Average Temperature and Performance in International Football

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Contents

1. Introduction

This paper is about the performance of countries in international men's football. There are two relevant dimensions of international performance to be acknowledged: performance in the competition between national teams (e.g., the World Cup) and international competition between domestic football clubs (e.g., the Champions League). This paper's primary focus lies with the first kind of performance. There are prima facie conceivable determinants of success in international football; this paper centres on one of these factors: geography or climate. Against this background, the research question addressed in this paper is: what influence, if any, has a country's average temperature on the performance of its national football team? Using cross-country data and controlling for economic, demographic, cultural, institutional, and regional factors, this research based on an Overlapping Least Squares (OLS) estimation with heteroskedasticity robust standard errors to will arrive at the following main result: Temperature has a moderate influence on the performance of a country's national team. Moreover, there is an inverted-U shaped relationship between temperature and performance with 14 degrees Celsius as the ideal 'football temperature'. Though this result is robust for the performance of a country's national team, there is some evidence that temperature plays no role in the international performance of a country's domestic football clubs.

The economic study of international football performance based on cross-country data begins with Hoffmann et al. (2002b) who apply their approach for modelling Olympic success to football. Using a sample of 76 countries and the FIFA-Ranking as a dependent variable, they found that economic, demographic, cultural and climatic factors are important. Regarding the climate factors, they specify their regression model as a quadratic function in temperature and corroborate their previous finding (2002a) that the temperature ideal for sports is 14 degrees. Since this paper was published, two major contributions have been made in the literature. Macmillan and Smith (2007) followed Hoffmann et al. closely. They increased Hoffmann et al.'s sample by 100 countries but used basically the same econometric model. One modification was that they also studied the influence of political institutions and found it to be significant. Leeds and Leeds (2009) departed more radically from Hoffman et al. in two ways: They used a production function and a more encompassing approach to model football performance; and they found that the international performance of a country's domestic club has a positive effect on the success of its national team. They did not, however, consider the role of temperature. This paper contributes to the existing literature in two ways. First, it reconsiders the role of geographical factors in the more encompassing framework of Leeds and Leeds (2009). Second, it checks for robustness of the results by using Nate Silver's Soccer Power Index (SPI), an alternative measure for the dependent variable., It also checks for the robustness of the previous results with respect to the second dimension of success in international football (contra Leeds and Leeds, who use the international success of domestic clubs as an explanatory variable).

This paper is structured as follows: Section 2 introduced our analytical production function framework, the variables and data we will use, our main empirical regression equation, and specifies our estimation technique. Section 3 presents and discusses our primary and secondary results together with our diagnostic tests and robustness checks. Section 4 concludes.

2. Framework, data and methodology

2.1 Analytical framework

Building on Leeds and Leeds (2009), we address modelling long-term performance in international football with a theoretical production function:

$$P = f(X) \tag{1}$$

This general production function links performance or success in international football P (output) to a vector of factors X (inputs). What are the elements of vector X? In the economics of sports or football literature, the following factors have been considered (see Hoffmann et al. 2002b, Macmillan and Smith 2007, Leeds and Leeds 2009): economic factors (i.e., capital); demographic factors (i.e., population size); cultural factors (i.e., how deeply rooted football is in the popular culture of a country); institutional factors (factors related to political institutions as well as factors related to football institutions); and geographical or climatological factors (i.e.. average temperature). We can thus rewrite the production function as:

$$P = f(G, K, N, C, I) \tag{2}$$

where G a vector of geographical factors, K is capital, N is population size, C is a vector of cultural factors, and I a vector of institutional factors. Note that one could follow Leeds and Leeds (2009) in interpreting N and K as production factors and G, C, and I as determinants of total factor productivity (TFP), where TFP is defined as the proportion of output which is unexplained by the amount of production factors (see The New Palgrave Dictionary of Economics, i.e., Comin 2008); or: TFP captures how well a country translates its human and capital resources into football success.

Ideally, we would know the functional form of this production function. However, as Bernard and Busse (2004) point out in the context of modelling Olympic success, there is 'no theoretical guidance on the precise form of […] $f(.)$.' The same seems to apply in the context success in international football. We will thus follow Hoffmann et al. (2002b), Mcmillan and Smith (2007), and Leeds and Leeds (2009), who opt for linear production functions; or more precisely, for production functions which are linear in parameters but non-linear in some variables.[1]

2.2 Variables and data

We will now introduce the variables for our econometric specification of the football production function (see section 2.3) and for subsequent robustness checks (see section 3.3). Summary statistics of all variables can be found in Table 1; the correlation matrix for these variables is contained in the appendix.

Our dependent variable is performance in international football which has two dimensions: performance of national teams (e.g. of England's 'The Three Lions') and performance of domestic football clubs (e.g., of Manchester United) playing in international competition. This paper's focus lies in the first kind of performance.

To measure performance in international football at the level of national teams, we use the FIFA/Coca Cola World Ranking as of February 2014. In this ranking, the performance of a national team in all matches (including friendlies) over a period of four years (with decreasing weights in time) is evaluated on a monthly basis by using a formula which incorporates factors like the importance of the match.[2] The ranking provides for each country points (here denoted as FIFA_POINTS) and a derived rank (FIFA_RANK). We use FIFA_POINTS as the main measure for the dependent variable and FIFA_RANK only in the context of robustness checks. Also, in the context of robustness checks and to accommodate the critiques of the FIFA ranking, we will employ Nate Silver's Soccer Power Index as of March 2014 (SPI_POINTS) as an alternative measure (our source is ESPN 2014). According to Nate Silver (2009), this rating is designed to be more of a forward-looking nature than the FIFA ranking and incorporates additional factors such as offensive, defensive and player performance (the correlation coefficient between FIFA_POINTS and SPI_POINTS is 0.87).[3] While previous measures are for the dependent variable performance on the level of national teams, for a subsample of countries, there is a measure for the alternative dependent variable international performance of domestic clubs readily available and will be utilized for a robustness check:

[1] Note that Hoffmann et al. (2002b) as well as Macmillan and Smith (2007) do not explicitly follow a production function approach. Nevertheless, their regression equations can be interpreted as empirical specifications of a general production functions.

[2] Details can be found in FIFA's (2009) fact sheet.

[3] Details can be found in Silver's (2009) comment.

Table 1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
FIFA_POINTS	184	437.48	330.37	0	1506.00
FIFA_RANK	184	95.60	57.43	1	207
SPI_POINTS	184	51.95	21.76	3.90	91.40
UEFA_POINTS	49	23.30	22.24	2.88	90.57
TEMP	184	19.33	8.21	-3.90	28.80
GDPPC	184	14191.28	19696.25	215.22	110573.00
POP	184	38.22	140.04	0.06	1360.76
LATIN	184	0.18	0.39	0	1
HOST	184	0.09	0.28	0	1
AFFILIATION	184	58.72	28.89	2.00	110.00
FHCAR	184	3.30	1.91	1.00	7.00
AFRICA	184	0.29	0.45	0	1
ASIA	184	0.22	0.42	0	1
EUROPE	184	0.27	0.44	0	1
OCEANIA	184	0.04	0.19	0	1
SOUTHAMERICA	184	0.05	0.23	0	1

Notes: These table summarizes all variables used either as meausures of our independent variable (FIFA_POINTS, FIFA_RANK, SPI_RANK, UEFA_POINTS) or as an explanatory variables. Note that TEMP has the unit degree Ceslius, GDPPC U.S. dollar (current prices) and POP is in millions. For the sources of the data, see the text.

the UEFA country coefficient as of March 2014 (UEFA_POINTS). This coefficient allocates points on the basis of the performance of a country's domestic clubs in the five previous Champions League and Europa League seasons.[4]

Now we examine explanatory variables. According to the research question of this paper, the key explanatory variable of interest is temperature (TEMP). Here we build on work done by Hoffmann et al. who have shown that there is an inverted U-shaped relationship between a country's temperature and its success in the Olympic Games (2002a) as well as between temperature and its success in international football (2002b). They point out that extreme temperatures have a negative impact on the popularity of outdoor training and playing activities which are especially relevant in the initial development phase of an athlete's or footballer's talent. Building on this research, we will specify our econometric model as a quadratic function in the variable TEMP. Moreover, we expect the resulting coefficient of TEMP to be positive and the coefficient of $TEMP^2$ to be negative. The data we use for the TEMP variable is a country's average annual temperatures (in degree Celsius) which we have obtained from the Centre for Environmental Data Archival (2014).

[4] Details can be found on http://www.uefa.com/memberassociations/uefarankings/country/index.html [retrieved 7 March 2014]. Unfortunately there is no similar coefficient for FIFA's other Confederations to our knowledge.

We control for several other explanatory variables which could affect international football performance. The first two are capital and population size (POP). Here we use GDP per capita as a proxy for a country's capital (GDPPC). The data for both GDPPC and POP for the year 2013 are taken from the International Monetary Fund (IMF; 2013); note the population size is reported in millions. Following Leeds and Leeds (2009), we assume capital and population size have diminishing marginal returns. To account for this, we will specify our econometric model as a quadratic function in the variable GDPPC and likewise in the variable POP.[5] Moreover, we expect the coefficient for the variables GDPPC and POP to be positive and the coefficients for the variables $GDPPC^2$ and POP^2 to be negative.

A further control variable is cultural; that is, how highly football is valued in the country's popular culture. As Hoffmann et al. (2002b) point out, football seems to be of special importance in Latin countries. To accommodate for this, we use a dummy variable LATIN which assigns the value of 1 to Latin countries and the value 0 to other countries. Which are Latin countries? Being aware that every answer to this question incorporates some definitional arbitrariness, we use membership or permanent observer status in the Latin Union instead (our source is here the Latin Union 2014). If our hypothesis about Latin football infatuation is correct, then the coefficient of LATIN will be positive.

Institutional variables could also play a role in a country's football performance. Different kinds of institutions could be relevant: football institutions and political institutions. A country's football institutions can be defined as 'the national soccer association and private or public soccer clubs and of the resources at their disposal' (Leeds and Leeds 2009: 377). Since the quality of a football institution cannot be observed directly and since we lack corresponding financial data, we use two proxies proposed in previous studies (e.g., Leeds and Leeds 2009). As a first proxy variable, we use the number of years elapsed since a country has joined the FIFA (AFFILIATION), with data retrieved from FIFA (2014). The maturity of football institutions is positively correlated with their quality; we expect the coefficient of the variable AFFILIATION to be positive. As a second proxy, we use the dummy variable HOST, with the value 1 if a country has been a host nation for the World Cup and 0 otherwise; data are taken from FIFA (2014). Since hosting a World Cup is a major organizational and financial task, we expect it to be positively correlated with the quality of a country's football institutions. Therefore, the coefficient of HOST should be positive. We now turn to the possible effect of political institutions. According to Foer (2004), political freedom leads to greater creativity and risk-taking and thus to better football performance. However, in another context, Foer claims fascist countries are an ideal breeding ground for football performance due to 'inspiration,

[5] Alternatively one could, for example, address the diminishing marginal returns of these two variables by specifying the model as a logarithmic function of GDP and POP respectively; see Leeds and Leeds (2009) for this route.

intimidation, and diversion of resources into sports programs'(Leeds and Leeds 2009: 375). To measure a country's political regime, we follow Leeds and Leeds (2009) in using the combined Freedom House Index (2014) for political rights and civil liberties (FHCAR) which ranges from 1 (most free) to 7 (least free). Since the above-mentioned effects have some a priori plausibility, we abstain from an expectation about the sign of FHCAR's coefficients.

We will also control for regional factors. The FIFA's member countries are divided into six regions or confederations; therefore, we use five dummy variables (AFRICA, ASIA, EUROPE, OCEANIA, SOUTHAMERICA) while taking the North American Confederation as the base group (the data are taken from FIFA 2014).[6]

We arrived at our final sample of 184 countries by the following procedure: we started with the FIFA ranking, which contains 209 countries.[7] For 180 of these FIFA countries, there are data from the IMF for GDPPC and POP available. We were able, however, to estimate the GDPPC for the four countries of the United Kingdom (which all have their own national team but no IMF data), leaving us with a sample of 184 countries.[8] Since for all other variables data or straightforward estimates were available, our final sample consists of 184 countries.[9]

2.3 Empirical Model and estimation method

Building on our theoretical production function approach and the variables (including the specification of their functional form) introduced in the previous sections, we can now write down our empirical model. Our main regression equation is the following:

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[6] The official FIFA abbreviations of these six confederations in the order used above are: CAF; AFC; UEFA; OFC; CONMEBOL; CONCACAF.

[7] Note that there are, according to Wikipedia, currently only six recognized states which are not members of the FIFA; among them is the United Kingdom which is represented by the national teams of each of its four countries: England; Scotland; Wales; and Northern Ireland.

[8] The case of United Kingdom was treated as follows: the UK Office for National Statistics (ONS) reports the population sizes of the four countries (2012 data). Moreover, the ONS (2014) provides each of the four UK countries' share of the UK Gross Value Added (GVA). In 2012, these shares were: England, 84.8%; Scotland, 7.7%; Wales, 3.4%; Northern Ireland, 2.1%. Multiplying the IMF value of the United Kingdom's GDP by the shares of the four countries and dividing by the respective population sizes gives us estimates of the countries' GDPPC.

[9] For two variables, we use estimates: for TEMP and FHCAR. For the nine countries with missing TEMP values, we take temperature data from a more encompassing entity (e.g., Sudan's temperature for South Sudan) or a neighbor country with similar latitude (e.g., Hong Kong's temperature for Chinese Taipei/Taiwan). In the case of FHCAR, we only lack data for the four countries of the United Kingdom and assume they earn the highest freedom ranking (as the United Kingdom does).

$$P_i = \propto + \beta_1 TEMP_i + \beta_2 TEMP_i^2 + X_i' \Gamma_i + \varepsilon_i \quad (3)$$

where P_i is the country *i's* performance in international football as measured by FIFA_POINTS (with alternative measures used in the robustness check section), $TEMP_i$ is our key explanatory variable of interest, X_i' is a vector of control variables, uppercase Gamma Γ_i is a vector of coefficients, and ε_i is the error term. After successively introducing control variables into (3), we will ultimately arrive at the following fully specified regression equation:

$$P_i = \propto + \beta_1 TEMP_i + \beta_2 TEMP_i^2 + \gamma_1 GDPPC_i + \gamma_2 GDPPC_i^2 + \gamma_3 POP_i + \gamma_4 POP_i^2 + \gamma_5 LATIN_i + \gamma_6 HOST_i + \gamma_7 FOUNDATION_i + \gamma_8 FHCAR_i + \gamma_9 AFRICA_i + \gamma_{10} ASIA_i + \gamma_{11} EUROPE_i + \gamma_{12} OCEANIA_i + \gamma_{13} SOUTHAMERICA_i + \varepsilon_i \quad (4)$$

where these terms are defined as in equation (3) or in the previous section, respectively.

Since we are using cross-section data, we run Breusch-Pagan tests for heteroskedasticity: we reject the null hypothesis of constant variance at the 10% significance level for the fully specified regression equation (4) and at a lower significance level for some of our partly specified equations. We take this as evidence for the presence of heteroskedasticity. Although heteroskedasticity leaves the standard OLS estimator unbiased and consistent, it alters the variance of the OLS estimator and thus makes the OLS standard errors invalid for the routinely conducted hypothesis tests (Wooldridge 2009:258-259). Faced with the two options for dealing with the problem—using OLS estimation with heteroskedasticity-robust standard errors or generalized least squares (GLS) estimators—we follow Leeds and Leeds (2009) in choosing the first procedure. Our reason is that OLS estimation with heteroskedasticity-robust standard errors. in contrast to the GLS procedure. does not require us to specify the structure of the heteroskedasticity unknown to us (Wooldridge 2009: 286). Furthermore, multicollinearity seems to be no issue here (see Table in the appendix).

3. Discussion of the results

3.1 Primary results

The results regarding our key variable of interest TEMP are displayed in Table 2. We estimated our main regression equation (3) six times in total: starting without any controls, we introduced stepwise control variables (capital and demographics; culture; football institutions; political institutions; regions), until we ended up with our fully specified regression equation (4).

Table 2: The influence of temperature on international football performance						
Variable	REG1	REG2	REG3	REG4	REG5	REG6
TEMP	30.707	34.565	24.937	19.478	19.659	16.177
	13.387 **	11.324 ***	10.877 **	10.404 *	10.212 *	7.973 **
TEMP2	-1.425	-1.388	-1.135	-0.859	-0.871	-0.573
	0.401 ***	0.342 ***	0.328 ***	0.323 ***	0.318 ***	0.257 **
GDPPC, POP	No	Yes	Yes	Yes	Yes	Yes
LATIN	No	No	Yes	Yes	Yes	Yes
HOST, AFFILIATION	No	No	No	Yes	Yes	Yes
FHCAR	No	No	No	No	Yes	Yes
Regions	No	No	No	No	No	Yes
N	184	184	184	184	184	184
r2	0.212	0.344	0.468	0.543	0.544	0.643
F	24.127	14.940	20.940	29.421	27.006	40.181
P-value	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***
Optimal TEMP	10.78	12.45	10.99	11.33	11.28	14.10

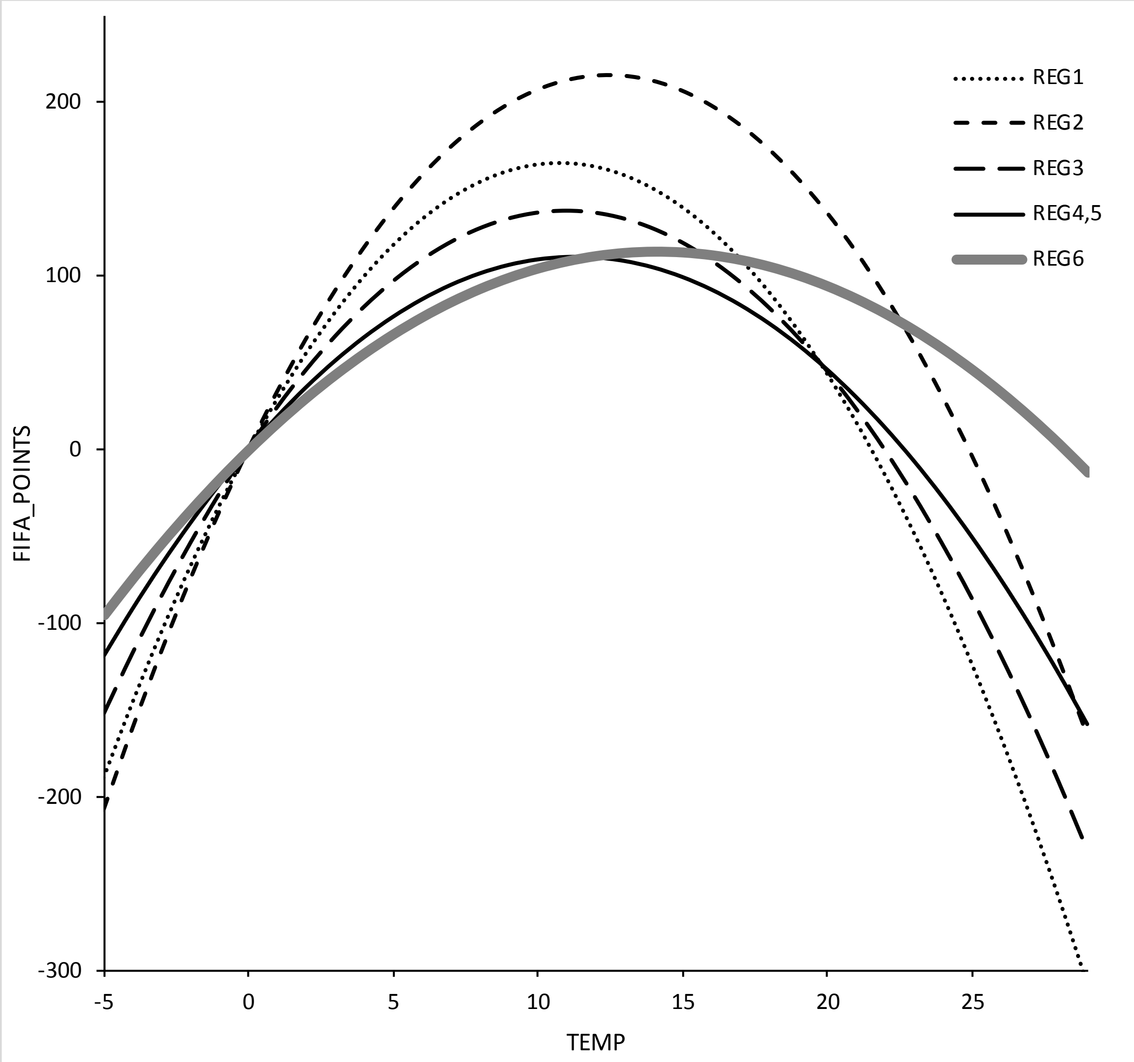
Notes: This table presents out primary results. That is: The six regression results for our main estimation equation (3) which result from successively introducing more control variables. The dependent variable is FIFA_POINTS (which measures international performance in football). Our key explanatory variable of interest is average temperature (TEMP). Our control variables are: GDPPC (proxy for capital) and POP (population size); LATIN which is dummy variable for Latin culture; HOST and AFFILIATION which are two proxies for the quality of football institutions; FHCAR which is our measure for the quality of political institutions; Regions stands for a total of five dummy variables used to control for regional effects associated with FIFA's six regions/confederations. We used OLS estimation with heteroskedasticity-robust standard erros. T-tests are two-sided and the null hypothesis is that the respective coefficient is equal to zero. Note regarding the summary statistics that Stata does only provide the unadjusted R-squared (r2) in heteroskedasticity-robst OLS estimation. Optimal TEMP deontes the optimal temperature for football performance which was calculated on the basis of the two coefficients for TEMP and TEMP2. Notation: * Significant at 10%; ** significant at 5%; *** significant at 1%. The numbers below the coefficient are the standard errors.

Beginning with the summary statistics, we can report that, in each of the six regressions, all respective explanatory variables (i.e., key and control variables) are jointly statistically significant at the 1% level. Moreover and hardly surprisingly, the (unadjusted) R-squared—the proportion of the total variation of the dependent variable FIFA_POINTS explained by the explanatory variables—increases with additional control variables from 0.21 to 0.64. (Note that this is fairly consistent with the values found, for example, by Hoffmann et al. 2002 and Leeds and Leeds 2009.)[10]

Regarding our two-sided hypothesis tests, we find that in all six regressions the coefficients for both TEMP and $TEMP^2$ are individually statistically significant at the 5% level or below except for regressions REG4 and REG5 where the coefficient for TEMP is only significant at the 10% level. We see this as a statistically rather robust result and take it as evidence of an influence of temperature on the football performance of national teams.

[10] One drawback of using OLS estimation with robust standard errors is that STATA does not report a value for the adjusted R-squared which penalizes for additional explanatory variables.

Figure 1: The estimated quadratic relationship between temperature and football performance



Notes: This is a geometrical illustration of our main results (see Table 2). We run six regressions of out main empirical model (3) with FIFA_POINTS as the dependent variable and TEMP as our key explanatory variable of interest; in each regression we controlled for additional explanatory variables. The estimated coefficients for TEMP and TEMP2 where used to plot this five curves. Note that the results for REG4 and REG 5 are so similar that we only plotted one of this curves.

But what is nature of this influence? Notice first that in each regression the coefficients of TEMP have the expected positive and the coefficient of $TEMP^2$ have the expected negative signs. This means that there is a robust inverted U-shaped relationship between a country's temperature and its success in football; in other words, there is an optimal temperature for football performance with deviations punished at an increasing rate. Finally, we turn to the "economic" significance of our results. In order to compare the measured values over the six regressions, we have plotted the estimated relationships in Figure 1 (but see also Table 2 for the calculated optimal values). We can notice the following points: First, the optimal football temperature rises from 10.78 degree with no controls (REG1) to 14.1 degree Celsius in the last regression with all controls in

(REG6); just to make a quick comparison to some classical football countries: Spain's average temperature is 14.2, Italy's is 14.6, and Argentina's is 15.5 degrees. Second, the slope of the curves declines with additional controls (i.e., deviations from the optimum become less punished). Third, focusing now only on the final regression (REG6), we would like to specify what it means for a country to deviate from the optimal temperature: Holding everything else equal, a deviation of 5 degrees from the optimal football temperature of 14 degrees in the negative (roughly given for England) or in the positive (approximately given for Uruguay) is associated with minus 14 FIFA points (about 0.05 of a standard deviation); and a deviation of plus or minus 10 degrees is associated with minus 57 FIFA points (about 0.17 of a standard deviation). In our view, these are rather moderate effects.

3.2 Secondary results, diagnostic tests and robustness checks

As a secondary result, in Table 3, we present the detailed results of our estimation of the fully specified model (4) which corresponds to REG6 from above. We would like to point out that the coefficients of all variables are individually statistically significant at the 5% level or below except for the coefficients of FHCAR (proxy for political institutions) and AFRICA (regional dummy). Thus, we have found some evidence for a positive influence on football performance of capital and population size (both with diminishing returns), a Latin football culture, and the quality of football institutions. By and large, these results are similar to the findings in previous literature (see, for example, Leeds and Leeds 2009).

The quality of our statistical model depends on how well the Gauss-Markov assumptions are met, which can be stated as follows: the expected value of the error term is zero, the explanatory variables and error term are independent, homoskedastictiy, and no autocorrelation (Verbeek 2004: 16). We will thus run two diagnostic tests: a version of the Breusch-Pagan test for heteroskedasticity (which addresses the homoscedasticity assumption) and a Ramsey RESET test for the functional form using fitted values of

Table 3: The influence of temperature on international football performance			
Variable	REG6	Variable (cont.)	REG6 (cont.)
TEMP	16.177	FHCAR	15.101
	7.973 **		11.645
TEMP2	-0.573	AFRICA	80.586
	0.257 **		57.365
GDPPC	0.007	ASIA	-105.135
	0.002 ***		53.238 **
GDPPC2	0.000	EUROPE	228.203
	0.000 **		68.209 ***
POP	1.054	OCEANIA	-122.708
	0.395 ***		44.455 ***
POP2	-0.001	SOUTHAMERICA	276.840
	0.000 **		87.474 ***
LATIN	145.485	Constant	5.4523
	60.667 **		80.6802
HOST	255.291	N	184
	64.602 ***	r2	0.643
AFFILIATION	1.934	F	40.181
	0.822 **	P-value	0.000 ***

Notes: This table displays our secondary results. That is: The detailed results of the estimation of the fully specified regression equation (4) which corresponds to regression REG6 in Table 2. The dependent variable is FIFA_POINTS (which measures international performance in football). The definition of the explanatory variables can be found in the main text. We used OLS estimation with heteroskedasticity-robust standard erros. T-tests are two-sided and the null hypothesis is that the respective coefficient is equal to zero. Note regarding the summary statistics that Stata does only provide the unadjusted R-squared (r2) in heteroskedasticity-robst OLS estimation. Notation: *Significant at 10%; ** significant at 5%; *** significant at 1%. The numbers below the coefficient are the standard errors.

FIFA_POINTS (which at least partly addresses the independence assumption).[11] The results for the tests are displayed in Table 4.

The Breusch-Pagan test is based on a regression of the squared OLS residuals on the explanatory variables in the model and uses as the null hypothesis that the variance is constant (Wooldridge 2009: 839). For our model (4) with all controls, in we can reject this null hypothesis at the 10% significance level; we therefore used OLS with heteroskedasticity-robust standard errors, as already discussed in more detail in section 2.3. The Ramsey RESET test proceeds as follows: it adds to the right hand side of the model (4) powers of the fitted dependent variable P_i as additional "explanatory" variables (i.e. $+\ \delta_1\widehat{P_i^2} + \delta_2\widehat{P_i^3} + \delta_3\widehat{P_i^4}$) and tests the null hypothesis that the model is correctly specified. This amounts to an F-test for the null hypothesis that the δ coefficients are jointly equal to zero (Cameron and Trivedi 2009: 99f). In our test the null hypothesis

[11] We do not test for autocorrelation since we are not dealing with time-series data.

Table 4: Diagnostic tests		
Breusch-Pagan test:		
H0: Constant variance	chi2(1):	3.400
H1: Non-constant variance	P-value:	0.065 *
Ramsey RESET test:		
H0: Functional form of the model is correctly specified	F(3, 165):	0.830
H1: Functional form of the model is incorrectly specified	P-value:	0.479

Notes: This table presents the results of our diagnostic tests for the fully specified regression equation (4) with FIFA_POINTS as the measure of our dependent variable international performance in football. The Breusch-Pagan/Cook-Weisberg test for heteroskedasticity is run with Stata's iid option (drops the normailty assumption). The Ramsey RESET test is using powers of the fitted values of FIFA_POINTS. Notation: *Significant at 10%; ** significant at 5%; *** significant at 1%.

is not rejected due to the large p-value of 0.48. We assume, therefore, that our model (4) is correctly specified.

We have run some additional regressions as robustness checks. The results are shown in Table 5. First we estimated the empirical model (4) but with the FIFA_RANK instead of FIFA_POINTS as the measure for the performance of the national teams. The results are similar (Note that due to the use of rank instead of points, the coefficients have switched the sign.); only the coefficient for the variable HOST has become insignificant (see REG1). Next, we used Nate Silver's Soccer Power Index as our measure for success (REG2): the results for our key explanatory variable of interest remain unchanged. (There are some changes regarding the other variables, however.) Eventually, we approached the second dimension of performance in football—namely international performance of domestic clubs instead of the performance of national teams. We did this by using the variable UEFA_POINTS as a dependent variable in our model (4). Note that our main result breaks down in this case: the coefficients of TEMP and $TEMP^2$ have become highly insignificant (see REG3). Is this due to the fact that we reduced our sample to a subsample of 49 European countries? Our last regression, using again the FIFA_POINTS as a dependent variable but this time for the European subsample, suggests that this is not necessarily the case (REG4): the coefficients of TEMP and $TEMP^2$ are significant at the 5% and 10% level, respectively, and have the expected signs. A plausible explanation for the different findings in REG3 and REG4 could be that temperature effects are offset by the high international mobility of professional football players.

Table 5: Robustness checks

Variable	REG1	REG2	REG3	REG4
TEMP	-3.303	1.249	1.437	64.075
	1.438 **	0.502 **	1.434	30.133 **
TEMP2	0.134	-0.051	-0.021	-2.663
	0.050 ***	0.019 ***	0.063	1.398 *
GDPPC	-0.001	0.001	0.001	0.011
	0.000 ***	0.000 ***	0.000 *	0.006 *
GDPPC2	0.000	0.000	0.000	0.000
	0.000 **	0.000 *	0.000 *	0.000 *
POP	-0.178	0.064	0.812	1.914
	0.079 **	0.034 *	0.264 ***	5.521 *
POP2	0.000	0.000	-0.003	0.030
	0.000 **	0.000 *	0.002	0.048
LATIN	-22.383	8.181	9.790	102.278
	10.647 **	3.443 **	8.878	165.885
HOST	-14.986	8.202	12.306	202.592
	9.202	3.938 **	8.402	147.359
AFFILIATION	-0.428	0.166	0.017	-0.305
	0.152 ***	0.054 ***	0.045	1.469
FHCAR	-3.694	2.907	0.103	-17.436
	2.379	0.871 ***	1.492	36.626
AFRICA	-14.299	6.062		
	11.952	4.249		
ASIA	26.465	-17.706		
	11.229 **	4.534 ***		
EUROPE	-26.768	7.475		
	12.763 **	4.658		
OCEANIA	39.904	-7.791		
	10.620 ***	5.485		
SOUTHAMERICA	-38.340	16.694		
	12.846 ***	4.193 ***		
Constant	165.377	21.288	-12.34235	150.0788
	14.921 ***	5.106 ***	12.22444	276.3876
N	184	184	49	49
r2	0.573	0.599	0.795	0.488
F	49.793	37.782	9.403	3.903
P-Value	0.000 ***	0.000 ***	0.000 ***	0.001 ***

Notes: This table presents the results of our robustness checks. The regression equation used is (4) where we excluded the regional dummy variables in REG3 and REG4. The dependent variable in REG1 is FIFA_RANK. The dependent variable in REG2 is Nate Silver's SPI_POINTS. The dependent variable in REG3 is FIFA_POINTS. Whereas these three variables are measures for the success of national teams, the dependent variable in REG3 is UEFA_POINTS which is a measure of the international success of a country's domestic clubs. We used OLS estimation with heteroskedasticity-robust standard erros. T-tests are two-sided and the null hypothesis is that the respective coefficient is equal to zero. Note regarding the summary statistics that Stata does only provide the unadjusted R-squared (r2) in heteroskedasticity-robst OLS estimation. Notation: *Significant at 10%; ** significant at 5%; *** significant at 1%. The numbers below the coefficient are the standard errors.

4. Conclusion

The research question in this paper focused on what influence, if any, a country's average temperature has on the performance of its national football team. Using cross-country data, employing OLS estimation with heteroskedasticity-robust standard errors and controlling for several other variables, we arrived at the following main result: Temperature has an influence on the performance of a country's national team. Moreover, the ideal "football temperature" is 14.1 degrees Celsius with positive and negative deviations both punished at an increasing rate. The effect of temperature, however, is only moderate as a deviation of 10 degrees reduces the value for FIFA_POINTS only by about 57 points (0.17 standard deviations). Though this result is fairly robust for the performance of a country's national team, there is some evidence that temperature plays no role for the international performance of a country's domestic football clubs.

Further research could point in several directions: First, we could check whether estimation methods other than OLS are better suited for estimating the regression model with FIFA_RANK as a dependent variable. Second, it would be interesting to study our mobility-explanation of why there is no effect of temperature on performance on the level of domestic clubs. A first natural step would be to check whether there is a similar difference in the Non-European confederations. In a next step, we would probably try to control for football mobility.

Appendix

Table: Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) FIFA_POINTS	1.00														
(2) FIFA_RANK	-0.95	1.00													
(3) SPI_POINTS	0.87	-0.92	1.00												
(4) TEMP	-0.38	0.39	-0.33	1.00											
(5) GDPPC	0.31	-0.29	0.25	-0.38	1.00										
(6) POP	0.02	-0.02	0.01	-0.06	-0.05	1.00									
(7) LATIN	0.33	-0.28	0.30	0.13	-0.13	-0.03	1.00								
(8) HOST	0.53	-0.41	0.42	-0.23	0.28	0.09	0.25	1.00							
(9) AFFILIATION	0.58	-0.56	0.53	-0.38	0.46	0.13	0.20	0.38	1.00						
(10) FHCAR	-0.35	0.30	-0.22	0.34	-0.39	0.08	-0.15	-0.31	-0.42	1.00					
(11) AFRICA	-0.18	0.13	-0.03	0.41	-0.37	-0.08	-0.09	-0.15	-0.32	0.35	1.00				
(12) ASIA	-0.31	0.32	-0.41	0.07	0.05	0.24	-0.19	-0.07	-0.14	0.36	-0.34	1.00			
(13) EUROPE	0.46	-0.46	0.41	-0.70	0.41	-0.09	-0.10	0.12	0.41	-0.43	-0.38	-0.32	1.00		
(14) OCEANIA	-0.21	0.26	-0.19	0.10	-0.06	-0.05	-0.09	-0.06	-0.15	-0.07	-0.13	-0.11	-0.12	1.00	
(15) SOUTHAMERIC	0.35	-0.29	0.33	0.04	-0.06	0.00	0.50	0.27	0.24	-0.09	-0.15	-0.13	-0.14	-0.05	1.00

Notes: This table presents the correlation coefficient between all our variables for which there are 184 observations. Notive that the variable UEFA_POINTS had to be exluded since there are only 49 observations for this variable. For the sources of the data, see the text.

Bibliography

Literature:

Bernard, A. B., Busse, M. R. (2004): Who Wins the Olympic Games: Economic Resources and Meal Totals, in: The Review of Economics and Statistics, 86, 1, 413-417.

Cameron, A. C., Trivedi, P. K. (2010): Microeconometrics Using Stata, Revised Edition, Stata Press.

Hoffmann, R., Ging, L. C., Ramasamy, B. (2002a): Public policy and olympic success, in: Applied Economics Letters, 9, 545-548.

Hoffmann, R., Ging, L. C., Ramasamy, B. (2002b): The socio-economic determinants of international soccer performance, in: Journal of Applied Economics, 5, 2, 253-272.

Foer, F. (2004): How soccer explains the world, An unlikely theory of globalization, Harper Collins.

Leeds, M. A., Leeds, E. M. (2009): International Soccer Success and National Insitutions, in: Journal of Sports Economics, 10, 4, 369-390.

Macmillan, P., Smith I. (2007): Explaining International Soccer Rankings, in: Journal of Sports Economics, 8, 2. 202-213.

Verbeek, M. (2004): A Guide to Modern Econometrics, 2nd Edition, John Wiley and Sons.

Wooldridge, J. M. (2009): Introductory Econometrics, A Modern Approach, Fifth Edition, South-Western.

Data sources (incl. articles related to sources):

Center for Environmental Data Archival (2014): Year-by-Year Variation of Selected Climate Variables by CountrY (CY), University of East Anglia Climatic Research Unit (CRU), http://badc.nerc.ac.uk [retrieved: 7 March 2014]

Comin, D (2008): Total factor productivity, in: Blume, L. E, Durlauf, S. N. (eds): The New Palgrave Dictionary of Economics Online, Second Edition.

ESPN (2014): Soccer Power Index, http://espnfc.com/spi/rankings?cc=5739 [retrieved: 6 March 2014]

FIFA (2009): FACT *Sheet*, How are points calculated in the FIFA/Coca-Cola World Ranking? www.FIFA.com.

FIFA (2014): Fact Sheet, FIFA's 209 Member Associations, www.fifa.com.

Freedom House (2014): Freedom in the world 2014, www.freedomhouse.org/report/freedom-world/freedom-world-2014 [retrieved: 7 March 2014]

International Monetary Funds (October 2013): World Economic Outlook, http://www.imf.org [retrieved: 6 March 2014]

Office for National Statistics (2014): Region and Country Profiles, Population and Migration, December 2013, http://www.ons.gov.uk [retrieved 0 March 2014]

UEFA (2014): UEFA Country Coefficient, http://www.uefa.com [retrieved: 7 March 2014]

Silver, N. (2009): Commentary, A guide to ESPN's SPI rating, www.ESPN.com