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Capital rationing under perfect information

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Abstract

In this paper, we discuss a scenario in capital structure where two divisional managers compete for capital from a firm for their projects in a perfect information setting. We consider verifiable profits and study take-it-or-leave-it contracts where the managers ask for capital from the firm privately or sequentially in public and offer a part of the profit to the firm. Under capital constraint, we demonstrate that in private meeting, there is no sub game perfect Nash equilibrium (SPNE) in pure strategies; but in sequential public meeting, SPNE exists in pure strategies and, for the firm it is better to operate under capital constraint to increase the competition among managers.

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1 Introduction

Capital rationing is defined in [Antle and Eppen(1985)] as the under-allocation of capital i.e. an increase in the amount allocated would generate profit[1]. Initially, capital rationing was thought to be exogenously imposed on the firms by the market ([Lorie and Savage(1949)]), but then there were opinions from [Hirschleifer(1970)] and [Weingartner(1977)] that capital rationing might be endogenously imposed by the firm. These opinions have been supported by the following empirical works: in a survey of capital budgeting techniques used by 268 major U.S. firms by [Gitman and Forrester(1977)], it was found that the major cause of capital rationing was the debt limit imposed internally by the central management. [Pike(1983)], in the empirical analysis of a capital budgeting survey of 208 largest UK industrial companies, shows that capital rationing tends to be internally-imposed rather than externally-imposed by the capital market. The survey by [Mukherjee and Hingorani(1999)] shows that 64% of Fortune 500 firms in their sample frequently place a quantity limit on the internal capital available for investments. Among them, 82% indicate that such rationing is imposed voluntarily by firms rather than by external lenders.

The theoretical papers that try to explain capital rationing as an endogenous phenomenon (e.g. [Harris et al.(1982)], [Antle and Eppen(1985)], [Balakrishnan(1995)], [Paik and Sen(1995)], [Zhang(1997)], [Chen and Deng(2011)]) offer the explanation that capital rationing occurs as a response by the firm to the informational asymmetry that exists between the firm and the managers. In this paper, we show that informational asymmetry may not be the sole reason that the firm is concerned with; using a basic model of two managers and a firm in a perfect information environment, we show that the firm can use capital rationing as an instrument to create competition between managers for capital which is beneficial to the firm.

We consider a model of two divisional managers (he) competing for capital from a firm (she) for their projects and each project's capital requirement is not a fixed amount. In our model, a project needs a minimum capital to start with zero profit and as more capital is available, the profit gets higher. Then there is a maximum amount of capital investment after which the income does not increase further and so the profit falls down with more capital investment as the project manager has to pay back the firm at least the cost of capital.

We consider a financial contracting framework. In our analysis, managers have ex-ante bargaining power that is they offer take-it-or-leave-it contracts to the firm like [Aghion and Tirole(1994)]. In the beginning, the managers know the total amount of capital that the firm keeps for investment. Each manager offers a contract where he asks for an amount of capital for his project and promises to give back a part of the profit to the firm. The firm can accept or reject the offer. We analyse complete contracts as we consider verifiable profits, so the ownership of projects does not matter unlike [Grossman and Hart(1986)].

The main findings are that when the managers meet the firm privately, we cannot have any sub game perfect Nash equilibrium (SPNE)[2] under capital constraint (defined as when

[1] In this paper, our focus is on absolute capital rationing rather than on relative capital rationing in which the cut off rate is set higher than the marginal cost of capital.

[2] We focus on SPNE in pure strategies.

the firm has less capital than the sum of the optimal investment requirements of the managers). Therefore, we consider the situation where the managers meet the firm sequentially in public and in this case, we demonstrate that equilibrium (SPNE) always exists even under capital constraint. If the firm has enough budget to finance both the managers, the firm gets zero profit and it is not optimal for her. So the firm chooses to operate under capital constraint such that there is the highest competition among the managers and she gets the benefit of this competition. The firm desires the manager who can generate maximum profit to be the first in the sequence to meet her because that creates more competition among the managers and the firm gets maximum profit.

Our analysis can also be applied to the situation where a venture capitalist wants to invest with two entrepreneurs who want investments for their projects. The venture capitalist prefers to create a competition among the entrepreneurs by limiting her capital available for investment and she can choose the optimal capital for investment which maximizes her profit.

The structure of the paper is as follows: in section 2, we present the model of two managers competing for capital from a firm. In section 3, we derive the equilibria when the managers meet the firm privately or sequentially in public and in section 4, we derive the optimal capital rationing for the firm. Section 5 concludes the paper.

2 Model of Two Managers

Consider a market where there are two divisional managers and one firm. The managers (he) are denoted by M_1 and M_2 and the firm (she) is denoted by F. The managers have zero wealth and they want capital investment from the firm for their projects. Let the capital that M_j ($j = 1, 2$) receives from F be denoted by y_j. If the firm sets aside y_0 amount of capital for investment, then, $y_1 + y_2 \leq y_0$.

We consider the case of perfect certainty and that there is only one period. The project involving M_j yields an income $v_j(y_j)$. We assume that $v_j(y_j) = 0$ till some $y_j \geq 0$ because a minimum amount of capital is needed to start the project and have some income. Then $v_j(y_j)$ increases with increase in y_j, but at a decreasing rate and after certain capital investment of y_j, it remains constant.

We assume that the reservation utility of F with investment y_j is $(1 + r)y_j$ where r is the hurdle interest rate. For an investment to occur we must have that the profit $\pi_j(y_j)$ is positive which can be written as,

$$\pi_j(y_j) = v_j(y_j) - (1 + r)y_j \geq 0. \tag{1}$$

Let $y_{j_{\min}}$ be the minimum value of capital at which $\pi_j(y_j) = 0$ and then as y_j increases, profit increases. Since equation (1) holds and $v_j(y_j)$ is a decreasing returns to scale function, there exists $y_{j_{\max}}$ where the profit is maximum and then decreases. So $\pi_j(y_j)$ is an inverted u-shape function. For analytical convenience, we assume that $\pi_j(y_j)$ is a concave function. The profit functions are plotted in Figure (1).

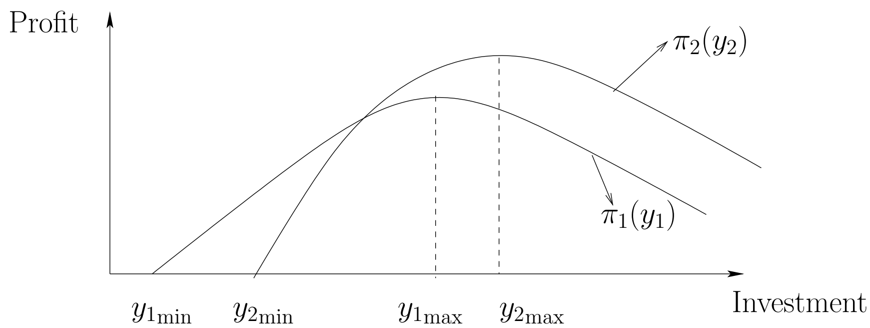

Figure 1: The profit functions of the managers

3 Equilibria Analysis

3.1 Private Meeting

Consider the firm F is contracting with both the managers privately or simultaneously. F has y_0 amount of capital for investment in the projects of the managers and the amount y_0 is a common knowledge.

The game-theoretic formulation is given by,

- The strategy of M_j is a pair $(y_j, h_j(y_j))$ where y_j is the capital that M_j asks from F and $h_j(y_j) \leq \pi_j(y_j)$ is the profit that M_j offers to F. Since the profit is verifiable, the contract mentions how the profit is divided between the firm and the manager.
- The strategy of F is to accept or reject M_j's offer.
- If the project of M_j gets accepted by F, the profit of M_j and the profit of F with M_j are respectively,

$$V_{M_j} = \pi_j(y_j) - h_j(y_j), \quad V_F^{M_j} = h_j(y_j)$$

  If the project of M_j gets rejected by F, both F and M_j earn zero profit.

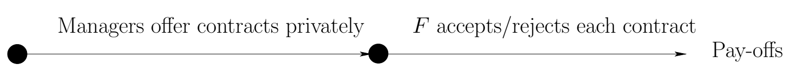

Figure 2: Sequence of events in private meeting

We are going to impose a restriction on y_0 which is mentioned below in (2). The restriction (2) is made throughout the paper for ease of analysis and to avoid corner solutions. This ensures that both the managers can be financed to earn non-negative profit as manager M_j will never ask more than $y_{j_{\max}}$ which maximizes his profit.

$$\textbf{Restriction:} \quad y_0 \geq y_{1_{\max}} + y_{2_{\min}} \text{ and } y_0 \geq y_{2_{\max}} + y_{1_{\min}} \tag{2}$$

In spite of this restriction, we are able to establish all the results that we are interested in. This restriction is not a severe restriction on F because F is never capital constrained, she can always raise capital from outside and therefore we assume that F raises enough capital to finance both the projects.

Proposition 3.1 *1. If $y_0 \geq y_{1\max} + y_{2\max}$, then in the SPNE, F_1 asks for $y_{1\max}$ and offers zero profit, e_2 asks for $y_{2\max}$ and offers zero profit, F accepts both the offers.*

2. If $y_0 < y_{1\max} + y_{2\max}$, then there is no SPNE in pure strategies.

Proof : If $y_0 \geq y_{1\max} + y_{2\max}$, then it is obvious that M_j can get his desired capital $y_{j\max}$ and he will not offer F any profit.

Consider the other case $y_0 < y_{1\max} + y_{2\max}$ in the following analysis. In the SPNE, if M_j asks and is offered $y_j > y_{j\max}$, then he will deviate to ask for an amount $y_{j\max}$ because his profit is maximized at $y_{j\max}$. So no manager will be offered more than $y_{j\max}$. This fact and the restriction (2) imply that each of them is offered $y_{j\min} \leq y_j \leq y_{j\max}$ meaning that each project is financed with a non-negative profit. Also in the equilibrium $y_1 + y_2 = y_0$ because (1) if it is strictly less, then one manager can ask for the rest amount by offering a little amount of profit to F (2) if it is strictly more, then one manager is not offered the contract as he is asking beyond the budget limit, therefore for him it is better to deviate and ask within the budget limit so that he gets the contract and earns some positive profit.

If an SPNE exists, we must have that $h_j(y_j) = 0$ because that maximizes the utility of M_j as his project is always financed for a non-negative profit and $y_1 + y_2 = y_0$. But this is a contradiction because say if M_1 gets less than $y_{1\max}$, then he would like to deviate and request for $y_{1\max}$ by offering a small amount $h_1(y_1) = \epsilon > 0$ to F and F would accept the offer. ∎

Since there is no SPNE in the private (simultaneous) meeting case in pure strategies, we consider sequential public meeting to see if a SPNE exists in pure strategies.

3.2 Sequential Public Meeting

There is a protocol of sequence in which the managers approach the firm and let M_1 be the manager who first offers the contract to the firm F and M_2 be the manager who offers the contract next and observes the contract that M_1 offers before him.

The game-theoretic formulation is given by,

- The strategy of M_j is a pair $(y_j, h_j(y_j))$ where y_j is the capital M_j asks from F and $h_j(y_j) \leq \pi_j(y_j)$ is the profit that M_j offers to F.
- M_1 first offers his contract, after observing M_1's contract, M_2 offers his contract.
- After each M_j $(j = 1, 2)$ offers his contract, the strategy of F is to accept or reject M_j's offer.

- If the project of M_j gets accepted by F, the profit of M_j and the profit of F with M_j are respectively,
$$V_{M_j} = \pi_j(y_j) - h_j(y_j), \quad V_F^{M_j} = h_j(y_j)$$
If the project of M_j gets rejected by F, both F and M_j earn zero profit.

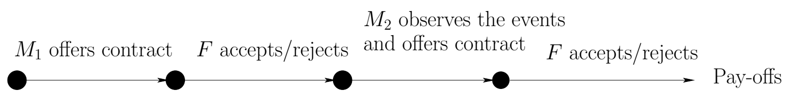

Figure 3: Sequence of events in sequential public meeting

The minimum profit that M_j can earn is $\pi_j(y_0 - y_{3-j_{\max}})$ $(j = 1, 2)$ which is when M_{3-j} gets his desired capital $y_{3-j_{\max}}$. The maximum profit that M_j can earn is $\pi_j(y_{j_{\max}})$. So the maximum amount that M_j can offer to F is $\pi_j(y_{j_{\max}}) - \pi_j(y_0 - y_{3-j_{\max}})$.

Proposition 3.2 *1. If $y_0 \geq y_{1_{\max}} + y_{2_{\max}}$, then in the SPNE, M_1 and M_2 receive $y_{1_{\max}}$ and $y_{2_{\max}}$ respectively.*

2. If $y_0 < y_{1_{\max}} + y_{2_{\max}}$, then we have the following cases:

- *Let M_1 can offer more or equal amount to F than the maximum amount that M_2 can offer. Then in the SPNE, M_1 offers the maximum amount that M_2 can generate which is $\pi_2(y_{2_{\max}}) - \pi_2(y_0 - y_{1_{\max}})$ and asks for $y_{1_{\max}}$, M_2 asks for $y_0 - y_{1_{\max}}$ and offers zero amount, F accepts both the offers.*
- *Let M_2 can offer more or equal amount to F than the maximum amount that M_1 can offer. Then in the SPNE, M_1 offers zero amount to F and asks for $y_0 - y_{2_{\max}}$, M_2 asks for $y_{2_{\max}}$ and offers zero amount, F accepts both the offers.*

Proof : We can see that both managers prefer $y_{j_{\max}}$ in their respective projects because of the profit function. If $y_0 \geq y_{1_{\max}} + y_{2_{\max}}$, then F allocates to both M_j the profit maximizing amount $y_{j_{\max}}$.

The following analysis considers when $y_0 < y_{1_{\max}} + y_{2_{\max}}$ with restriction (2). Let $\pi_1(y_{1_{\max}}) - \pi_1(y_0 - y_{2_{\max}}) \geq \pi_2(y_{2_{\max}}) - \pi_2(y_0 - y_{1_{\max}})$ which says that the maximum that M_1 can offer to F is greater than the maximum that M_2 can offer to F. Then M_1 asks for $y_{1_{\max}}$ and offers $\pi_2(y_{2_{\max}}) - \pi_2(y_0 - y_{1_{\max}})$ to F, M_2 asks for $y_0 - y_{1_{\max}}$ and offers zero to F. If $\pi_1(y_{1_{\max}}) - \pi_1(y_0 - y_{2_{\max}}) \leq \pi_2(y_{2_{\max}}) - \pi_2(y_0 - y_{1_{\max}})$, then M_1 offers zero amount to F and asks for $y_0 - y_{2_{\max}}$, M_2 asks for $y_{2_{\max}}$ and offers zero amount. ∎

4 Optimal Capital Rationing

To find the optimal capital rationing for the firm F (the under-allocation of capital that is optimal for F), we need to find the capital investment that maximizes the sum of profits that F receives from the managers. As there is no SPNE in pure strategies for simultaneous (private) meeting, we consider the equilibria that are achieved in the sequential public meeting which are given in proposition (3.2). If $y_0 \geq y_{1\max} + y_{2\max}$, then the sum of profits that F receives from the managers is zero. Hence for F, it's always good to keep the optimal capital less than $y_{1\max} + y_{2\max}$ and we need to find how much capital F should hold for investment that maximizes her profit.

Therefore, let's consider $y_0 < y_{1\max} + y_{2\max}$ for the following analysis. Consider the first case where M_1 can offer more or equal amount to F than the maximum amount that M_2 can offer. In this case, in the equilibrium, the sum of profits that F receives is $\pi_2(y_{2\max}) - \pi_2(y_0 - y_{1\max})$ which gets maximized when $\pi_2(y_0 - y_{1\max})$ is minimum. Since we are working under restriction (2), this implies $\pi_2(y_0 - y_{1\max})$ is minimum when $y_0 = \max\{y_{1\max} + y_{2\min},\ y_{2\max} + y_{1\min}\}$.

Consider the second case where M_2 can offer more or equal amount to F than the maximum amount that M_1 can offer. In this case F is getting zero profit. Hence if F has the right to make a protocol in which sequence the managers meet her, she does not prefer this sequence, rather she prefers the sequence that is used for the first case above. We summarize the above analysis in the following proposition:

Proposition 4.1 *Under restriction (2), the optimal capital rationing is given by,* $y_0 = \max\{y_{1\max} + y_{2\min},\ y_{2\max} + y_{1\min}\}$.

Capital rationing is important for F to gain more profit as it increases the competition between the managers and with this model, we are able to explain theoretically that capital rationing can occur even with perfect information.

5 Conclusion

We considered a model of two managers competing for capital investment from a firm in a perfect information environment. The main findings are that when the managers meet the firm privately, we cannot have any equilibrium (SPNE) under capital constraint. But if the managers meet the firm sequentially in public, then equilibrium always exists under capital constraint. We can also see that if the firm has enough capital to finance both the managers, the firm gets zero profit which is not optimal for her. So a firm desires the managers to meet her sequentially in public and the best for the firm is that the manager who can generate maximum profit should be the first in the sequence to ask for investment which is the main result of proposition (3.2). We find from proposition (4.1) that, the firm chooses to keep an optimal amount of capital for investment such that there is the highest competition among the managers and she gets the benefit of this competition. Our model adds another explanation to the question why the firms opt for capital rationing as observed in the empirical studies of [Gitman and Forrester(1977)], [Pike(1983)] and [Mukherjee and Hingorani(1999)].

Our work can be extended easily to the scenario when there are more than two managers competing for capital from the firm. An interesting direction of research is to introduce unobservable managerial effort as an input into our profit function. This may complicate the analysis, but may help us to study the impact of both asymmetric information and the competition among the managers, on optimal capital rationing.

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