Research on Diversification and Financing Constraints of Technological Innovation Companies

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Abstract. This paper uses a variable investment analysis framework to examine the impact of the investment of two independent innovation projects by technology innovation company operators on their financing capabilities. The results show that simultaneous diversification has improved equity multipliers and borrowing capacity, and diversified investments have increased the operator's expected net utility. The higher the degree of project correlation, the more difficult it is for operators to obtain financing.

1. Introduction

Diversification is a series of cross-product and cross-industry expansionary business activities in related or unrelated industries to fully utilize its existing resource advantages to accelerate its growth after the company has developed to a certain scale. Jiang Fuxiu et al. pointed out that whether companies should pursue “professionalization” or “diversification” in their operations is a matter of great controversy since Rumelt’s groundbreaking research. It is an urgent problem that has yet to be resolved. There are three perspectives on the relationship between diversification and performance: Diversification premium theory, diversification discount theory and diversification are not related to performance.

For technology innovation companies, diversification is an important strategic decision for the company and has a positive impact on corporate technological innovation. For example, diversification can expand the scale and scope of business, and encourage companies to carry out technological innovation activities in various fields. Diversification is conducive to diversifying operational risks and technological innovation risks, reducing innovation costs and improving innovation efficiency. Based on the above theory, this paper uses the fixed investment model and variable investment model to influence the innovation company's managers to engage in multiple risk innovation projects on their financing capabilities and production value.

2. Simultaneous investment in two independent innovation projects

2.1 Basic assumption

Using a variable investment analysis framework, the basic assumptions are:

H1: The technical innovation company's managers are engaged in the investment of two independent innovation projects.

H2: Both innovative projects are conducted at the same time, and the results of the two innovative projects will only be shown after the operators have made efforts.

H3: Project i (i=1, 2) requires investment $I_i$, Innovative company owns initial assets $A_i$, and $A_i < I_i$.

H4: Project i (i = 1, 2) generates verifiable revenue $RI_i$ when the investment is successful, and does not generate any revenue when it fails.

H5: The probability of the success of the project i (i=1, 2) is affected by the degree of work hard work of the operator: If the managers perform their duties, the probability of success is $p_H$ that...
the operators have no private benefits; if the operator shirks, the probability of success is $p_L$. Private benefits is $BI > 0$, $\Delta p = p_H - p_L > 0$. Innovation company managers and banks are risk-neutral.

H6: The bank is completely competitive. $I = I_1 + I_2; A = A_1 + A_2$.

2.2 Contract and Optimization Model

It may be possible to establish the contractual between the operator and the bank is that the operator gets $R_b$ when two innovation projects are successful or gets 0 otherwise. Therefore, the operator’s optimization problem is:

$$\max_{(R_b, I)} \ p_H^2 R_b - A$$

(1) $p_H^2 R_b \geq p_L^2 R_b + BI$

(3.1)

(2) $p_H (RI) - p_H^2 R_b \geq I - A$

The first constraint is the operator’s incentive compatibility constraint condition, which indicates that the operator "strives for both innovation projects" is better than "displacement on both innovation projects". The second constraint is the bank’s participation constraint.

It is worth emphasizing that if and only if the following formula is established, the operator is better than “driving responsibilities on two projects” and “responsibility on another project and performing on another project”:

$$p_H^2 R_b \geq p_L, p_H R_b + \max[BI_1, BI_2] \iff \frac{p_H}{p_H + p_L} \geq \frac{\max[I_1, I_2]}{I}$$

Only when the investment scale is divided equally between two innovative projects can this condition be strictly established. If all or most of the investment is placed on an innovative project, the manager will have moral hazard on one of the innovative projects. Especially we can get the conclusion that $p_H^2 R_b \geq p_L^2 R_b + BI \Rightarrow p_L p_H R_b + \max[BI_1, BI_2]$ and the gain from Diversification is largest when $I_1 = I_2 = I/2$.

2.3 Model Solving and Analysis

Note that the participation constraint (2) of the optimization model (3.1) always takes the equal sign, so the optimization model (3.1) can be simplified to

$$\max_{(R_b, I)} \ U_b^* = (p_H R - 1) I$$

s.t. (1) $p_H^2 R_b \geq p_L^2 R_b + BI$

(3.2)

(2) $p_H (RI) - p_H^2 R_b \geq I - A$

It is easy to prove that the optimal investment scale is $I^* = \frac{A}{1 - \hat{\rho}_0}$ where

$$\hat{\rho}_0 \equiv p_H [R - (1 - d_2) \frac{B}{\Delta p}]; \ d_2 = \frac{p_L}{p_H + p_L} \in (0, \frac{1}{2})$$. The optimal contract is $R_b^* = \frac{B}{p_H^2 - p_L^2} \times \frac{A}{1 - \hat{\rho}_0}$.

2.4 Important conclusion

Summarizing the optimal contract for diversified investment under the framework of variable investment analysis, we can easily find the following conclusions:

The first conclusion is that the simultaneous diversification has increased equity multipliers and borrowing capacity.
This is because \( \hat{\rho}_0 \equiv p_H (R - (1 - d_1) \frac{B}{\Delta p}) > p_H (R - \frac{B}{\Delta p}) \equiv \rho_0 \) where equity multipliers

\[
k = \frac{1}{1 - p_H (R - B/\Delta p)}
\]

and borrowing capacity is \( dA, \quad d = \frac{\rho_0}{1 - \rho_0}, \quad d_2 = \frac{p_L}{p_H + p_L} \).

The second conclusion is that synchronous diversification improves the net utility of operators. This is because \( U_n^x = \frac{\rho_1 - 1}{1 - \rho_0} A > \frac{\rho_1 - 1}{1 - \rho_0} A \) where \( \rho_1 = p_H R \).

3. At the same time, investing in two less fully related projects

3.1 Basic assumption

Using a fixed investment analysis framework, the basic assumptions are:

H1: Participants include innovative company operators and external investors (banks).

H2: The operator has two projects that need to invest at the same time. The results of two of these projects will only be shown after the operators have worked hard.

H3: Each project requires a fixed investment \( I \), in which the operator owns the initial assets \( 2A \).

H4: Each project investment generates a verifiable revenue when it is successful, and does not generate any revenue when it fails.

H5: The probability of success of the project is affected by the degree of hard work of the operator: if the operator works hard, the probability of success is \( p_H \), and the operator has no private benefit; if the operator shirks, the probability of success is \( p_L \), and the private benefit is \( B \).

Let \( \Delta p = p_H - p_L > 0 \).

H6: Operators and banks are risk-neutral. And operators are protected by limited liability.

H7: Operators and banks do not have time preference, may wish to set the risk-free interest rate to 0. Banks are completely competitive.

H8: The success of the two projects is not completely related. It is reasonable to assume that the probabilities of the two items with \( x \) are completely related, and the \( 1-x \) probabilities are independent of each other. Where \( 0 \leq x \leq 1 \).

3.2 Optimization model

If the project financing is successful, then the operator can choose to perform the two projects with due diligence, the two projects are shirked, and one strives for one responsibility. There are four types of project investment results: 2 successful; 1 successful; 0 successful. It may be desirable to set up a financing contract between the operator and the bank in such a way that when both projects are successful, the operator gets \( R \), otherwise it gets 0. First, the probabilistic distribution table for two, one, and zero successes for the project is shown below.

<table>
<thead>
<tr>
<th>Table 1. Probability distribution</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Independent (Due diligence, Due diligence)</td>
</tr>
<tr>
<td>(Discharge responsibility, Discharge responsibility)</td>
</tr>
<tr>
<td>(Due diligence, Discharge responsibility)</td>
</tr>
<tr>
<td>Completely relevant (Due diligence, Due diligence)</td>
</tr>
</tbody>
</table>
(Discharge responsibility, Discharge responsibility) | $p_L$ | 0 | $1-p_L$
---|---|---|---
(Due diligence, Discharge responsibility) | $p_L$ | $p_H - p_L$ | $1-p_H$

| Operator’s income | $R_z$ | 0 | 0 |
| Bank's earnings | $2R-R_z$ | $R$ | 0 |

Second, based on the above probability distribution table, it is easy to calculate:

If the project is not completely related, then the probability that the operator succeeds in two when both projects are dutiful is $xp_H + (1-x)p_H^2$

If the project is not completely related, then the probability of two projects succeed is $xp_L + (1-x)p_L^2$ when the operator shirks both projects.

If the project is not completely related, then the probability of two projects succeed is $xp_L + (1-x)p_L p_H$ when the operators perform due diligence on one project and responsibility on another project.

Therefore, the operator’s optimization problem is expressed as:

$$\max_{R_z} [xp_H + (1-x)p_H^2]R_z - 2A$$

s.t. (1) $[xp_H + (1-x)p_H^2]R_z \geq [xp_L + (1-x)p_L^2]R_z + 2B$

(2) $[xp_H + (1-x)p_H^2]R_z \geq [xp_L + (1-x)p_L p_H]R_z + B$

(3) $x(2p_H R - p_H R_z) + (1-x)(2p_H R - p_H^2 R_z) \geq 2(I - A)$

### 3.3 Sufficient and necessary conditions for successful financing

In the optimization problem, the necessary and sufficient condition for solving is

$$p_H R \frac{[x+(1-x)p_H]p_H B}{[x+(1-x)(p_H + p_L)]\Delta p} \geq (I - A) .$$

The minimum initial funding for the operator to obtain financing is

$$A_{\min} = I - p_H R \frac{[x+(1-x)p_H]p_H B}{[x+(1-x)(p_H + p_L)]\Delta p}$$

Since

$$\frac{\partial A_{\min}}{\partial x} = \frac{p_H B}{\Delta p} \frac{p_L}{[x+(1-x)(p_H + p_L)]^2} > 0$$

we get the following conclusion:

First, in the diversification of technology innovation companies, the higher the relevance of innovation projects, the harder the operators get financing.

Second, in the diversification of technology innovation companies, managers obtain financing at the time, and the net utility of the operators has nothing to do with the relevance of the project.

### 3.4 Discussion of project relevance choice

It is assumed that the operator can freely choose the degree of correlation between the projects, that is, the operator chooses. Here are two situations to discuss:

Case 1: The operator chooses before the project gets financing, and the choice method is open information.

According to the inverse induction method, in order to maximize the financing, the operator's choice of optimal correlation should satisfy $\min_x A_{\min} \Rightarrow x^* = 0$ This shows that operators should choose independent projects in order to obtain financing.
Case 2: The operator is under financing both projects. If the financing contract is given, it is a constant. At this point the bank has committed to funding, then the operator’s expected return \( [xp_H + (1 - x)p_H^2]R_2 \) is increasing with increasing value. Therefore, if the operator chooses relevance after the project is financed, the operator will select the project that is completely related to it.

In summary, the open choice of project relevance in diversified investments prior to the financing stage is conducive to the financing of the operators, and the managers must choose independent projects; the choice of project relevance in diversified investments after the financing stage is not helpful. The operator is financing and the operator must choose the fully relevant project after obtaining financing.

4. Analysis conclusion
The technology innovation company's managers simultaneously engaged in the investment of two independent innovation projects. Synchronized diversification increased equity multipliers and borrowing capacity, and diversified investments increased the operator's expected net utility. When the operator is engaged in the investment of two incompletely related projects at the same time, the higher the degree of relatedness of the project, the harder it is for the operator to obtain financing. If the operator can openly select the relevance of the project before the project is financed, the operator must choose the independent project. On the contrary, if the operator chooses the relevance of the project after the project is financed, the operator must choose the relevant one completely project.

References

