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INSTITUTIONAL COMPLEXITY AND MANAGERIAL EFFICIENCY: A SIMPLE MODEL

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Institutional Complexity and Managerial Efficiency: A Simple Model*

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Abstract
This paper analyzes the relation between resource inputs and managerial effort in firms. The discussion is motivated by a theoretical model that suggests that firms use managerial effort as a substitute of capital resources in the production process. In this framework, different levels of effort are always optimal decisions given its relative cost. Thus, the relatively higher effort exerted by small (compared to big) firms is not a consequence of hidden information or incentive problems in the organization but it is a optimal decision of small firms to offset capital market restrictions. Managers in big firms, on the other hand, are not obliged to offer their maximum personal effort given that it can be more easily substituted by capital resources in the production process.

Keywords: managerial effort, organizational diseconomies of scale, small firms.

JEL Classification: J44, L83, M50

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1 Introduction

This paper studies the relationship between the institutional complexity and managerial effort. We propose a theoretical model that explains firm performance as a function of these two variables. A key hypothesis in our model is that the required managerial effort is another production factor that can be used to offset capital constraints. This assumption generates the following trade-off. On the one hand, a small firm subject to investment restrictions may be expected to perform worse than a bigger one but, on the other hand, managers in small firms react to financial restrictions by increasing their level of effort.

The fact that complex institutions are harder to manage efficiently is not new in the literature and it has attracted the attention of researchers in different disciplines such as management, operational research, psycology and sport science. Alchian and Demsetz (1972) in their seminal paper explain that small firms with small teams are more effective as it permits more reciprocal monitoring and restrains free-riding by workers. Another justification for the presence of organizational diseconomies of scale is provided by McAfee and MacMillan (1995) based on the "hierarchical distance" between the information source and the decision maker. Zenger (1994) analyzes data collected from 912 current and former engineering employees of two large high-technology companies finding evidence to support the hypothesis that small firms more efficiently resolve the severe agency problems of hidden information and hidden behavior in R&D. More recent empirical work also demonstrates the presence of organizational diseconomies of scale (Zenger and Marshall, 2000; Zenger and Lazzarini, 2004). Even this effects persist when firms structurally isolate a group or a team within the firm and implement group-based incentives to its performance, as the firm increases in size, empirically these incentives become less and less high powered (Zenger and Marshall, 2000).

This paper provides an additional explanation for this issue based on the strategic interactions of firms in a given industry. In our model, the relatively higher effort exerted by small (compared to big) firms is not a consequence of hidden information or incentive problems but it is a optimal decision of small firms to offset capital market restrictions. Managers in big firms, on the other hand, are not obliged to offer their maximum personal effort given that it can be substituted by capital resources in the production process. Thus, effort can be seen as an additional production factor that cannot be constrained by financial restrictions and it is used by small firms to offset these restrictions.

An empirical test of this theory is an issue to be considered in future research. However, an initial attempt in the field of sport economics can be found in Jara, Paolini and Tena (2012) who estimate the potential sources of managerial inefficiencies for two extreme cases such as the Italian and the Chilean football league finding that managerial decisions play a more important role in an industry dominated by complex institutions such the Italian league compared to an industry with small institutions, i.e. the Chilean league, where managerial decisions are easily undertaken.

In the next section of the paper, we address the theoretical framework and in Section 3 we develop a simple analytical model designed to capture the factors that determine decisions on resources and managerial efficiency for two competitive firms in an industry. Conclusion are drawn in Section 4.

2 Some general issues

In this section we develop the analysis about the way in which restrictions on total resources might influence managerial efficiency and investment in physical capital. Our interest is in how competitive balance is determined given restrictions on total resources and whether these restrictions could affect managerial effort. We adopt a Cournot model for a finite set of n firms. A generic firm $i \in \{1, ..., n\}$ has to decide, simultaneously with all the other $n-1$ firms in the market, its amont of resource investment, k_i, and the amount of effort, s_i.[1]. Firm i maximizes its objective function

$$V_i = V_i(s_i, s_{-i}, k_i, k_{-i}) \tag{1}$$

where $k_{-i} = \sum_{j \neq i}^{n} k_j$ and $s_{-i} = \sum_{j \neq i}^{n} s_j$ correspond respectively to decisions on resource investments and managerial effort undertaken by all the other firms in the industry.

To guarantee the existence of equilibrium we assume that V_i is continuous in all variables and strictly concave jointly in (k_i, s_i). Moreover, we assume

[1]Both variables are modelled as one-dimensional, non negative real variables beloging to some compact interval $[0, \bar{s}_i]$ and , respectively.

that $\frac{\partial V_i}{\partial s_i} > 0$, $\frac{\partial^2 V_i}{\partial s_i^2} < 0$,$\frac{\partial V_i}{\partial k_i} > 0$, $\frac{\partial^2 V_i}{\partial k_i^2} < 0$ and $\frac{\partial V_i}{\partial s_{-i}} < 0$, $\frac{\partial V_i}{\partial k_{-i}} < 0$. These are standard conditions in non-cooperative games and simply state that the objective function of the *ith* firm is a positive and concave function of its own level of resources and investment but it depends negatively on decisions on resources and managerial effort undertaken by rival firms.

To find a Cournot-Nash equilibrium for this model, consider firm i's maximization problem given the choices of all the other firms:

$$\underset{s_i \geq 0; k_i \geq 0}{Max} V_i(s_i, s_{-i}, k_i, k_{-i}) \tag{2}$$

An interior optimal quantity choice for firm i must satisfy the first-order conditions:

$$0 = \frac{\partial V_i(s_i, s_{-i}, k_i, k_{-i})}{\partial s_i} = R_i^S(s_i, s_{-i}, k_i, k_{-i}) \tag{3}$$

$$0 = \frac{\partial V_i(s_i, s_{-i}, k_i, k_{-i})}{\partial k_i} = R_i^K(s_i, s_{-i}, k_i, k_{-i}) \tag{4}$$

These two condition gives us the set of the firm i's optimal choice (reaction curve) that can be calculated for each value of (s_{-i}, k_i, k_{-i}) and (s_i, s_{-i}, k_{-i}) in the case of effort and total resources respectively.

Equilibrium is then determined by the intersection of the reaction functions for the different firms.[2]

Given the focus of the article, we are interested in studying the impact of the resource costraints on effort, s_i. A situation is considered in which

[2] The equilibrium concept we use is the standard Cornout-Nash equilibrium (see for example Varian (1992) p.285-86). The only difference here is that in our framework we have two decision variables, instead of one.

firms in the industry cannot undertake their preferred resource investment decisions in equilibrium.

We denote by k_i^* the amount of resource investment (which, in the general case might be in physical capital but in the case of football is likely to be in human capital in the form of coaching and playing staff to be assembled) undertaken by the firm and we assume that this investment decision is constrained to be less or equal to $\bar{k}_i$, $\bar{k}_i < k_i^*$. Given the hypothesis $\frac{\partial V_i}{\partial k_i} > 0$, firm i will choose to invest $\bar{k}_i$.

Using the implicit function, it is straightforward to see that the variation of the level of effort with respect to changes in the amount of resources is given by the following expression,

$$\frac{ds_i}{dk_i} = -\left[\frac{\partial R_i^s(.,\bar{k}_i)}{\partial k_i} + \frac{\partial R_i^s(.,\bar{k}_i)}{\partial k_{-i}}\frac{dk_{-i}}{dk_i} + \frac{\partial R_i^s(.,\bar{k}_i)}{\partial s_{-i}}\frac{ds_{-i}}{dk_i}\right] \setminus \left[\frac{\partial R_i^s(.,\bar{k}_i)}{\partial s_i}\right] \quad (5)$$

If (5) is positive the representative firm has an incentive to increase its level of effort after a marginal loosening of the constraint on resuource investment. However, the sign of the last expression is ambiguous because, on the one hand, it is possible to assume that restricting the amount of resources makes managerial effort less productive but, on the other hand, it could be assumed that simpler firms can be easily managed more easily, which will motivate managers to put in more effort.

In the following section we propose a simple analytical model and apply it in the context of sport sector in order to discuss the conditions under which the presence of capital constraints could increase or decrease managerial effort.

3 A simple analitical model

In this section we propose a model designed to analyze the conditions that could explain a positive impact of capital restrictions on managerial effort. We apply it in the context of sport industry. The framework is closely related to D'Aspremont and Jacquemin (1998) who generalized the standard Cournot model to a case with two complementary decision variables: capital and research. Our paper diverge from this approach in the sense that the endogenous variables, resource and managerial effort, could interact positively on the revenue side of firms increasing the probability of winning a match and negatively on the cost side as the cost of managerial effort increases with the complexity of the firm (that is determined by the amount of capital investment).

The model in the previous section is simplified by constructing a static model with only two risk-neutral firms (or clubs in sport economics), $i = 1, 2$, whose main decisions are to decide, simultaneously, the amount of resource to invest, k_i, and amount of effort, s_i, in order to maximize their respective objective functions, V_i.

To investigate this variation in more detail we will give a functional form to the function of profit. We suppose that

$$V_i = \Pi_i - C_i \tag{6}$$

where Π_i is the revenue from the business and C_i is the cost to implement the activity.

Revenue, Π_i, is composed of two parts, one certain and one uncertain. Formally, we have

$$\Pi_i = Dk_i + Fp_i \tag{7}$$

We assume that $F > D$. Note that this is a plausible assumption for sports clubs as an important proportion of their revenue comes from the uncertain output of the game. However, it can also be generalized to other types of industry as firms can usually use contracts to insure some proportion of their revenue while the remaining proportion depends on the uncertain decisions of competitors in the same industry. The certain value is a linear increasing function of the amount of resources invested by firm i. The fact that D cannot be altered by managerial decisions is a plausible assumption if we suppose that this variable is related to institutional factors of the firm that are fixed in the short run. For example, in the context of sport, a big club can sign contracts with the media and with different sponsors that depend on the history of the club and/or the reputation of the players in the squad. These contracts are generally fixed during the year and they are not adjusted depending on managerial decisions for each match.

Conversely the model also assumes that F is an uncertain revenue that depends on the result of the competition in the industry. In particular, we denote by p_i the probability of success in the industry by firm i and assume that function F depends positively on this probability. More specifically, we assume that p_i for firm i depends positively on its own resource investment and managerial effort, denoted by k_i and s_i respectively and negatively on the level of capital investment and managerial effort undertaken by its competitor, k_j and s_j. Of course, values of this probability should be bounded in the interval $[0; 1]$ and this condition is explicitily stated by assuming $p_i \in [0; 1]$; with $p_1 + p_2 = 1$. And in particular by assumining that

$$p_i = \begin{cases} 1 \text{ if } q_i > 1 \\ q_i \\ 0 \text{ if } q_i < 0 \end{cases} \tag{8}$$

where

$$q_i = \frac{1}{2} + \frac{1}{2}\left[(s_i - s_j) + (k_i - k_j)\right] \tag{9}$$

with $i = 1, 2$ and $i \neq j$.

This function implies a positive interaction of capital investment and managerial effort on the probability of success. This is a plausible assumption as effort payoff is typically higher in well-equipped compared to badly-equipped firms.

Regarding the cost function, it is assumed that cost depends on the club's own resources, k_i, and effort, s_i, as well as on the level of resource investment undertaken by the rival firm in the industry, k_j. Formally, we suppose that

$$C_i = (k_i + k_j)k_i + s_i(s_i + k_i) \tag{10}$$

with $i = 1, 2$ and $j \neq i$.

Expression (10) implies that the cost of acquiring resources is not constant but depend positively on the total amount of resources in the industry. Thus, a decision to invest taking by a given firm reduces the total amount of capital in the industry, affecting its price and therefore the resource costs of the rival firm. Note also that equation (10) hypothesizes that the cost function for firm i is a convex function of its own capital investment and managerial effort. The convexity assumption is a typical assumption in the micro literature. In the case of capital, one plausible explanation is, for example, that teams spend first their own funds and the cost of spending more than that is increasing due to frictions in the financial markets. In the case of managerial effort, convexity can be explained because there is a physical limit to the total amount of time and effort devoted by the managers of the company and at some point it becomes very costly to increase that effort.

A key aspect of our model comes from the interactive effect of managerial effort and capital investment in the cost function. This is a realistic hypothesis that can be justified as the required managerial effort to lead an organization increases with its resources to the extent that the organization became more complex to manage.

In the unconstrained case, clubs 1 and 2 decide their respective levels of investment, $k_i \in [0, +\infty)$ and effort, $s_i \in [0, +\infty)$ with $i = 1, 2$. By equalizing the marginal returns of firms i and j, it is straightforward to show that

$$k_i^* = \frac{1}{2}(D - k_j^*) + \frac{1}{4}(F - 2s_i^*) \tag{11}$$

$$s_i^* = \frac{1}{4}(F - 2k_i^*) \tag{12}$$

It should be noted that strategic investment on resources undertaken by a given firm depends negatively on its own effort, s_i^*, and on the amount of resources invested by the other firm (k_j^*). We find these results because although capital and investment interact positively on the revenue side by affecting the probability of victory there is also a negative interaction on the cost side. However, while the positive interaction is bounded because the probability cannot exceed the value 1, there is no limit in the negative interaction on the cost side. As a result of this, s_i^* depends negatively on the amount of resources invested.

Clearly, we can also note that the effort s_i^* undertaken by a given firm depends negatively on its strategic investment, k_i^*. Moreover, we want to underline that the effort s_i^* depends, indirectly and positively on the amount of resources invested by the other firm (k_j^*): an increase of k_j^* influences negatively on the optimal choice of k_i, that, acts negatively on the choice of s_i^*.

In this model, the Cournot-Nash Equilibrium value of resources and effort are respectly: $k_i^* = \frac{F+4D}{10}$ and $s_i^* = \frac{(F-D)}{5}$. Thus, investment increases with the prize given to victory, F, and with the certain payoff to capital, D. Managerial effort in equilibrium, on the other hand, increases on F but decreases on D.

Now let us assume that only one firm, say firm 2, is constrained such that it cannot undertake its desired level of investment[3]. This restriction is formally represented by $\bar{k}_2 < k_2^* = \frac{F+4D}{10}$. In this case, firm 2 will choose the maximum amount of capital investment allowed $\bar{k}_2$ and its new level of effort is given by $\bar{s}_2 = \frac{1}{4}(F - 2\bar{k}_2)$. Given these values, firm 1 also decides a new level of capital and effort different from those undertaken in equilibrium. More specifically, $\bar{k}_1 = \frac{1}{8}\left[4D + F - 2\bar{k}_2\right]$ and $\bar{s}_1 = \frac{1}{4}\left[F - D - \bar{s}_2\right]$.

Figure 1 describes this situation. Note that, in the absence of constraints, the level of effort in equilibrium by the two firms is determined by the intersection of the reaction functions for effort at point A. However, when capital in firm 2 is constrained, the new equilibrium is given by point B. In that situation, s_2 cannot be lower than $\bar{s}_2$ because the upper constraint on investment also imposes a lower constraint on its level of effort. This correspond to a new point on the reaction function of firm 1.

A more realistic situation is when resources in both firms are constrained such that $\bar{k}_1 < k_1^* = \frac{F+4D}{10}$ and $\bar{k}_2 < k_2^* = \frac{F+4D}{10}$. In this case, the levels of effort of the firms are not given by the intersection of their reaction functions but by the constraints. Now therefore the level of effort of each firm does not depend on the different decisions of its rival but on its own constraint, $\bar{s}_i = \frac{1}{4}(F - 2\bar{k}_i)$, $i = 1, 2$. As shown in the figure, when both firms are

[3] A similar option for representing capital restrictions on clubs is to employ a Stackelberg framework in which leader and a follower teams choose their amounts of capital sequentially. In this case, we would be implicitly assuming that the follower team faces some restrictions on the adjustment of its capital investment compared to the leader team. For simplicity, we prefer to model explicit restrictions on the amount of capital.

constrained, each will react by increasing its managerial effort compared to the unconstrained equilibrium regardless of whether these firms are subject to capital restrictions of different magnitudes.

According to this model, an industry subject to investment restrictions will devote more effort to managerial decisions and technical ineficiencies will be less likely to be observed compared to an unrestricted industry.

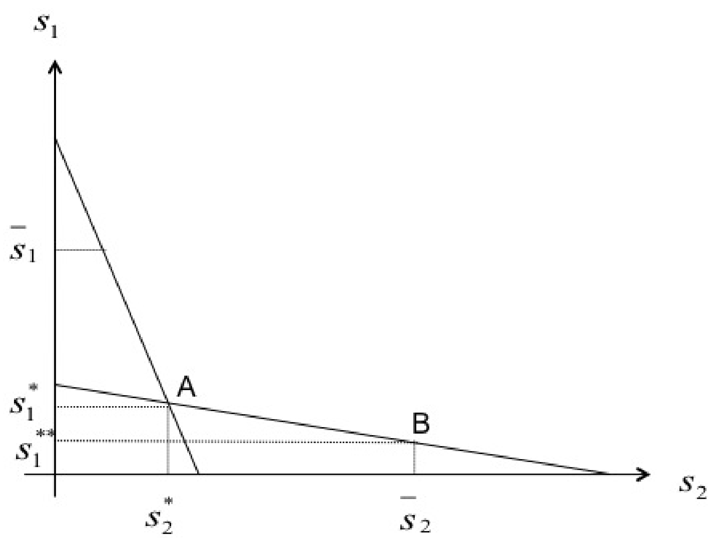

Figure 1

4 Concluding remarks

This paper analyzes the relationship between resources inputs and managerial effort in firms. This discussion is motivated with a theoretical model that suggests that firms use effort as a substitute of capital in the production process. Thus, small firms that are more likely to suffer capital constrain react by increasing their managerial effort to offset this restriction.

This model provides an alternative explanation for the relative higher managerial effort in small (compared to big) firms that is not based on organizational inefficiencies due to hidden information or incentive problems as in our model the level of managerial effort is always optimal given its relative cost.

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