Research paper

The stochastic incentive effect of venture capital in partnership systems with the asymmetric bistable Cobb–Douglas utility

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A B S T R A C T

Partnerships, between multiple sides that share cooperative goals, strive for mutual benefit, and acknowledge a high level of mutual interdependence, are ubiquitous both between and within the enterprises, and the internal or external stochastic factors driving competition and cooperation are the fundamental characteristics of partnership systems. Thus motivated, we establish an over-damped Langevin equation to describe the stochastic dynamical behaviors of the enterprise subject to asymmetric bistable Cobb–Douglas utility (CDU) potential. Due to the contemporaneous presence of periodic capital-product switches and stochastic fluctuations of internal and external capital environment, the stationary response of partnership systems is driven by the combination of the two driving effects cooperatively cause the enterprise to switch between the two utility equilibriums, and produce the maximum of stochastic incentive effect in the statistical sense. Based on the two-state theory, we derive the analytical results of performance measurement, including output signal-to-noise ratio (SNR), stationary unit risk-return (URR) and the incentive risk, which are divided into two categories: systematic risk and bilateral risk. Finally, one true example are introduced, and our proposed model is used to fitly explain the 'U'-shape phenomenon observed from small and medium-sized enterprise (SME) samples. The purpose in this paper is to develop a quantitative method and the associated prototype system try to answer the questions of how the venture capital incents the partners especially associated with partnership success, what roles the internal and external risks play respectively, and how to avoid risk resonance and create portfolio strategies of introducing venture capital and optimizing the portfolio risk.

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1. Introduction

Partnership systems can be defined as the purposive strategic relationships between the two or more sides that share compatible goals, strive for mutual benefit, and acknowledge a high level of mutual interdependence [1]. They join efforts, including their time, technology, resource, etc., to achieve goals, gaining competitive advantage in the marketplace, such as

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accessing to new technologies, improving the ability to provide a wider range of products or services, achieving economies of scale in joint research or production, increasing the knowledge self-accumulation beyond the boundaries, and sharing risks [2–5], and all these cannot be attained easily by each side, acting alone. Therefore, partnerships are nearly the ubiquitous characteristics of small and micro enterprises (SMEs), in which the cooperatively combined resources may improve the ability of attracting external venture capital to grow rapidly [6,7]. In recent years, the number of attempted partnerships has grown almost geometrically, while the rate of success keeps at a low level, and all these prescriptions often overlook the drawbacks of such relationships, for instance, the increase of complexity, loss of autonomy, and even the potential vicious competition caused by information asymmetry.

From the micro perspective of intra-enterprises, the purposive strategic relationships in partnership systems can be decomposed into two essential aspects, competition and cooperation, which are randomly evolved with the periodic switches between capital and product. That is, capital-to-product is mainly accomplished by the master of technology resources (technology side), and product-to-capital is dominated by the master of marketing resources (marketing side). Actually, as large as an enterprise and as small as a project, in all walks, their development contains many kinds of intrinsic periodic structures, in which different products have different research and development (R&D) cycles and market transformation cycles. Simultaneously, motivated by the introduction of external venture capital, the rhythm synchronism between the internal and external environments can affect or magnify the efficiency of capital-product switches. Even in large enterprises, the complicated business flows can be also decomposed into multiple stochastic capital-product switching processes, in which different roles of multilateral masters are involved, and the processes, with different duration periods, can be further considered as mutually independent or correlative. Therefore, individual process of stochastic evolution, associated with bilateral competition and cooperation, is the elementary unit to describe the incentive behaviors in complicated partnership systems driven by external venture capital.

Although extensive academic literatures show that researchers are gradually becoming aware of this important managerial concern [2,4,5], little guidance has emerged on how to better ensure partnership success quantitatively, and how to measure the different risks of partnership systems based on the stochastic dynamical behaviors. Another neglected aspect is the importance of measurement of venture capital, which is characterized by the following salient features: on one side, the infusion of capital occurs in some crucial stages of capital-product switches, matching investment decisions based on information that arrives over time, on the other side, venture capitalists intervene very actively in the management of the enterprises that they fund: they use their experience, contacts, and reputation in order to provide advice to the entrepreneurs, especially with regard to issues such as the selection of qualified personnel or the dealing with suppliers and customers. In most cases, the incentive to guarantee the continuation of the project on to the next developing stage, by exerting effort in order to inspire the enterprise from one utility equilibrium towards the other equilibrium with a certain probability, is sufficient to keep the entrepreneurs' moral hazard problem under control [8,9]. Therefore, the presence of venture capital accompanied by periodical capital-product switching process, profitably leads to the enterprise state hopping between two wells, and the partnership system probably keeps the globally stable state. Strictly speaking, this holds only in the statistical sense.

Here it is supposed that the target enterprise has initial investment, and requires external venture capital to develop the new product. This funding can be the investment portfolio, which is provided by a large number of venture capitalists, and it can also be from the cash pool employed by companies holding funds at almost all financial institutions [10,11]. It saves the net interest by balancing the negative and positive accounts, and one source of benefits arises from the reduced volatility and counterparty risk of the net accumulated cash flow due to the diversification. With the introduction of internal investment and venture capital, the product-capital structure can be divided into four stages: start-up, product improvement, market expansion and cash-out return. At the initial time of product development, nobody knows the projects potential profitability, and only internal initial investment is put into the project at the start-up stage. Gradually, some supportive information gets revealed, and the potential profitability becomes observable, and external venture capital as the financial contract is involved to further R&D. Then, the project is followed by the product improvement stage. At the initial time of market transformation, named market expansion stage, market revenue is always less than expansion input, and then enterprise enters the cash-out stage after cash-burn state. The realization is assumed to be observable and verifiable, and the efforts from two sides are contributed throughout the whole process. Nevertheless, under the insufficient capital condition, the development plan has to be adjusted according to the total input, and the enterprise traps at a low level of capital-product switches. That is, one option is the enforced cut on technical investment to ensure the marketing expenses, which will make the enterprise be situated near the utility equilibrium of marketing-side. Conversely, the proposed cut on marketing expenses will leads to the other local stable state, which corresponds to the maximum utility of technology-side. Fortunately, with the introduction of venture capital, which profitably inspires the enterprise regularly switching between the two states, and the partnership system probably keeps the global optimal.

In this paper, we are motivated to establish bistable Langevin equation, driven by periodic force and additional noise, to describe the dynamical behaviors of bilateral partnership systems, which are subject to cooperative relationship of generalized Cobb–Douglas utility (CDU) potential [12,13], and the competitive condition of initial wealth-constraint. Based on the bistable stochastic resonance (SR) theory [14–22], when a weak periodic force, associated with capital-product switching effect, is applied together with a wide-band stochastic fluctuations, associated with the internal or external capital environment [23–26], the stationary response is driven by the combination of the two forces that compete and cooperate to make the system switch between the two local stable states, corresponding to the respective maximum utilities, and there