scale in year 3.

Case B: project is to expand to full scale in year 2, and double the scale in year 4.

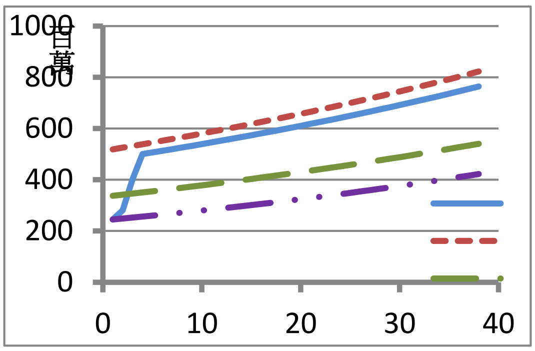
Case C: project is to expand to full scale in year 2, and double the scale in year 5.

Case D: project is to expand to full scale in year 3, and double scale in year 4.

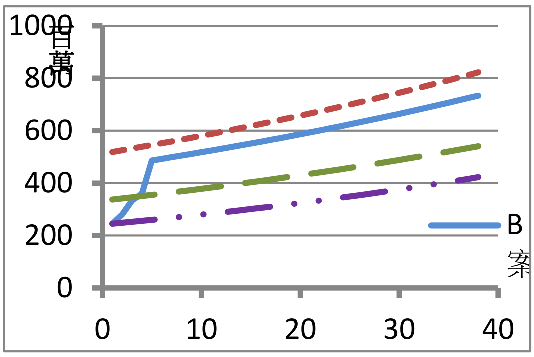
Case E: project is to expand to full scale in year 3, and double scale in year 5.

Case F: project is to expand to full scale in year 3, and double scale in year 6.

Case A



Case B



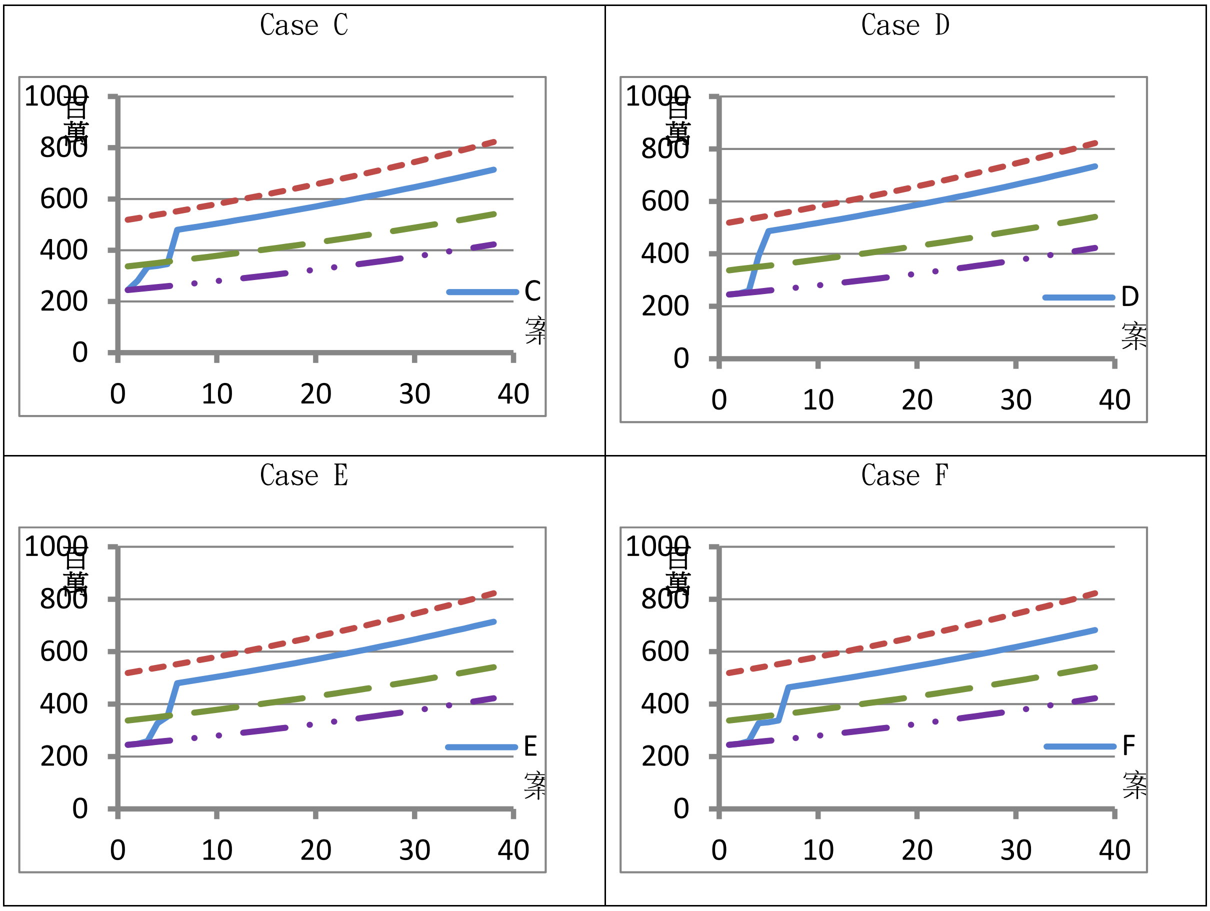


Figure 2: The cash flows of six cases

Table 3: the option price of six cases

Year	1	2	3	4	5	6
A(2,3)	35,793,987	130,716,363	132,956,710			
B(2,4)	35,793,987	63,067,802		77,966,459		
C(2,5)	35,793,987	63,067,802			25,168,716	
D(3,4)	3,634,851		91,007,305	127,555,061		
E(3,5)	3,634,851		26,150,376		80,322,929	
F(3,6)	3,634,851		26,150,376			19,926,188

CONCLUSIONS

Investment timing is always a critical issue to consider. A pricing model for different investment time of project is established in this study. We find that case A has highest option value. It is found that in period of economic growth, it is worth to expand the project scale and the option price increase. In the other word, in the period of economic recession, it would be better to reduce the project scale. And, the option price decreases.

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