Institutional Complexity and Managerial Efficiency: A Theoretical Model and an Empirical Application[1]

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This paper studies the effect of the level of a firm's resources on managerial inefficiency. We motivate our analysis with a theoretical model which predicts that better resourced and therefore more complex institutions tend to be more likely to generate x-inefficiency. The empirical analysis estimates stochastic production frontiers for Chilean and Italian football and finds that, consistent with the theoretical predictions, team performance in the Chilean League is mainly explained by institutional factors related to the level of resources available to a club whereas team performance in the Italian League appears in addition to be related to technical decisions taken by management.

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1. INTRODUCTION

This paper studies the relationship between the level of resources and technical inefficiency in sports industries. We motivate the analysis with a simple theoretical model that explains team performance as a function of resources and managerial effort. A key hypothesis in our model is that the required managerial effort to lead a team increases with total resources. This assumption generates a trade-off between resources and technical efficiency. 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, as the complexity of the institution increases it becomes more difficult to manage efficiently. According to this, managerial variables should become especially relevant in markets dominated by big companies.

Our theory is related to at least two different strands in the economics literature. The first of these focuses on the role of capital constraints in production decisions; see for example Kiyotaki and Moore (1997) and Bernanke and Gertler (1989). Here we contribute to this literature by showing the way in which these restrictions could affect the degree of managerial inefficiency of firms in a given industry. The second strand emphasizes the role of human learning in dealing with capital investment. Although, in an Arrowian world, labor productivity should be positively related to the amount of capital available, in recent years a number of authors have challenged this assumption. For example, Greenwood et al. (1997) argue that capital investment should be good in the long-run, but in the short-run the accumulation of capital requires a costly learning period during which productivity and growth may slow down. This adjustment process could even affect long-run growth due to the obsolescence costs of capital; see Boucekkine et al. (2002). In the present paper the impact of capital accumulation on productivity is studied using a game theoretical framework showing that, when the managerial effort required to deal with an institution is an increasing function of the total amount of resources, competitive firms in an industry react to capital market restrictions by increasing their amount of managerial effort (and therefore managerial efficiency).

Although an industry level empirical test of the trade-off proposed by our theoretical model could be highly relevant, it is especially difficult to perform for standard industries for at least two main reasons. First, defining an industrial sector, its output and the objective function of the firms is generally a difficult task because products are heterogeneous and there is not a clear cut-off for the set of substitutive products. More importantly, even if an industrial sector could be clearly defined, firms are usually black boxes and many managerial decisions concerning the production process can be observed only highly imperfectly.

In this context, sport offers a fruitful ground to test our hypothesis because: 1) the market is clearly defined- teams compete in a national league, the objective functions of clubs is, in the great majority of cases, to maximize the number of points won in the competition and this 'output' is unambiguously observed for every one of them; and 2) unlike standard firms, a large number of managerial decisions taken by teams can also be observed.

Therefore the hypothesis is tested here through the empirical estimation of stochastic production frontiers for the top divisions in the Chilean and Italian football leagues. This enables identification of the share of team performance that is explained by indicators of power and resources and the share that can be explained by managerial decisions. The comparative analysis of these two extreme cases, one a very modest league and the other amongst the richest in the world, is another novel aspect of our paper compared to related literature on sport that usually focuses on a single national league; see for example Hofler and Payne (2006), Kahane (2005) and Simmons and Frick (2008).

We find that, as suggested by our theoretical framework, team performance in the Chilean league can be explained mainly by institutional factors, such as the history of teams and the size of the stadium, that impact the level of resources available to a club; by contrast, in the Italian League, a significant share of team differences is due to technical factors related to the efficiency of club management.

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. Section 4 explains the econometric approach we use to estimate the impact of resource variables and technical inefficiencies on output in the Chilean and Italian football leagues and reports and discusses the results of the estimation. Conclusions are drawn in Section 5.

2. THEORETICAL UNDERPINNINGS

In this section we develop analysis about the way in which restrictions on total resources might affect on influence on 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 risk-neutral firms. A generic firm $i \in [2, +\infty)$ 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[2], s_i. We assume that the space of the strategies are compact. Firm i maximizes its objective function

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

where $k_{-i} = \sum_{i=2}^{n} k_i$ and $s_{-i} = \sum_{k=2}^{n} s_i$ 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 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 optimal quantity choice for firm i must satisfy the first-order conditions:

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

[2] Both variables are modelled as one-dimensional, non negative real variables.

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

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.[3]

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 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 *ith* 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. Thus, the issue of whether restrictions on resource investment increase or reduce managerial effort (and therefore managerial efficiency) can be settled only empirically.

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 and subsequently we will implement an empirical test of the prediction from this framework.

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

[3] 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.

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). Our framework could also be considered an extension of previous theoretical models applied to sports economics by Haan et al. (2002) and Flores et al. (2008) to the case with two decision variables.

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

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

where

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

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

$$C_i = (k_i + k_j)k_i + s_i(s_i + k_i) \quad (10)$$

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

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

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

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 this 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 a probability cannot exceed the value 1, there is no limit in the negative interaction on the cost side. As a result of this, s_j^* depends negatively on the amount of resources invested.

The reaction functions of the two firms for effort and capital are:

$$k_i^* = \frac{1}{8}\left[4D + F - 2k_j^*\right] \quad (13)$$

$$s_i^* = \frac{1}{4}\left[F - D - s_j^*\right] \tag{14}$$

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

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.

Note also that when a firm increases its level of effort it is also optimal to reduce its own capital investment as the interaction of these two variables has an impact on costs. This also has an effect on the decisions on effort and investment undertaken by the rival firm given that, as indicated by the reaction functions (13) and (14), these decisions are negatively related. Therefore, each firm reacts to an increase in the level of effort of its rival by reducing its own effort and increasing its amount of investment.

Now let us assume that only one firm, say firm 2, is constrained such that it cannot undertake its desired level of investment[4]. 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 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. In the following section we test this hypothesis by estimating a stochastic production frontier in two extreme cases, the Chilean and Italian football leagues.

[4] 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.

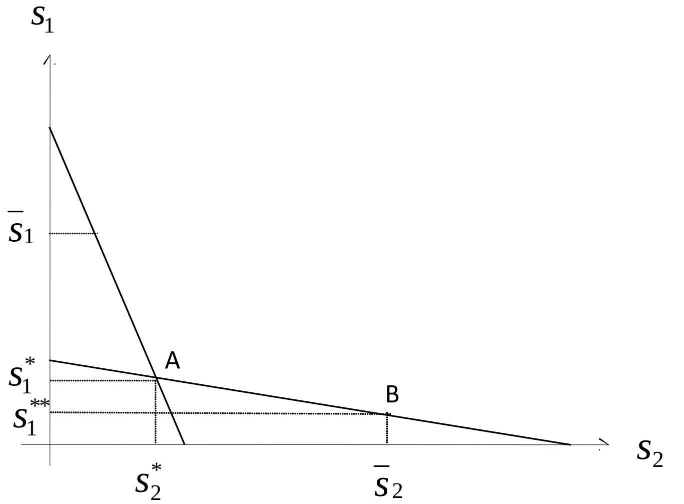

Figure 1

4. DATA ON THE ITALIAN AND CHILEAN FOOTBALL LEAGUE

This section describes the data we assembled for inclusion in the modeling exercise reported below. The reasons for collecting and constructing the particular variables listed will be presented alongside the statistical model in Section 5.

Our season-level variables relate to the period from 1992/93 to 2007/08 in the case of Italy and from season 1993 to 2008 in the case of Chile. In both cases, information on the performance of the different teams came from the Recreation and Sports Soccer Statistics Foundation (http://www.rsssf.com). Additional information used in the analysis for Chile was obtained from Centro de Estudios del Deporte (CEDEP), Instituto Nacional de Estadìsticas (INE) and Confederaciòn Sudamericana de Fùtbol (CONMEBOL) while for the Italian case it was collected from Football.it and http://www.comuni-italiani.it.

Chilean and Italian football represent two extreme cases. There are important differences in the economic and geographical characteristics of these two countries and, more importantly, the degree of interest in and professionalization of the top division in each league differs drastically. Historically, the Italian top division has produced the highest number of European Cup finalists from a single country. In total, Italian clubs have reached the final of the European Champions League on a record twenty-five occasions, winning the title eleven times. The Chilean League, on the other hand, is weak relative to other football competitions in Latin America, notably the Argentinean and the Brazilian top divisions, according to the International Federation of Football History and Statistics (IFFHS). During our lengthy sample period, only once did a Chilean team reach the Final of Copa Libertadores, the counterpart in Latin America to the European Champions League.

In the final data base for the Italian League, the panel sample consists of 296 observations for 42 different teams observed while the panel for the Chilean league contains 274 observations for 28 different teams through sixteen seasons in each case. It is interesting to note that the structure of the competition and the number of teams during the sample period were fairly similar in the two countries. The Chilean first division is currently composed of eighteen teams which play two single-round tournaments per season (known as Apertura and Clausura). Traditionally, the League was contested as one annual, double round-robin tournament but the number of contesting teams varied through the years. The actual number of teams in the Italian Serie A is currently twenty, playing in one annual double round-robin tournament; but the number of teams in this league has also varied over time.

A description of the variables considered in the analysis follows:

Output (performance) measure

(i) Number of points divided by the maximum available for the *ith* team in season t ($y_{i,t}$). Note that in our sample period the number of points awarded for a victory changed from two to three in season 1995/96 for the Italian league and 1996 for the Chilean league (in each case, the award for a draw remained at one point for each team). Thus, to make the performance measure consistent across seasons, we computed it on the basis of three points for a win throughout the whole period. A dummy variable will be used in the estimation to represent the seasons when three points was actually employed as the change in incentives was likely to have influenced the pattern of results. Simmons and Frick (2008) followed a similar procedure for Germany.

Group I (variables related to resources)

(ii) International tournament ($x_{1,i,t}$): a variable that takes the value 1 when club i is playing in that season's European Champion League (Italy) or Copa de Libertadores (Chile) at season t.

(iii) Stadium capacity ($x_{2,i,t}$).

(iv) Population size of the city (where the team plays its home games) ($x_{3,i,t}$).

(v) Champion in previous years ($x_{4,i,t}$): a weighted sum of the number of national league trophies in the previous three years. The weights were ($1/t^2$) where t was 1 for the previous season, 2 for the season before and 3 for the season before that.

(vi) Performance in previous years ($x_{5,i,t}$): A weighted measure of the inverse of the ranking of each team in each of the top division competitions in the preceding three years. Weights are defined similarly to the previous variable.

(vi) Capital city ($x_{6,i,t}$): a dummy variable that takes the value one when the team plays in the capital of the country, Santiago de Chile in the case of Chile and Rome in the case of Italy. Note however that around 40% of the Chilean population lives in Santiago de Chile whereas the Italian population is not as concentrated around the capital. We will test the robustness of results to different definitions of this variable for Italy.

Group II (variables related to technical decisions)

(viii) Total number of players ($z_{1,i,t}$): total number of footballers in each squad.

(ix) Number of foreigners ($z_{2,i,t}$):: total number of foreigners for each club.

(x) % goalkeepers ($z_{3,i,t}$): share of goalkeepers in the squad.

(xi) % defenders ($z_{4,i,t}$): share of defenders in the squad.

(xii) % midfielders ($z_{5,i,t}$): share of midfielders in the squad. We do not include the share of forward players in the regression to avoid perfect multicollinearity.

(xiii) Number of high scoring players ($z_{6,i,t}$): number of players at each club who had scored more than twenty goals in the previous season.

(xiv) Manager quality ($z_{7,i,t}$): proportion of matches won during the career of the manager of the club prior to season t.

(xv) Manager experience ($z_{8,i,t}$): number of years that the coach of the team has been involved in managerial activities.

(xvi) Foreign manager ($z_{9,i,t}$): a dummy variable that takes the value 1 when the manager is a foreigner and zero otherwise.

Table 1 displays descriptive statistics for these variables. The average values for many of the variables are very similar in Italy and Chile. The most relevant differences between the two leagues can be observed in stadium capacity, which, on average takes higher values for Italian football. Also, the size of the city reveals that top division teams are more concentrated in the big cities for the Chilean football league (mainly in the capital Santiago de Chile) whereas in Italy there are top football teams in relatively small cities. This is the case for example of Atlanta, Livorno, Empoli, Siena and Udinense. Some important differences also relate to the number of foreign players and managers in the two countries. As expected, the Italian league attracts a higher number of foreigners.

	Italy				Chile			
	Average	Variance	Min	Max	Average	Variance	Min	Max
Points divided by maximum	0.472	0.020	0	0.851	0.471	0.017	0.144	0.33
Capital	0.138	0.119	0	1	0.395	0.240	0	1
International tournament	0.194	0.157	0	1	0.172	0.143	0	1
Stadium capacity	46,312	536×10^{-6}	10,001	82,955	2,591	$1,34 \times 10^{-7}$	500	53,000
Size of the city	684,266	6.51×10^{-11}	46.85	2,705,317	2,091,875	4.26×10^{12}	30,854	8,414,450
Champion in previous years	0.130	0.119	0	1833	0.143	0.110	0	1.583
Performance in previous years	0.909	0.094	0.121	1.539	0.928	0.080	0.333	1.521
N. of foreigners	8.039	20.756	0	24	3.953	1.804	0	7
Total number of players	25.836	11.575	17	36	26.219	18.836	18	43
% goalkeepers	0.087	0.001	0.036	0.167	0.090	0.001	0.036	0.174
% defenders	0.326	0.002	0.174	0.448	0.306	0.003	0.136	0.48
% midfielders	0.370	0.003	0.227	0.538	0.376	0.004	0.214	0.545
N. of high scoring players	1.190	0.639	0	4	0.974	1.301	0	7
Manager quality	0.374	0.021	0	0.697	0.310	0.032	0	0.705
Manager experience	2.224	2.772	1	13	3.957	14.653	0	17
Foreign manager	0.138	0.119	0	1	0.330	0.222	0	1

Table 1. Descriptive statistics.

5. EMPIRICAL RESULTS

The model of stochastic frontier production functions was initially developed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) and extended to panel data by Battese and Coelli (1995). It allows for non-positive deviations of the stochastic frontier that may reflect technical inefficiencies in the usage of inputs. The standard specification for a set of firms indexed by i over a number of periods t can be represented as:

$$Y_{it} = \alpha + \beta^{'} x_{it} + (v_{it} - u_{it}) \quad i = 1, \ldots, N; \quad t = 1, \ldots, T \tag{15}$$

where Y_{it} is a measure of output of firm i at time t, x_{it} is a vector of the inputs defined in the previous section and β is a vector of unknown coefficients to be estimated. A common practice in the literature is to take logs of variables Y_{it} and x_{it}. However, here we do not apply this transformation of the dependent variable as it is already defined as a ratio (points divided by maximum possible points in a season).[5]

The remainder of the equation is an error term composed of two components. The component v_{it} is a random error term assumed to be $iid \sim N(0, \sigma_v^2)$. The component u_{it} is a non-negative random error term that is assumed to be independent and following a normal distribution that is truncated at zero and $\sim N(m_{it}, \sigma_u^2)$ with mean inefficiency, m_{it}, modeled as a function of various firm-level factors. Specifically,

$$m_{it} = \delta' z_{it} + w_{it} \tag{16}$$

where z_{it} is a vector of technical decisions undertaken by firm i in period t and δ is another vector of coefficients to be estimated. The error term is assumed to be $\sim N(0, \sigma_w^2)$ truncated at $-\delta' z_{it}$ for consistency with the assumption that u_{it} is non-negative and truncated at zero.

The model presented in Equations (15) and (16) is estimated following the maximum likelihood method proposed by Battese and Coelli (1993) and made available in Coelli's (1996) computer program FRONTIER 4.1. Further, this likelihood function utilizes the parameterization of Battese and Corra (1977) who replace σ_v^2 and σ_u^2 with , σ^2=$\sigma_v^2 + \sigma_u^2$ and $\gamma = (\sigma_u^2)/(\sigma_v^2 + \sigma_u^2)$. The parameter γ takes values in $[0, 1]$ and it is particularly important as it shows the proportion of the sum of the two error variances that is accounted by technical inefficiencies. In the case that this parameter is not statistically different from zero then it is not possible to reject the null hypothesis of zero technical inefficiencies and the specification should be a standard panel data econometric procedure to estimate the production function.

We estimate the parameters in equations (15) and (16) for the the model applied in the context of a sports league. In previous studies of this sort, for example Kahane (2005), the production frontier is taken as relating performance on the (in his case) ice to the quality of the playing staff at the club as proxied by its total wage bill. It is then possible to test whether management at every club is extracting maximum possible success given the amount it has spent on players. In our study it was impracticable to follow practice in the previous literature because the size of budget at each club was not available at all in the case of Chile; even for Italy, the figures for wage bills were probably unreliable either because clubs had an incentive to misreport or simply because complex bonus arrangements make it hard

[5] Note that this estimation would be consistent with the log transformation of a Cobb-Douglas functional form such as $exp(Y_{it}) = \prod_{i=1}^{K} (\exp(x_{it}))^{\beta_i} * \exp(v_{it} - u_{it})$ where $x_{1t} = 1$ and β_i is the ith component of vector β.

to represent a club's financial commitment with a single summary figure.[6] In any case, our focus is not so much on the ability of one layer of management (the coach) to extract the best possible performance from the players given his budget but on the overall ability of the organization to transform its potential power over resources to the best possible outcome in terms of league points. Note that, given their focus on coaching ability, the wage bill is properly taken as exogenous in the empirical models of Kahane (2005), Hoflet and Payne (2006) and Simmons and Frick (2008) but its size will in fact be influenced by any inefficiencies in management elsewhere in the organization. For example, a club might not extract as much ticket revenue as it could given the size of its market and therefore might be fielding a lower quality of team than it should; or it may not choose the most appropriate balance between expenditure on playing staff and on other inputs.

Because our focus is on the efficiency of the organization as a whole, we therefore choose to define the production function as the relationship between output (points) and the endowment of potential inherited at the start of the period in which decisions are taken. Buraimo et al. (2007) report high correlation, for the 92 clubs in English professional football, between the potential of a club (as represented by variables capturing its geography and history) and both the club's revenue and its ranking in the league. This is consistent with the central proposition in the most influential theoretical model in sports economics, the two team league model of El-Hodiri and Quirk (1971), that large market clubs will dominate small market clubs on the field because they generate greater revenue and hire better players. For example, a club may be located in a large city and have won many trophies in the past. This 'big' club would therefore have a larger fan and revenue base than its rival and greater power in the player labor market. If both clubs are managed efficiently, the 'big' club is expected to win more matches than the small club. Any deviation from this outcome would be attributable only to random noise.

Accordingly, our Group I explanatory variables, the x_{it} in equation (15), seek to represent factors from the geography and history of the club that should, collectively, determine its power to command resources. The task of management in the organization is to translate power into output (points). Decisions are, of course, taken at a number of levels in the club. In the stylized club we have in mind, the owners (perhaps represented by the chairman) or other senior managers hire a coach. The coach is then co-opted into management and may well have some input in the recruitment of the playing staff with whatever budget has been made available (in some cases a director of football will play the primary role here). Errors of judgment may be made, for example, by the chairman (who may choose too low a quality of coach to work with the more expensive players which the club can then afford) or by the director of football (who may use his budget to hire a sub-optimal balance of stars and journeymen or international and local players). Poor decisions at any level of management will prevent the club from reaching the level of performance (in terms of league points) that should be possible given its power and status. In our specification of equation (16) above, the z_{it} (the Group II variables) represent a selection of such technical decisions. Studying them would not yield any conclusions if the management team at every club operated with maximum efficiency because then each club would be achieving the level of sporting performance commensurate with its endowment of power.

[6] In addition, distortions will result if high quality players are willing to accept a lower wage at a 'big' club.

Table 2 reports results from estimation of the stochastic frontiers for the two leagues (for Italy, columns (2) to (4) relate to re-estimation in robustness tests reported below; the lead results are in column (1)). The core finding is from the estimation of γ. This coefficient is significantly different from zero at the one per cent level for Italy but far from significant for Chile. This suggests that, consistent with our theoretical model, the main differences in performance across clubs in the Chilean League arise from institutional factors related to the history of the teams or where they are located or what the capacity of their stadium is. By contrast, in Italy, where the competition is more professional and club managements oversee more sophisticated operations, technical decisions appear to play a more important role than institutional factors in explaining differences in performance across teams. The finding for Italy is consistent with Simmons and Frick (2008), Hoflet and Payne (2006) and Kahane (2005) who all show that managerial efficiency is an important determinant of performance in sports competitions in a developed country. A plausible explanation for Chile being different from developed countries is that financial markets are imperfect in small leagues and, although it is more difficult for their clubs to obtain funds to sign quality players, a small level of resources can be allocated relatively easily. But when more funds are available, as in major leagues in rich countries, institutions become more complex and it is more difficult to manage capital in an efficient way.

		Italy				Chile
		(1)	(2)	(3)	(4)	(1)
Intercept	β_0	0.788	0.755	0.788	0.790	0.359
		(13.46)	(24.74)	(8.30)	(8.91)	(21.55)
		(***)	(***)	(***)	(***)	(***)
3 points dummy	β_1	0.049	0.051	0.051	0.051	0.038
		(3.23)	(12.24)	(3.33)	(8.91)	(2.06)
		(***)	(***)	(***)	(***)	(***)
Capital	β_2	-0.099	-0.069	0.004	0.010	0.057
		(-2.35)	(-1.73)	(0.30)	(0.42)	(4.04)
		(***)	(*)			(***)
International tournament	β_3	0.008	0.002	0.013	0.013	0.047
		(0.55)	(-2.95)	(0.73)	(0.71)	(2.10)
						(***)
Stadium capacity	β_4	-7.491	-7.113	-1.897	-2.046	5.429
		(-2.25)	(-2.95)	(-0.47)	(-0.44)	(3.09)
		(***)	(***)			(***)
Size of city	β_5	0.0732	0.582	0.243	0.215	0.244
		(3.43)	(2.52)	(2.51)	(1.99)	(0.58)
		(***)	(***)	(***)	(*)	
Champion in previous years	β_6	-0.011	0.021	-0.008	-0.009	0.049
		(-0.68)	(1.23)	(-0.42)	(-0.54)	(2.05)
Performance in previous years	β_7	0.029	0.027	0.030	0.028	0.058
		(1.78)	(3.01)	(1.99)	(1.79)	(3.01)
		(*)	(***)	(**)	(*)	(***)

Intercept	δ_1	0.290 (9.11) (***)	0.227 (5.49) (***)	0.305 (25.18) (***)	0.302 (14.71) (***)	-0.038 (-0.61)
Number of foreign players	δ_2	-0.004 (-3.06) (***)	-0.004 (-3.75) (***)	-0.004 (-2.85) (***)	-0.004 (-2.73) (***)	-0.008 (-1.67 (*)
Total number of players	δ_3	0.009 (5.46) (***)	0.010 (14.04) (***)	0.009 (5.16) (***)	0.009 (5.23) (***)	0.007 (4.71) (***)
% goalkeepers	δ_4	0.438 (2.37) (***)	0.226 (2.60)	0.499 (2.68) (***)	0.496 (2.55) (***)	-0.125 (-0.70)
% defenders	δ_5	0.016 (0.13)	0.112 (1.03)	0.019 (0.16)	0.019 (0.16)	0.077 (0.84)
% midfielders	δ_6	0.024 (0.24)	0.102 (1.16)	0.028 (0.27)	0.023 (0.23)	-0.125 (-1.36)
Number of high scoring players	δ_7	-0.022 (-3.19) (***)	-0.028 (-4.48) (***)	-0.021 (-3.00) (***)	-0.021 (-3.24) (***)	-0.018 (-2.79) (***)
Manager quality	δ_8	-0.441 (-9.38) (***)	-0.527 (-13.95 (***)	-0.458 (-10.21) (***)	-0.458 (-9.79) (***)	-0.099 (-2.83) (***)
Manager experience	δ_9	-0.0003 (0.09)	0.002 (0.65)	0.0001 (0.04)	-0.0002 (-005)	0.004 (2.06) (***)
Foreign manager	δ_{10}	0.016 (1.14)	0.020 (5.28) (***)	0.016 (1.09)	0.016 (1.07)	0.002 (0.17)
Composed error variance	σ^2	0.006 (12.37) (***)	0.004 (28.14) (***)	0.006 (12.54) (***)	0.006 (22.52) (***)	0.008 (11.72) (***)
Proportion of error variance due to technical inefficiencies	γ	1.00 (8.14) (***)	1.00 (15.26) (***)	1.00 (86.13) (***)	1.00 (32.23) (***)	0.00000001 (0.02)
Log-likelihood		341.23	319.83	339.00	339.08	267.09
Observations	296	236	296	296	274	

(1) Baseline estimation. (2) Estimation excluding observations from seasons 2004/05, 2005/06 and 2006/07. (3) Estimation similar to (1) but variable 'Capital' refers to the capital of any Italian province. (5) Estimation similar to (4) but variable 'Capital' refers to any of the 4 biggest Italian cities. t-values are shown between brackets. ***, **, * denotes rejection at the 0.01, 0.05 and 0.10 significance level respectively.

Table 2. Stochastic Production Frontier Estimation for the Italian and Chilean League.

Among the Group I variables, the results for Italy show that the size of city is indeed an important determinant of the level of achievement of a football club, just as was suggested in the two team league model.However, the benefit from city size is mitigated by location in the capital city; this could reflect diminishing returns to city size in the sports sector (Buraimo et al., 2009) or the fact that, in the Italian context, the capital city have competing high level football clubs that split the market. Stadium capacity (for a given size of city) is shown to have a negative impact on performance. Possibly managers with a large number of seats to fill relative to the size of the local market will have to price tickets lower: with the inelastic demand claimed to prevail in sports markets in developed countries (Fort, 2006), this will imply depressed revenue compared with what would be expected to be available from the size of the city. Results on these spatial variables are different in Chile. There population itself is not significant but location in Santiago de Chile assuredly is. This combination of results likely reflects that a high proportion of clubs are located in the capital and, given they all have the same value for city size, this will prevent the importance of population size per se from being detected in the estimation. In contrast to Italy, Chilean clubs have faced restrictions on their ability to finance stadium development and therefore it is unsurprising that stadium size is a positive predictor of performance in this case. While results on these spatial variables display contrasts between Italy and Chile, the history variables yield similar findings: a history of achievement raises performance in the current period. Again, this is consistent with the importance of market size as clubs that were successful in the past will have collected more supporters on the way to the present.

Our Group II variables test for effects from several individual categories of technical managerial decisions. The choice of coach is shown to matter substantially. For Italy, similar to Simmons and Frick (2008) for Germany, we find that the quality of the coach (as reflected in his career win-ratio)is important but his length of experience has no independent role. Since it is inefficiency that is being modeled, the negative sign indicates that clubs who employ a coach with a better than average career record tend to be the clubs which are more efficient in converting status to sporting performance. The same is found in Chile. One of several possible explanations is that decision takers at some clubs undervalue coaching relative to player inputs. Note that we do not include a variable to account for the influence of a new manager (compared to the one who finished the previous season). The reason is that for the Chilean league we do not have information about the manager of teams playing in the second division the previous year and here we show a similar estimation in both countries for the purpose of comparison. However, when we run a similar estimation of Italy, including this variable, there are not significant changes in our results; the proportion of error variance due to technical inefficiencies is still significant (0.928 with a t-value of 12.22) and the variable new manager exerts a negative impact (but not significantly different from zero) on performance. This result accords with previous analysis in Tena and Forrest (2008) using match level data, who suggest that a new manager has only a very small effect and then only for a small number of matches. This is consistent with the scapegoat hypothesis.

The wages of players account for the largest part of expenditure by professional sports teams and it is clearly key that whatever budget is available is spent judiciously. One trade-off clubs face is between the number of players on the roster and the average quality of players (higher quality players are likely to be more expensive) and a striking feature from Table 1 is the very high variance in squad size. In both countries, clubs with a below average squad size appear to be more efficient than those who opt for fewer players. Perhaps the former enjoy greater success because of substitution of quality for quantity or it could be that players in a small squad benefit from getting more playing time. Of course, it is also (just) possible that clubs who employ a higher number of personnel understand that this lowers expected performance but accept the fact because they are risk averse and, for example, want to guard against the adverse consequences of an exceptional number of injuries. The same remark qualifies the finding that a higher number of goalkeepers in the squad (in Italy) appears to be associated with lower efficiency. But the ratios of defenders and midfielders are not significant explanatory variables in either country, so that there seems to be efficient decision taking across the clubs in respect of the balance of different categories of outfielder (notwithstanding that relative numbers display high variation across clubs).

From the results, a particularly tricky decision for football clubs (as will be the case for managers in other creative industries, such as opera or research) is the proportion of resources to be used up on star performers. In football, these are usually successful strikers, defined here by the variable 'number of high scoring players'. This attracts a negative coefficient estimate for both countries, implying that clubs who choose to employ none or only a small number will fail to reach the production frontier. The implication that some clubs undervalue genuine strikers is weakened, of course, if there are labor market imperfections that restrict their movement away from their current clubs.

The degree of efficiency shown by a club in the Italian League also appears to be associated with its propensity to recruit foreign players compared with other clubs. Just as Kahane (2005) demonstrated that clubs which displayed a reluctance to employ francophone ice hockey players tended to pay a price in terms of a lower level of performance, so here a club with a below average number of foreigners is shown to fare worse as a result. Recent papers have highlighted the beneficial effects of foreign players in increasing the probability of success of the national team (Alvarez et al., 2008 report this effect and attribute it to spillover effects that raise the ability level of domestic players) and in increasing the level of competitiveness in domestic leagues (Flores et al., 2008). However, no significant effect is found in Chile, probably because its weak league cannot attract foreigners of a quality who would provide better value than local players.

Broadly the results from the model imply that, while historical and geographical variables, intended to capture market size, play their expected roles in both Italy and Chile, impacts from the pattern of technical decisions across clubs are much less important in magnitude in Chile. To test the robustness of these results, we analyze now the implications of two different set of experiments. These estimations are also shown in Table 2. More specifically, our first group of experiments refers possible distortions resulting from penalties imposed on clubs for illegal activities (mainly match fixing scandals) in the Italian league during seasons 2004/05, 2005/06 and 2006/07. We eliminate these three seasons from the sample and estimate the model. Main results were also robust to this experiment.

Finally, the model was also estimated for different definitions of variable for the Italian case. More specifically, we consider a dummy variable that takes value 1 when the team is located in any of the biggest four Italian cities: Roma, Milano, Napoli and Torino also in a capital of any Italian province. Conclusions are not affected in either of the two cases and the null of managerial efficiency could be rejected in both cases at the 1% level.

To summarize, we have presented results of the estimation of a stochastic production frontier for the top divisions of the football leagues in Italy and Chile. We found that institutional factors linked to the power and history of different teams explain a high proportion of the variation of output between clubs in the Chilean League but are relatively less important for the Italian case. The analysis relating to technical decisions indicates that acquiring scarce inputs such as quality players and managers are the main routes to improving performance in the Chilean and the Italian Leagues.

6. CONCLUDING REMARKS

This paper analyzes the relationship between resource inputs and managerial efficiency in firms. The discussion is motivated with a simple theoretical model that suggests that, although more complex institutions are expected to perform better than small firms, big companies are more difficult to manage efficiently. The model is illustrated with the estimation of stochastic production frontiers for the top divisions in Chilean and Italian football. Results indicate that, accordingly to our model, managerial variables play a more important role in Italy compared to Chile.

Although more empirical tests are still required, an important implication of this result is that the analysis of competition would be different in highly concentrated and low concentrated industries. Thus, capital constraints would be a more important issue in low concentrated sectors while technical inefficiency variables become more relevant in sectors dominated by big firms.

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