

Research Process of Two-Sided Matching in Venture Capital

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Abstract: Venture capital supports not only to the continual increase of the size of start-up companies, but also to their research and innovation, thereby transforming scientific and technological advantages into competitive advantages. Venture capital would enhance the competitive advantage of businesses and assist them in reaping a double harvest of dollars and reputation. It is vital that venture capital institutions and startups are matched in a reasonable, steady, and effective manner. This study covers the evolution and research process of two-sided matching between venture capital institutions and start-up businesses through a literature review. With the ongoing evolution of society, matching decisions in venture capital are also evolving. The promotion of economic growth and technical innovation, as well as the improvement of international competitiveness, can be aided by the reasonable and efficient pairing of venture capitalists.

Keywords: two-sided matching, venture capital, axiomatic design, prospect theory

1. Introduction

Entrepreneurship ventures are vital to the economy [1]. Venture capital not only contributes to the continual increase of the size of start-up businesses, but also helps to improve their varied growth capacities, such as R&D and innovation, so enhancing their competitive edge and allowing them to grow larger and stronger [2]. Institutions of venture capital participate in investments and chase large profits generated by technology or service innovation. When introducing venture capital, venture businesses not only receive monetary support, but also utilize the participation of venture capital enterprises to develop the firm's reputation, present its value-added services, and improve the value of the company. In practice, the development of venture capital is a two-way selection process that requires the unanimity of both sides. Hence, the appropriate and efficient pairing of venture capital institutions and venture firms is advantageous for enhancing the effectiveness and success rate of venture capital activities. Currently, there are numerous research on the matching of venture capital institutions and startups. Cao Guohua and colleagues use Gale & Shapley's college admission model and combine it with the reality of venture capital to develop a two-sided matching model to examine the two-way selection interaction between venture funders and entrepreneurs [3-4]. On the basis of two-sided matching between venture capital institutions and venture enterprises, Chen Xi and colleagues further considered their expected level and actual level, and provided a matching decision analysis method based on axiomatic design [5]; Considering the problem of two-sided matching and selection of venture capital in the context of Internet finance, and taking into account the

psychological expectation of venture capital investors and venture enterprises in two-way selection, Wu Feng put forward a decision model of two-sided matching of venture capital investment based on prospect theory [6].

This paper explores the development and research process of two-sided matching between venture capital institutions and start-up enterprises through a method of literature review and introduces different two-sided matching selection decisions from the two-way selection relationship established by venture capital, to the matching decision analysis method based on axiomatic design, and then to the multi-index decision-making characteristics aiming at the psychological equivalence. In the matching problem between venture capital institutions and start-up businesses, the demand information of matching subjects is multi-level and multi-type due to the complexity and unpredictability of financial market information [7]. Thus, the two-sided matching problem in venture capital will keep changing as society evolves. The repeated perfection of bilateral decision-making has provided a significant drive for the nation's economic progress and greatly encourages the efficient allocation and sensible use of social resources.

2. Two-way Selection Relation

Sorensen finds that companies backed by venture capitalists with greater experience are more likely to go public [8]. This implies that before forming an investment connection, venture capitalists and entrepreneurs must select one another according to their respective evaluation criteria, with the outcome having a significant impact on the startup company's performance and profitability. To maximise the benefits of start-ups, both venture capitalists should evaluate each other based on their respective criteria. This closely resembles Gale & Shapley's study on the College Entrance Issue [3]. Cao Guohua and others consider the two-sided matching game model to be an efficient solution for addressing this type of issue. In the two-sided matching game of venture capital, venture capitalists select matching venture firms to invest in, and entrepreneurs select matching venture capitalists to provide financing [4].

Gale and Shapley devised a "delayed acceptance" algorithm to solve the equilibrium of the two-sided matching model, which is also applicable to the two-sided venture capital matching model [3-4]. The approximate solution procedure is as follows. In the first step, entrepreneurs submit business plans to the venture capitalists they believe to be the greatest match based on the value of the business plan. After receiving the business plans, venture capitalists approve the applications of the top q entrepreneurs based on the matching values, while rejecting the applications of other entrepreneurs. All applications will be considered if the number of entrepreneurs presenting business proposals is less than their investment capacity. The rejected entrepreneur presents a business proposal to the second-best venture capitalist in the second step. According to their matching value and residual investment capacity, venture capitalists accept the financing applications of the most successful entrepreneurs and reject those of the others. When all company plans submitted by entrepreneurs are accepted by venture capitalists, or when all venture capitalists' investment capabilities are met, the two-sided matching procedure for venture capital will end.

3. Two-sided Matching Scheme Based on Axiomatic Design

Chen Xi and others proposed the two-sided matching decision analysis method based on axiomatic design, which effectively measured the expected level and actual level of venture capital and start-up enterprises for evaluation indicators, took into account the needs or requirements of both venture capital parties, and then achieved satisfactory matching results for both parties [5].

There are three primary entities in the matching process between venture capitalists and start-up businesses: venture capitalists, start-up businesses, and investment intermediaries. Investors in

venture capital are investment operators. Venture capitalists are necessary for the growth of entrepreneurial firms. The investment intermediary is responsible for summarizing the information of both parties, doing a thorough research and objective appraisal of both parties, and matching them as closely as feasible to their respective objectives or requirements.

To construct a matching evaluation index system for mutual evaluation between venture capitalists and venture enterprises, the relevant literature is analyzed and sorted, and the matching evaluation index systems for venture capitalists to venture enterprises (table 1) and venture enterprises to venture capitalists (table 2) are in both established [5].

Table 1: The matching evaluation index system of venture capitalists to venture enterprises (original) [5].

Indicator	Indicator description
Payback period of investment (C1)	The time from the expected investment project of the venture enterprise to the date when the accumulated total amount reaches the total investment.
Annual return on investment (C2)	The ratio of annual profit to total investment of a venture enterprise measures the profitability of the venture enterprise.
Technical level (C3)	Novelty and advancement of technology (or product), as well as the leading domestic and foreign expertise, copyright, formula, brand, franchise and franchise operation.
Ability to avoid risks (C4)	The ability of venture enterprises to avoid the development risk and marketing risk of technology (or products)
Accessibility of the market (C5)	Technical barriers and trade barriers in the target market, and the market competitiveness of major competitors.
Entrepreneur quality (C6)	Venture entrepreneurs' sense of responsibility, self-realization motivation, innovation ability, leadership and organization ability, communication and cooperation ability, professional and technical ability and entrepreneurs' time in the industry.
Investment environment (C7)	The geographical location, traffic conditions, economic development level and investment environment of the surrounding areas where the venture enterprise is located.
Tax preference (C8)	Risk enterprises enjoy preferential policies provided by the government and the possible future situation, especially the preferential policies on market access, tax reduction and exemption, etc.

Table 2. Matching evaluation index system of venture enterprises to venture capitalists (original) [5].

Indicator	Indicator description
Investment quota (X1)	The investment quota that ventures capitalists can provide for each venture enterprise.
Investment strength (X2)	The existing total capital scale of investors, the number and investment scale of venture enterprises that investors have invested in.
Investment success rate (X3)	The success rate of venture enterprises that investors have invested in.
Reputation (X4)	The reputation evaluation of investors investing in other venture enterprises.
Entrepreneur quality (X5)	Venture capitalists' sense of responsibility, self-realization motivation, innovation ability, leadership and organization ability, communication and cooperation ability, professional and technical ability and entrepreneurs' time in the industry.

Axiomatic design is a design theory proposed by Professor Suh of Massachusetts Institute of Technology [9], who distills the essence of the design process by studying and summarizing an extensive number of effective design instances. Three parameters must be considered throughout the design phase of applying the information axiom: design scope, system scope, and public scope. Public interval can be used to measure the information capacity between actual level and expected level.

When the actual level is highly consistent with the expected level and the "public scope" is close to the "system scope", the information capacity of the indicators calculated by the information axiom is small; When the actual level meets the requirements of the expected level the best, the "public range" is equal to the "system range" and the index information capacity is at its smallest, or zero; When the actual level is not in close agreement with the projected level, the "open range" is relatively small and the information capacity of the acquired indicators is high. When the actual level does not satisfy the requirements of the expected level and the "common range" is zero, the information capacity of the obtained indicators is ∞ , and the two-sided matching scheme created by the corresponding matching subjects is deleted. Thus, the axiomatic design-based method can be utilized to find a good two-sided matching scheme.

4. Two-sided Matching Scheme Based on Prospect Theory

In the context of online finance, there are few options for matching the two parties, hence investment intermediaries are required. The investment intermediary calculates the profit and loss decision matrix of the actual level of the matching parties relative to the reference point, calculates the prospect value of the matching parties' satisfaction based on prospect theory, and then standardizes the prospect value to obtain the comprehensive prospect value of the matching parties. After constructing a dual-objective function programming model with the objective of maximizing the total prospect value of both parties' satisfaction, the matching outcomes are achieved once the model is solved.

Kahneman and Tversky introduced the prospect theory in 1979. This idea splits the decision-making process of decision-makers into two stages: editing and assessment. In the editing phase, decision-makers establish a reference point and edit all potential decision outcomes as gains or losses relative to the reference point. In the evaluation phase, the decision-maker reviews each prospect that

has been altered, makes a selection, and then selects the best candidate [6]. In accordance with prospect theory, decision makers are risk-averse when confronted with benefits, risk-preferring when confronted with losses, and more sensitive to losses. Considering the psychological expectations of both parties, the reference point for the prospect theory is the psychological expectations of both sides. If the assessment value of the venture firm is more than the venture capital institution's expectation value, the psychological feeling of the venture capital institution is positive (win), and vice versa. The psychological sensations of entrepreneurial companies are favorable if the evaluation value of venture capital institutions is greater than their expectation value, and vice versa.

Supposing that the prospect value of venture capital x_i institutions to start-up enterprises y_j is $V(F_{ij}^x)$, the prospect value of start-up enterprises y_j institutions to venture capital x_i is $V(F_{ij}^y)$. $V(F_{ij}^x) = \sum_{i=1}^n [u_i^x \cdot v(f_i^x)]$, $v(f_i^x)$ is the prospect value of the single indicator profit and loss value of x_i to y_j ; $V(F_{ij}^y) = \sum_{j=1}^m [u_j^y \cdot v(f_j^y)]$, $v(f_j^y)$ is the prospect value of the single indicator profit and loss value of y_j to x_i .

$$v(f_i^x) \begin{cases} (f_i^x)^\alpha, & f_i^x > 0 \\ 0, & f_i^x = 0 \\ -\lambda(-f_i^x)^\beta, & f_i^x < 0 \end{cases}$$

According to the prospect theory, $0 < \alpha < 1, 0 < \beta < 1$. When venture capital institutions (start-ups) gain from the reference point (expected value), they are concave functions (risk aversion) and convex functions (risk preferent) when they lose. On this basis, the prospect decision matrix is established in turn, the comprehensive prospect value is determined, and the target programming model is constructed and solved.

5. Conclusion

This paper describes the research progress of two-sided matching in venture capital, from the construction of two-way selection relationship to the matching between the expected level and the actual level of venture capital based on axiomatic design, and finally to the application of prospect theory and prospect value in venture capital, through a review of the relevant literature. Yet, venture capital is a complicated, diverse, and polymorphic process, and there are many more elements to consider than those discussed in this study. Various analysis perspectives, analysis approaches, and analysis backgrounds will continuously optimize the matching problem in venture capital. As society and the economy continue to evolve, the matching theory in venture capital will be steadily refined, and more and more researchers will commit themselves to the study of this type of problem and continue to do so in order to find the ideal answer.

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