

Predicting the Comparative Strengths of National Football Teams*

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Objectives. The aim of this study was to identify the chief social and economic factors predicting the strength of national Association Football (soccer) teams. *Methods.* A theoretical model was developed to establish an appropriate functional form for the relationship between team strength and the number of individuals available for selection. OLS regression was used to predict the performance ratings of 201 national teams. *Results.* The results showed that the strength of a nation's football team depends on the number of men who regularly play football, the length of its football tradition, the wealth of its population, the percentage of expatriate players in the national team, and climatic conditions. These factors explain 70 percent of the variance in international team ratings. *Conclusions.* Many of the factors that determine team strength are structural and cannot be manipulated by policymakers. Nations could, however, strengthen their teams by encouraging wider participation in the sport. Poorer nations could develop stronger teams by encouraging their best players to play professional club football abroad, although this might have negative consequences for domestic football.

International politicians now accept that sport can make a positive contribution to the social, economic, and political life of nations. In a report to the General Assembly, the Secretary-General of the United Nations declared: "On the national level, sport and physical education contribute to economic and social growth, improve public health and bring different communities together. On the global level, if used consistently, sport and physical education can have a long-lasting positive impact on development, public health, peace and the environment" (United Nations, 2005:3).

National sporting performance began to attract scholarly attention in the 1970s with the appearance of studies examining the socioeconomic antecedents of Olympic Games success (Ball, 1972; Grimes, Kelly, and Rubin, 1974; Levine, 1974). After a gap of several decades, interest in predicting Olympic medal winning has recently revived (e.g., Bernard and Busse, 2004;

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Churilov and Flitman, 2006; Condon, Golden, and Wasil, 1999; Estellita Lins et al., 2003; Johnson and Ali, 2004; Lozano et al., 2002; Moosa and Smith, 2004; Tcha and Pershin, 2003). These studies have generally found that a country's size and wealth are major determinants of medal success.

Attention has now turned to international Association Football (Hoffmann, Lee, and Ramasamy, 2002a; Houston and Wilson, 2002). Association Football (soccer) is recognized as the world's most popular sport. Football's international governing body, the Fédération Internationale de Football (FIFA), estimates that about 240 million men and women regularly play football worldwide; of these, about 12.5 million are registered with their national associations, and about 125,000 play professionally (FIFA, 2001).

In this article, we build on previous studies of national sporting success to develop an explanatory model for the performance of international football teams. We advance previous research in this area by deriving a mathematical formula relating team strength to the number of players available for selection, and also by investigating the impact of expatriate players on team success.

The Organization of World Football

Currently, FIFA consists of more than 200 affiliated associations, the majority of which represent sovereign nations. However, the United Kingdom is represented by individual associations for England, Scotland, Northern Ireland, and Wales, and a small number of associations (e.g., Tahiti, New Caledonia) do not represent fully sovereign states. Member associations are grouped into six regional confederations.

FIFA Team Ratings

FIFA's current rating system for national teams was introduced in 1999. Points are awarded to both teams after an international match. The points allocated depend on the match result (win, lose, or draw), and points are added for goals scored and deducted for goals conceded. The number of points awarded for the match result, as well as for the number of goals scored or conceded, is dependent on the strength of the opposition, so that, for example, a win over a highly rated team earns more points than a win over a weak one. In addition, the away team is accorded bonus points, and weightings are applied to reflect both the status of the match and differences in strength between the six FIFA confederations. The averagely active team plays between seven and ten matches per year, and to equate for different numbers of fixtures, the ranking points for a season are based on a nominal seven best and seven average fixtures, the best seven results being given more

weight. Finally, to ensure that the ratings reflect current form, recent matches are given more weight.

Study Variables

Because we are interested in the relatively stable structural influences on the performance of national soccer teams, rather than short-term influences, we averaged each country's FIFA rating over a six-year period to obtain an index of team strength. The dependent variable for this study is the mean of the six FIFA ratings for the month of October in the period 2000 and 2005. (We omitted 1999 because it is temporally prior to one of our key explanatory variables.) Averaging is justified because ratings are highly stable over this period, with a mean correlation between years of 0.97. Ratings for 204 countries were obtained from the rankings and statistics pages of the FIFA website (FIFA, n.d.b).

Independent Variables

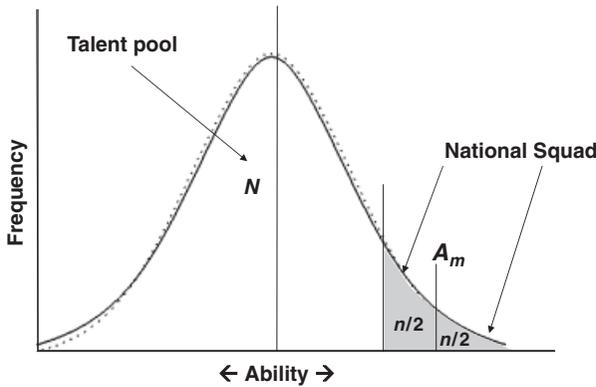
Size of the Talent Pool. Other things being equal, we would expect that countries with a large pool of talent to select from will produce stronger teams than those with a smaller pool to select from; more populous countries should therefore outperform smaller ones in competitive sports. Previous studies of national sporting success support this view. For example, Bernard and Busse (2004) and Johnson and Ali (2004) found that larger countries win more Olympic medals.

Intuitively and empirically, therefore, we can write $S = f(N)$, where S is the strength of the national football team, and N is the size of the talent pool. But what is the appropriate functional form for f ?

We first assume that individual football ability is distributed according to a common probability distribution that has the same parameters in all countries. A natural choice for this probability distribution would be a Gaussian (normal) distribution; however, the integral of the normal distribution does not have a closed form, and for simplicity of subsequent calculation, we assume a logistic distribution. Without loss of generality, we may assume this distribution to have a mean of 0 and a scale parameter of 1 in all countries.

We next assume that the strength of a country's football team is determined by the abilities of its n most able players, where n is some small number representing the effective size of the national squad. To allow for tactical variations, replacements in the event of injury, and to encourage effective competition for team places and so forth, we would expect n to be somewhat larger than the size of the squad (on-field players and substitutes) for any single match. However, the precise value of n is unimportant; as we

FIGURE 1
Hypothetical Distribution of Football Ability



NOTE: Solid line shows logistic distribution, dotted line shows normal distribution for comparison. N = size of talent pool, n = size of national squad, A_m = median ability of national squad.

show below, the only consideration is that it is the same for all countries and much smaller than the size of the pool, N , from which the players are selected.

Figure 1 shows the logistic distribution of individual football ability in a country, with the national squad depicted by the shaded area.

We shall assume here that the strength, S , of the national team is proportional to the median ability A_m of the players in the squad. Determining S then reduces to the problem of calculating A_m , the value of A such that the best $n/2$ players in the population have $A \geq A_m$.

A_m can be derived from the inverse cumulative distribution function of the probability distribution. This is denoted $F^{-1}(p)$, and gives the value of a random variable X , such that the probability that $X \leq F^{-1}(p)$ is p . For the logistic distribution with mean 0 and scale parameter 1:

$$F^{-1}(p) = \ln\left(\frac{p}{1-p}\right). \tag{1}$$

Let the pool size be N ; then the area under the distribution to the right of A_m , which corresponds to $1 - p$, is $n/2N$, so we can write $p = 1 - n/2N$.

Substituting for p in Equation (1) and rearranging yields:

$$F^{-1}(p) = A_m = \ln(2N - n) - \ln(n).$$

Because $n \ll N$, and because $\ln(n)$ is a constant (k) for all countries, we can approximate as follows:

$$A_m \approx 2 \ln(N) - k.$$

Thus, given the same (logistic) distribution of ability, and the same squad size, in each country, the median squad ability, and hence the strength of the national team, will be a linear function of the logarithm of the pool size from which the team is chosen.

To see whether a logarithmic relationship holds empirically, we examined three plausible measures of pool size; the total population (*PTOT*), the number of men who play football regularly (*PPLAY*), and the number of men who play for teams registered with their national football association, that is, registered male players (*PREG*). Values of *PTOT* for 2002 were obtained from the International Programs Center Database of the U.S. Census Bureau (U.S. Census Bureau, 2002) and missing values were added from the CIA *World Factbook* (Central Intelligence Agency, 2004). Values of *PPLAY* and *PREG* for the year 2000 were obtained from a FIFA survey of its member associations (FIFA, 2001). All pool sizes were measured in thousands.

We used a curve estimation technique to model the relationships between FIFA ratings and the linear and natural logarithmic forms of each of these measures. The results are shown in Table 1.

In Table 1, high R^2 values and low *RMSE* values indicate better model fit. The results clearly show that the logarithmic measures of pool size predict FIFA ratings much more strongly than do the linear measures. As shown by its low R^2 value, the relationship between FIFA ratings and (linear) total population is vanishingly small. This counterintuitive finding has also been reported by Hoffmann, Lee, and Ramasamy (2002a) for a sample of 76 countries. However, as we have argued above, there are sound theoretical reasons to suppose that the linear functional form is not appropriate here.

TABLE 1

Goodness-of-Fit Measures for FIFA Ratings as a Function of Talent Pool Size

Pool Size Variable (000s)	<i>N</i>	Fit Measures		Regression Parameters	
		R^2	<i>RMSE</i>	Intercept	β
<i>Linear</i>					
<i>PTOT</i> total population	204	0.01	201.2	401.6	0.12
<i>PPLAY</i> no. regular players	201	0.13	188.6	383.9	0.36
<i>PREG</i> no. registered players	202	0.18	183.3	378.8	0.42
<i>Logarithmic</i>					
<i>PTOT</i> total population	204	0.32	166.8	-8.7	0.57
<i>PPLAY</i> no. regular players	201	0.53	138.3	139.7	0.73
<i>PREG</i> no. registered players	202	0.52	139.8	264.0	0.72

NOTE: *N* = number of countries, R^2 = variance explained, *RMSE* = root mean square error, β = standardized regression coefficient.

In this article, we use the *PPLAY* as our measure of pool size because it has the strongest bivariate relationship with FIFA ratings.

Football Tradition. Nations with a history of fielding international football teams are likely to gain tactical expertise, organizational skills, and competitive intelligence that will improve their performance. A nation's football tradition (*TRAD*) was measured by the number of years between 2003 (the middle year of the study period) and the year in which its national football association was affiliated to FIFA. Year of affiliation was obtained from the member associations section of the FIFA website (FIFA, n.d.a).

A scatterplot of team ratings against *TRAD* showed the relationship was linear, with model fit indices $R^2 = 0.31$, $RMSE = 23.38$. However, we observed an interesting pattern among the outliers; the 15 former Soviet republics, the five former Yugoslav republics, and the Czech and Slovak republics had FIFA ratings that were noticeably higher than expected. All these countries are former members of a larger political entity and have relatively recent affiliations to FIFA, dating from their emergence as independent sovereign states. We suggest, however, that the football tradition in these countries predates their independent status and is an inheritance deriving from their previous membership in a super-ordinate political entity. For these countries, we substituted the year of affiliation by either the year they were absorbed into their super-ordinate entity, if that entity was already affiliated to FIFA, or by the year of affiliation of the super-ordinate entity if that entity became affiliated after absorption. These adjustments substantially improved the fit of the linear model (model fit: $R^2 = 0.46$, $RMSE = 20.68$), and the adjusted values of *TRAD* were retained in subsequent analyses.

Economic Resources. Previous studies of international sport have shown that wealthier countries outperform their poorer counterparts (e.g., Bernard and Busse, 2004). In wealthy countries, individuals are free to support and to engage in leisure activities and competitive sports to a greater degree than in poorer countries. Furthermore, the easier access to medical and advanced training resources in wealthy countries probably enables players to perform more consistently at higher levels than would otherwise be possible. For these reasons we would expect national income to have a positive impact on proficiency. Houston and Wilson (2002) provided indirect evidence that the relationship between proficiency in football and national income is, however, subject to a law of diminishing returns, such that increases in income have a progressively smaller impact on proficiency as per-capita GDP increases. We instantiate this relationship here by using the logarithm of per-capita GDP to represent national wealth. Per-capita GDP data for 2003, in U.S. dollars, was taken from *The World Factbook* (Central Intelligence Agency, 2004).

Playing Abroad. Professional football clubs are commercial enterprises and seek to recruit the best players from around the world. Using data kindly made available by Benjamin Strack-Zimmermann of National Football Teams, we calculated that between 2000 and 2005, 40.9 percent of the players representing their country played club football abroad. Of these, 76.8 percent played in a wealthier country, and 86.2 percent played in a higher-FIFA ranked country. We may suppose that these expatriate players bring additional resources of experience, skill, and fitness to their national teams. We thus predict that national teams with a higher percentage of expatriate players will have higher FIFA rankings. An expatriate index (*XPAT*) was calculated for each country by averaging the percentage of expatriate internationals in each season between 2000 and 2005.

Climate. A game of football makes considerable physical demands on the players, and the way it is played is influenced by the weather. For example, in hot conditions, games may be played at a slower pace. Under such conditions, skill may be more of an advantage than speed or stamina. The climate to which players must adapt might influence their style. (For evidence on the effects of climate on national sporting success, see Hoffmann, Lee, and Ramasamy (2002a, 2002b).)

Thirty-year annual averages (1961–1990) for the following climate variables were taken from Mitchell, Hulme, and New (2002): temperature (*TEMP*, degrees Celsius), precipitation (*PRECIP*, millimeters), and atmospheric vapor pressure (*VAPOR*, hectoPascals). Climate data were missing for 10 countries. In these cases, data from the geographically nearest country were substituted.

Cluster analysis of the climate variables, based on minimizing Schwarz's Bayesian Information Criterion, produced a three-cluster solution, with centroids as shown in Table 2.

TABLE 2
Centroids of Climate Clusters

Cluster	No. Countries	Annual Precipitation (mm)		Temperature (°C)		Vapor Pressure (hPa)	
		Mean	SD	Mean	SD	Mean	SD
1. Tropical-Subtropical	74	2,139	484	25.1	1.2	25.2	2.1
2. Medium-Pressure	65	643	448	22.7	3.7	16.5	4.4
3. Temperate	65	837	377	7.8	4.0	8.5	2.0

Cluster 1 countries are characterized by high precipitation, high temperature, and high vapor pressure, while Cluster 2 countries have low precipitation, high temperature, and moderate vapor pressure, and Cluster 3 countries have low precipitation, low temperature, and low vapor pressure. The validity of this solution was checked by reference to a database of Koeppen-Geiger (KG) climate zone populations (Gallup, Mellinger, and Sachs, 2001). For each country, this database reports the percentage of the population residing in each of the 12 KG zones, and data were available for 163 of the FIFA nations in our sample. For each cluster we computed the mean percentage population living in each climate zone. In Cluster 1 countries, the mean percentage of the population living in tropical or subtropical climate zones was 89 percent, and the mean percentage in temperate zones was 1 percent; accordingly, Cluster 1 was designated Tropical-Subtropical. In Cluster 3 countries, the mean percentage in temperate zones was 74 percent, and in tropical or subtropical zones, 4 percent; Cluster 3 was designated Temperate. Cluster 2 was more diverse, with 29 percent in tropical-subtropical zones, 19 percent in temperate zones, and 43 percent in steppe or desert zones. Cluster 2 was designated Medium-Pressure because it is most clearly distinguished from the other clusters by an intermediate level of vapor pressure.

It might be argued that the substantial proportion of expatriate players in many national teams would invalidate an analysis based on the climate of the home country. However, most expatriate players play in countries close to their home country and an analysis of the National Football Teams database showed that 83 percent of players played either in their own country or in a country in the same climate cluster. The climate cluster of the home country is therefore a good approximation of the climate experienced by a national team's players.

U.K. Home Nations

The home nations of the United Kingdom (England, Northern Ireland, Scotland, Wales) are registered as separate entities under FIFA. Populations for these countries were taken from the U.K. Census of 2001. Per-capita GDP and climate variables for these countries were set equal to the United Kingdom as a whole.

Results

Descriptive Statistics and Correlations

Means and standard deviations of the study variables and their correlations are shown in Table 3.

TABLE 3
Descriptive Statistics and Correlations

	Mean	SD	1	2	3	4	5	6	7
1. FIFA rating	407.6	202.0							
2. No. regular players (log)	4.2	2.3	0.73***						
3. Tradition	51.1	28.0	0.68***	0.70***					
4. Expatriate index	37.6	29.3	0.23***	0.02	0.17*				
5. GDP (log)	8.6	1.3	0.28***	0.08	0.32***	-0.05			
6. Temperature	18.8	8.2	-0.39***	-0.34***	-0.61***	-0.19**	-0.37***		
7. Precipitation	1,247.5	807.9	-0.36***	-0.28***	-0.31***	-0.13	0.01	0.41***	
8. Vapor pressure	17.1	7.5	-0.45***	-0.37***	-0.56***	-0.22**	-0.23**	0.86***	0.72***

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

NOTE: $N = 204$, except No. regular players, $N = 201$; Expatriate index, $N = 203$.

Regression Model

For modeling purposes, the climate clusters were represented by two dummy variables, DT and DM . DT was coded 1 for Tropical-Subtropical countries, and 0 otherwise, while DM was coded 1 for Medium-Pressure countries, and 0 otherwise. Interaction terms were computed for each cluster dummy and the continuous independent variables. To test the hypothesis that expatriate players are more valuable to poorer countries, we also included the interaction between logarithmic GDP and the expatriate index. To reduce multicollinearity between the interaction terms and their first-order components, all continuous independent variables were first centered about their means. The initial regression equation was thus:

$$\begin{aligned} FIFAI_i = & \beta_0 + \beta_1 \ln PPLAY_i + \beta_2 TRAD_i + \beta_3 XPAT_i + \beta_4 \ln GDP_i \\ & + \beta_5 DT_i + \beta_6 DM_i + \beta_7 (DT * \ln PPLAY)_i + \beta_8 (DT * TRAD)_i \\ & + \beta_9 (DT * XPAT)_i + \beta_{10} (DT * \ln GDP)_i + \beta_{11} (DM \\ & * \ln PPLAY)_i + \beta_{12} (DM * TRAD)_i + \beta_{13} (DM * XPAT)_i \\ & + \beta_{14} (DM * \ln GDP)_i + \beta_{15} (\ln GDP * XPAT)_i + \varepsilon_i, \end{aligned}$$

where i denotes the i -th country, $FIFA$ is the average FIFA rating in the period 2000–2005, $PPLAY$ is the number of regular male players (000s), $TRAD$ is the number of years between affiliation with FIFA and 2003, $XPAT$ is the percentage of expatriate internationals, GDP is the 2003 per-capita GDP in U.S. dollars, and DT and DM are dummy variables for the Tropical-Subtropical and Medium-Pressure climate clusters respectively. ε is a normally distributed error term.

A standard variable reduction procedure was used, in which terms that did not significantly add to the regression F value were successively eliminated from the model, beginning with the interaction terms, and followed by first-order terms that were not involved in a remaining interaction. Comparison of the initial and reduced models showed that the regression F values were not significantly different (F -change(7,184) = 0.57, p = 0.87). The Akaike Information Criterion (AIC) and the Amemiya Prediction Criterion (PC) for variable selection showed that the reduced model (AIC = 1,893, PC = 0.343) was superior to the initial model (AIC = 1,904, PC = 0.326). The final regression results are shown in Table 4.

Diagnostic tests showed that the regression assumptions were satisfied. A Kolmogorov-Smirnov test showed no evidence of nonnormality in the residuals distribution (Z = 0.91, p = 0.38), and a Cook-Weisburg test showed no evidence of heteroscedasticity ($\chi^2(1)$ = 0.14, p = 0.71). Excessive multicollinearity among the predictors is indicated when a variance inflation factor (VIF) exceeds 5 or 10 (Montgomery and Peck, 1992). The highest VIF was 3.2, indicating that multicollinearity was not a problem in this model.

TABLE 4
Regression Results

Predictor	<i>B</i>	β	<i>t</i> -value
(Constant)	392.88		22.6***
No. regular players (log)	48.28	0.54	9.1***
Football tradition (years)	1.22	0.17	2.4*
Expatriate index	1.17	0.17	4.0***
GDP (log)	61.23	0.37	6.9***
Tropical-subtropical dummy	-19.04	-0.05	-0.8
Medium-pressure dummy	68.05	0.16	2.7**
Tropical-subtropical \times GDP	-60.79	-0.18	-3.8***
Expatriate index \times GDP	-0.54	-0.10	-2.5*

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

NOTE: $N = 201$, B = unstandardized regression coefficient, β = standardized regression coefficient. $R^2 = 0.70$, $F(8, 191) = 56.4$. ***

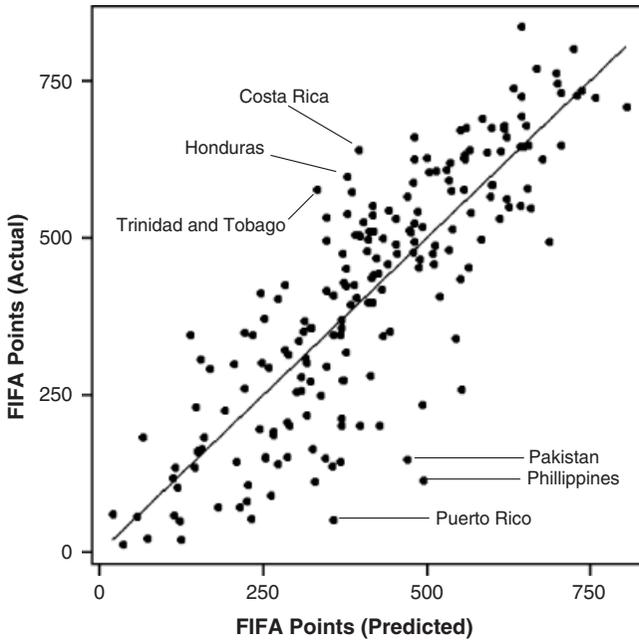
The results shown in Table 4 are broadly compatible with previous research. First, we find that the size of the talent pool has a substantial impact on team strength. Although previous research has shown that more populous countries outperform smaller ones in competitive sport, we are aware of no previous studies that have included a direct test of the size of the talent pool. We also find, in common with previous studies, a positive effect of national wealth. However, the negative sign of the $DT \times GDP$ interaction term implies that this effect is smaller in Tropical-Subtropical countries than in Medium-Pressure or Temperate countries. Third, we find a significant effect of climate, whereby countries in the Medium-Pressure zone outperform those in the Temperate and Tropical-Subtropical zones. As predicted, we also find an advantage of fielding expatriate players; however, as shown by the negative coefficient of the expatriate-GDP interaction, this advantage is less pronounced for wealthy countries. Finally, the length of a nation's football tradition also has a positive impact on team strength.

Figure 2 shows the relationship between the observed and predicted FIFA ratings. (The three largest positive and negative outliers are labeled.)

Discussion

Several limitations in the present study should be noted. First, the use of a complete census of FIFA countries limited the variables available for testing because many potentially interesting socioeconomic variables have not been measured for all countries in the sample. However, additional regression models not reported here in detail examined indices of human development, military capability, and political and civil rights as additional predictors of FIFA ratings on a reduced sample of countries. None of these indices

FIGURE 2
 Predicted Versus Actual FIFA Rating Points



NOTE. The solid line is the least squares regression line. The three furthest positive and negative outliers are labeled.

accounted for any significant increase in explained variance beyond that explained by our existing predictors.

The advantage of Medium-Pressure countries may have a physiological basis. It is well known that high vapor pressure depresses athletic performance because it inhibits the body's ability to cool by sweating, and leads to overheating; this effect is particularly important at high temperatures and the dangers of strenuous physical exertion in hot and humid conditions are well documented. However, exertion at low vapor pressures (i.e., in dry air) can induce respiratory conditions known as exercise-induced bronchostriction (EIB) and exercise-induced asthma (EIA), which reduce the capacity to exercise (Bar-Or, Neuman, and Dotan, 1977; Stensrud, Berntsen, and Carlsen, in press). The risks of EIA and EIB are particularly pronounced at low temperatures (Helenius, Tikkanen, and Haahtela, 1998; Rundell and Jenkinson, 2002; Üçok et al., 2004).

The present findings are consistent with these considerations. Countries in the Tropical-Subtropical cluster have hot and humid climates that increase the risks of physical overheating, and, on the other hand, countries in the Temperate cluster have low temperature, low vapor pressure climates that

are likely to increase the incidence of EIA and EIB. Teams whose players are accustomed to playing in either type of climate might not be used to performing at high intensity for extended periods.

Our results indicate that the international playing field is by no means level. Resource limitations and climatic factors dictate the typical degree of success nations can expect to achieve in international football. Many of these factors are inflexible, and admit little or no opportunity of adjustment by policymakers.

However, there are two options that policymakers might consider. One is simply to encourage more people to play football. There are currently wide variations in participation levels between countries; for example, in India, only 0.4 percent of men regularly play football, compared to 7.9 percent in Brazil. Encouraging wider participation might enable some countries to improve their performance, especially those where participation levels are currently low. A second option is to increase the proportion of expatriate players in the national team. The large majority of expatriate footballers are employed by professional clubs in wealthier or higher-FIFA ranked countries, where they presumably benefit from advanced coaching and medical facilities, and are exposed to expertise that is not available in their home country. In this way, nations can “borrow” resources from abroad to improve the quality of their teams. We suggest that nations might significantly improve the strength of their teams by adopting policies that increase the opportunities for players to gain professional experience abroad. The regression results indicate that this strategy would be particularly effective for poorer nations.

Neither of these policies are without snags, however. Encouraging wider participation involves opportunity costs that might better be deployed elsewhere, for example, in improved coaching at elite levels. Increasing the percentage of expatriate players might also have negative consequences; an exodus of talented players might reduce the quality of local club competition to the extent that interest in domestic football declines, and its economy suffers, reducing the ability of a country to generate further international talent.

That said, we note the existence of some large outliers in our results, which indicate that considerable room exists for individual nations to overcome their structural and resource disadvantages (or to fail to exploit them effectively). The competitive strengths of Pakistan, Puerto Rico, and the Philippines, for example, fall far below expectation, while Costa Rica, Honduras, and Trinidad and Tobago are three countries able to punch significantly above their weight. A detailed study of practices in these outlying nations would be an interesting avenue for further research, which might reveal strategies that other nations could adopt to improve performance.

Such departures from the norm also have considerable importance for football as a spectator sport; without them, there would be little point in

international competition. The enduring attraction of international football, and its value to the global community, depends far more on the existence of residuals and outliers than on the slope of the least squares regression line.

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