Venture Capital Investment Selection Decision-making Base on Fuzzy Theory

Xubo Zhang

School of Economics and Management Wuhan Polytechnic University, Wuhan, China

Abstract

Venture capital investment decision-making is the most important issue in venture capital investment selection. There are higher uncertainty and complexity in venture capital investment decision-making process. This paper analysis these uncertain risk in venture capital investment decision-making base the previous studies. Attributed the venture capital candidate firms’ select to fuzzy optimal decision-making. Build a risk-weight fuzzy optimal return model to avoid the decision-making risk. Get the optimal solution set.

Venture capital investment is collecting excess capital from those who have it and providing it to those who require it for development of business venture by venture capitalists (Barbara & Olle, 2006). With the open of China Growth Enterprise Market in October 2009, the growth of the Chinese’ venture capital industry has been spectacular over the last two years. According to ChinaVenture’s database CVSource, there are 791 venture capital investment cases and relate to USD 3.86bn only in the throw daylight deals during 2009 to 2010 in China. There are higher uncertainty and complexity in venture capital firm selection the portfolio firms’ decision-making. For example, the portfolio firms’ CEO and/or top executives hold on growth strategy, the status of technology and market, competitive position, growth strategy and customer management and so on. These uncertain factors bring larger risk to venture capital investment decision-making. How to hold the venture capital investment decision to avoid risk is the most important stratagem at the whole investment process.

1. Literature review

Lossen (2007) divided the venture capital studies into two types: focused on explain the invest performance and focused on discuss how to choice, build and management their investment. As the first type study, Cochrance (2005) has been system studied the venture capital investment performance base on
Dowjones Ventureone database and Corporate New Issues and Mergers and Acquisition database. He measures the mean, standard deviation, alpha, and beta of venture capital investments, using a maximum likelihood estimate that corrects for selection bias.

The second type studies interested in how to choice, build and management venture capital investment. Li(2008) takes a real options perspective towards venture capital staging and views the staging decision as a choice between holding the current option to invest and investing now to obtain the option to invest subsequently. It proposes that this staging decision depends on the factors that influence the value of these two options, such as competition and various sources of uncertainty. The empirical results suggest that market uncertainty encourages venture capital firms to delay investing at each round of financing, whereas competition, project-specific uncertainty and agency concerns prompt venture capital firms to invest sooner. Li & Mahoney (2009) analysis of 18,678 initial investments during 1980 – 2007 provides supportive evidence for the delay effect of market uncertainty and the attenuating effects of sales growth and competition on the relationship between market uncertainty and the timing of initial funding. It is evident from their study and others (e.g., Cochrane, 2005; Gompers et al., 2008) that absent sufficient information about private entrepreneurial companies, public market information is highly relevant to venture capitalists’ investment decisions. Kung & Wen (2007) evaluation the finical performance of Taiwan venture capital investment enterprises use grey relational analysis and grey decision-making. they used the ability of pay short-term debt, cash-flow ratio and cash reinvestment ratio, capital structure, profitability, growth rate, operating efficiency on assets to classify twenty items of financial ratios as research variables through the Globalization Grey Relational Analysis (GRA), to find the significant financial ratio variables and other financial indicators affecting the financial performance of venture capital enterprises in Taiwan, analyze the six variables of firm attributes and the differences between using different firms’ attribute variables and financial performance of venture capital enterprises as the result. Lauterbach, Welpe & Fertig (2007) found the experiences of venture capital firm investment have a positive influence to reduce venture capital investment lose and not use to optimum the investment return.

2. Venture capital decision-making evaluation factors

Considering the venture capital firms decision their investment depend on the investment projects’ expect return and risk, the prospective return and risk should be two sub objective under the overall objective of risk adjust return. In order to classify the risk each individual aspect could have on the ability to realize a venture capital investment’s value, this paper setting management, operation, strategy, transaction and cost five first level evaluation indicators and “Quality of management and key staff” etc. 18 sub-indicators as the secondary evaluation indicators. The venture capital investment decision-making indicators system can be expression as Table 1.

The evaluation indicator of candidate firm’s “management” included in the four aspects. How about the portfolio firms’ CEO and/or top executives hold on growth strategy is the key factor of assessment quality of management and key staff in the category of management. This included in the relationship between the portfolio firm and sales-force, the response to competitive moves and execute on defined initiatives. The planning and accountability and the compensation of Key staff have a significant influence on the quality of management. The information management and report in management indicator included in Sales plans defined or measured, Product profitability and the sales pricing.

The evaluation indicator of candidate firm’s “operation” included in the four aspects. At the status of technology and market is certain the firm’s profitability depend on the ability of firm’s operation management. This requires detail operation planning and high quality operation management and efficiency. The better operation can output greater investment return with lower cost. In the aspect of operation assessment, the revenue/profitability plan’s content and implementation, expense management
status, operational plans’ content and implementation and operation process quality and efficiency are the sub-assessment indicators.

The “strategy” is the key of venture capital investment realize profit. In the aspect of strategy assessment, the market trends, Competitive position, Growth strategy and Customer management are the sub-assessment indicators. The growth strategy and customer management have a significant influence in the assessment of strategy. The growth strategy mention the sale planning’s defined and measure mainly. It affects the firm’s development speed and direction. The customer management assessment improved CRM can or can not provide significant opportunity to cross-sell products. This is basic of firm development. The better customer management can discover the market’s need timely.

The firm’s value realization, add-on acquisitions and exit is the mainly risk in aspect of transaction assessment. The venture capital investment value realization and its time (the exit time) the venture capital investment’s key. If the value realization can not be expect realization or the time is too long, the venture capital investment will not be accepted by the investor. The accretive add-on acquisitions and exit is the key factor to assessment the transaction. The accretive add-on acquisition is the additive item to venture capital firm. Limited strategic buyers is the mainly gist of assessment exit.

The venture capital investment “cost” is the fundament of investment decision-making. The investment cost can be assessment from financial cost, input-output ratio and asset structure. The financial cost is very important to venture capital investment to realization investment return especially in buyout venture capital investments as them required a larger amount of money than other kind venture capital. The firm’s asset structure influence the venture capital investment’s financial structure and further investment cost. The input-output ratio is the basic measure standard in investment cost assessment.

Table1. Venture Capital Investment Decision-Making Evaluation Factor

| First Assessment Indicator | Secondary Assessment Indicator                   |
|----------------------------|-------------------------------------------------|
| Management                 | Quality of management and key staff             |
|                            | Planning and accountability                     |
|                            | Compensation                                    |
|                            | Information management and reporting            |
| Operation                  | Revenue/ profitability plan                     |
|                            | Expense management                              |
|                            | Operational plans                               |
|                            | Process quality and efficiency                  |
| Strategy                   | Market trends                                   |
|                            | Competitive position                            |
|                            | Growth strategy                                 |
|                            | Customer management                             |
| Transactions               | Value realization                               |
|                            | Accretive add-on acquisitions                   |
|                            | Exit (timing envisaged)                         |
| Cost                       | Financing cost                                  |
|                            | Input-output ratio                              |
|                            | Asset structure                                 |
3. **Fuzzy optimal decision-making model on venture capital investment**

3.1 **Problems described**

The venture capital firm has been selected \( n \) candidate investment firms through the initial screening. \( S = \{ S_1, S_2, \cdots, S_n \} \) is the candidate firm set. There are \( m \) evaluation indicators in the evaluation. \( U = \{ U_1, U_2, \cdots, U_m \} \) is the alternative candidate firms evaluation indicators set. \( 1 \sim q \) indicators are quantitative evaluation indicators, the \( (q+1) \sim m \) indicators are qualitative evaluation indicators. These evaluation indicators are more benefit the great type or more benefit the smaller type. The venture capital firm chooses one or more candidate firm give their investment.

3.2 **Set decision-making indicators evaluation matrix**

Evaluate the alternative candidate portfolio firms according to the evaluation experts’ past experience use a scoring. Non-dimensional quantitative indicators and determine the relative evaluation value of qualitative indicators through duality contrast sort. Get the all \( m \) evaluation indicators relative excellent matrix \( R \).

\[
R = \begin{bmatrix}
    r_{11} & r_{12} & \cdots & r_{1n} \\
    \vdots & \ddots & \cdots & \vdots \\
    r_{q1} & r_{q2} & \cdots & r_{qn} \\
    r_{(q+1)1} & r_{(q+1)2} & \cdots & r_{(q+1)n} \\
    \vdots & \cdots & \cdots & \vdots \\
    r_{m1} & r_{m2} & \cdots & r_{mn}
\end{bmatrix} = (r_{ij})_{m \times n}
\]

As has been mentioned in selection 3, this paper use candidate firms’ management, operation, strategy, transaction and cost as first level evaluation indicators. 18 secondary evaluation indicators are used as description in section 3. We set the risk-adjusted returns as the overall evaluation objective building a venture capital decision-making indicators system.

3.3 **determine indicators weight**

The different evaluators have different indicators evaluation weight in the venture capital investments’ selection. The traditional methods usually adopt AHP or experts’ opinion survey method to get the weight set. These methods have stronger subjectivity and weakness objectivity. In this paper, we use entropy weight method to avoid subjective judgments’ uncertainty. The \( i \) indicator’s weight under objective \( c \) is:

\[
w_{ij} = \frac{(c_i)w_i}{\sum_{j} (c_i)w_j}
\]

\[(c_i)w_i = 1 - e^{-K \sum_{j} p_{ij} \ln p_{ij}}, K = 1/\ln n, 0 \leq e^{-K} \leq 1, i = 1, 2, \cdots, m, j = 1, 2, \cdots, n.\]

3.4 **Determine optimal reference vector and worst reference vector**

Selection each indicator’s optimal value compose optimal reference vector \( G \) in standardization \( R \). Selection each indicator’s worst value compose worst reference vector \( B \) in standardization \( R \). Under the sub-objective \( c \) \( (c = R, F) \), the optimal reference vector and worst reference vector respectively is:

\[
G^{(c)} = (G^{(c)}_1, G^{(c)}_2, \cdots, G^{(c)}_m)^T, \quad G^{(c)}_j = \max_i r_{ij}, \quad B^{(c)} = (B^{(c)}_1, B^{(c)}_2, \cdots, B^{(c)}_m)^T, \quad B^{(c)}_j = \min_i r_{ij},
\]

\[i = 1, 2, \cdots, m, \quad j = 1, 2, \cdots, n.\]
3.5 Calculated distance to the optimal value and worse value

Suppose $Z_{j}^{+}$ is candidate firm $j$ subject degree relative to optimal value under objective $c$, thus $1 - Z_{j}^{+}$ is candidate firm $j$ subject degree relative to worse value under objective $c$. The distance to optimal value with subject degree as weight is:

$$
D_{j}^{(c)} = Z_{j}^{+} \left( \sum_{i=1}^{m} \left( \frac{w_{i}(G_{i}^{(c)} - r_{i}^{(c)})}{\rho} \right)^{p} \right)^{\frac{1}{p}}
$$

(2)

$\rho$ is distance parameter. The distance to worse value with subject degree as weight is:

$$
D_{j}^{(c)} = Z_{j}^{+} \left( \sum_{i=1}^{m} \left( \frac{w_{i}(r_{i}^{(c)} - B_{i}^{(c)})}{\rho} \right)^{p} \right)^{\frac{1}{p}} = (1 - Z_{j}^{+}) \left( \sum_{i=1}^{m} \left( \frac{w_{i}(r_{i}^{(c)} - B_{i}^{(c)})}{\rho} \right)^{p} \right)^{\frac{1}{p}}
$$

(3)

3.6 Determine optimize rule and optimal investment objective firm

Use weight distance’s square summation to optimal and worse value minimum as optimization rule build optimization objective function:

$$
\min F(Z_{j}^{(R)}) = (D_{j}^{(R)})^2 + (D_{j}^{(B)})^2 =
$$

$$
(Z_{j}^{+})^2 \left( \sum_{i=1}^{m} \left( \frac{w_{i}(G_{i}^{(R)} - r_{i}^{(R)})}{\rho} \right)^{p} \right)^{\frac{2}{p}} + (1 - Z_{j}^{+})^2 \left( \sum_{i=1}^{m} \left( \frac{w_{i}(r_{i}^{(R)} - B_{i}^{(R)})}{\rho} \right)^{p} \right)^{\frac{2}{p}}
$$

(4)

$$
\min F(Z_{j}^{(P)}) = (D_{j}^{(P)})^2 + (D_{j}^{(B)})^2 =
$$

$$
(Z_{j}^{+})^2 \left( \sum_{i=1}^{m} \left( \frac{w_{i}(G_{i}^{(P)} - r_{i}^{(P)})}{\rho} \right)^{p} \right)^{\frac{2}{p}} + (1 - Z_{j}^{+})^2 \left( \sum_{i=1}^{m} \left( \frac{w_{i}(r_{i}^{(P)} - B_{i}^{(P)})}{\rho} \right)^{p} \right)^{\frac{2}{p}}
$$

(5)

Let objective function’s first derivative equal to 0, thus

$$
\frac{dF(Z_{j}^{(R)})}{dZ_{j}^{+}} = 0
$$

(6)

$$
\frac{dF(Z_{j}^{(P)})}{dZ_{j}^{+}} = 0
$$

(7)

The solution is:

$$
Z_{j}^{+} = \left( \frac{\sum_{i=1}^{m} \left( \frac{w_{i}(G_{i}^{(R)} - r_{i}^{(R)})}{\rho} \right)^{p}}{\sum_{i=1}^{m} \left( \frac{w_{i}(r_{i}^{(R)} - B_{i}^{(R)})}{\rho} \right)^{p}} \right)^{\frac{1}{p}}
$$

(8)

$$
Z_{j}^{+} = \left( \frac{\sum_{i=1}^{m} \left( \frac{w_{i}(G_{i}^{(P)} - r_{i}^{(P)})}{\rho} \right)^{p}}{\sum_{i=1}^{m} \left( \frac{w_{i}(r_{i}^{(P)} - B_{i}^{(P)})}{\rho} \right)^{p}} \right)^{\frac{1}{p}}
$$

(9)

Use $Z_{j}^{+}$ as weight, get maximum return subject degree $\beta_{j}$ as final objective value:

$$
\beta_{j} = Z_{j}^{+} \cdot Z_{j}^{+}
$$

(10)
Compared $\beta_i$, the maximum $\beta_j$ is the optimal investment candidate firm.

4. Examples

A venture capital firm wants to give investment to a private company with better prospects in market. There are four candidate firms through the initial screening. The venture capital firm need decision an optimal investment object to achieve risk-weight return maximum objective. The candidate firms are $S_1$, $S_2$, $S_3$, $S_4$. The venture capital investor would select one or two candidate to investment.

4.1 Determine evaluation matrix

Suppose $U = (U_1, U_2, U_3, U_4, U_5)$ is the venture capital investor evaluating candidate firms’ indicators set. Where $U_1$, $U_2$, $U_3$, $U_4$, and $U_5$ indicated candidate firms’ cost, management, operation, strategy and transaction. 18 sub-indicators are used to evaluate these five first level indicators. The experts give each candidate’s scale in each secondary level indicator under return and risk sub-objective and get a first level indicator matrix:

$$ R^a = \begin{bmatrix} 0.692 & 0.790 & 1 & 0.728 \\ 0.734 & 1 & 0.541 & 0.445 \\ 1 & 0.405 & 0.905 & 0.677 \\ 0.423 & 0.543 & 0.7 & 1 \end{bmatrix}, \quad R^r = \begin{bmatrix} 0.692 & 0.790 & 1 & 0.728 \\ 1 & 0.53 & 0.87 & 0.78 \\ 0.405 & 1 & 0.905 & 0.677 \\ 0.323 & 0.543 & 1 & 0.3 \end{bmatrix} $$

4.2 Determine weight

We use entropy weight method described in 4.3 to determine the each indicator’s weight under return and risk sub-objective:

$$ w^r = (0.312, 0.204, 0.291, 0.193)^T, \quad w^a = (0.293, 0.301, 0.271, 0.134)^T $$

Determine optimal reference vector and worse reference vector

The optimal reference vector about candidate firm’s cost, management, operation, strategy and transaction under the return sub-objective is: $G^r = (1, 1, 1, 1, 1)^T$. The worse reference vector about candidate firm’s cost, management, operation, strategy and transaction under the risk sub-objective is $B^r = (0.692, 0.445, 0.405, 0.423)^T$. The optimal reference vector about s about candidate firm’s cost, management, operation, strategy and transaction under the risk sub-objective is: $G^a = (1, 1, 1, 1, 1)^T$. The worse reference vector about candidate firm’s cost, management, operation, strategy and transaction under the risk sub-objective is: $B^a = (0.692, 0.69, 0.45, 0.3)^T$.

4.3 Determine optimal candidate firm

Let distance parameter $\rho = 1$. Calculate candidate firms’ relative optimal subjective degree value due to formula (8) and (9):

$$ Z^{+} = (0.44, 0.21, 0.76, 0.32), \quad Z^{-} = (0.045, 0.365, 0.994, 0.071) $$

Calculate each candidate firms’ subjective optimal value degree use formula (10):

$$ \beta = (0.020, 0.075, 0.75, 0.023) $$

The $\beta$ value of $S_3$ is the biggest in all candidate firms. This means the $S_3$ have biggest risk adjusted return. Thus the venture capital investor should select $S_3$ as investment object.

5. Conclusion

Comprehensive evaluation the alternative candidate firms to avoid the venture capital investment risk and maximize the investment return is the main objective venture capital investment decision-making. As the venture capital itself has non-transparent, non-liquid characteristics, it faces many endogenetic and
exogenous risks in the operation process. The venture capital investment decision-making is the most important issue to venture capital firm. There are many uncertain factors in venture capital decision-making. Thus the venture capital investments decision-making have some fuzzy characteristics. This paper analysis the possible risk exists in the venture capital investment decision-making. Evaluation the venture capital investment risk exists in the investment decision-making process use fuzzy optimal build a risk-weighted optimal return model to avoid the risk in the venture capital investment decision-making. Get the optimal investment selection set. An example is used to demonstrate our fuzzy optimal risk avoiding model.

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