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David Forrest
J.D Tena
Carlos Varela-Quintana

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by

David Forrest[a]

J.D Tena[a,b]

and

Carlos Varela-Quintana[c]

[a] University of Liverpool Management School, Chatham Street, Liverpool, L69 7ZH, UK

[b] Department of Economics, University of Sassari and CRENoS, Via Muroni 25, Sassari, 07100, Italy.

[c] Department of Economics, University of Oviedo, Avda. del Cristo s/n, Oviedo, 33006, Spain

Abstract: The paper investigates national team success at the principal tournament of a prominent mind sport, chess. As in prior literature on physical sports, panel data estimation reveals population and per capita gdp as strong predictors. But when we add a measure of education capital, per capita income loses significance, suggesting that effects from income levels are mediated through schooling in the case of a cerebral game. However, when we estimated a similar model to account for medal wins at the Olympics, results were similar, implying that schooling levels are also relevant to success in physical sports.

key words: education capital, economic resources, sports economics, chess, Olympics

JEL codes: Z20, I26, C52.

1. Introduction

In sports, nations seek to outdo each other to win prestige (or even soft power). Most sports are physical and involve competition to ascertain, to borrow from the Olympics motto, who is fastest, highest or strongest. But here we investigate a different sort of game, chess, where players need cognitive ability rather than physical prowess. Its principal team tournament, the Chess Olympiad, takes place every two years and attracted 185 national teams at its last edition. We ask what drives national success at this Olympiad. We test for the influence of variables found in prior literature to predict country success in physical sports. But, because chess is a mind sport, we assess also the importance of education capital, based on the supposition that schooling develops cognitive skills.

Bernard and Busse (2004) analysed national success in physical sports, specifically at the Olympics. They regressed country medal share on log (population) and log (per capita gdp), adding dummy variables to capture hosting effects and over-performance by communist states, and found each highly significant. Papers in a successor literature, whether or not employing additional covariates, retained the essential features of the original model whether testing it on later editions of the Games (Scelles et al., 2020) or on individual sports within the Olympics (Forrest et al., 2017) or in international football (Gásquez and Royuela, 2016). All such papers confirm that countries with larger populations and higher incomes tend to enjoy greater success.

We found that the standard variables from the Olympics literature also explained country performance in chess. But in a cerebral game, a given population may be more likely to produce strong players in a country with greater educational capital. We employed a covariate representing average years of schooling, exploiting time-series maintained by the Institute for Health Metrics and Evaluation (IHME) (healthdata.org), University of Washington. It proved to be significant and rendered per capita income non-significant, suggesting that any effect from income was mediated through investment in education. Further, when we applied the same modelling to the Olympic Games, a similar result was obtained, implying that our findings are also relevant to physical sports.

2. The Chess Olympiad

We analyse results from the 'Open Section'. Each country is permitted to enter one team but the host is allowed additional teams (2-4 during our period). Teams of four each play the same number of matches, currently eleven, the schedule following the 'Swiss Tournament' format. This pairs first-round opponents based on pre-event rankings and, in subsequent rounds, teams play opponents with similar cumulative points. Each match consists of four one-on-one games; two points are earned for winning and one if the score is 2-2. Final tournament rankings are determined by total tournament points.

Our dependent variable was a country's percentage share of all points awarded in the tournament. We employed a panel random-effects model with year dummies, estimated over thirteen Olympiads. Bernard and Busse (2004) used tobit because most countries win zero medals at the Olympics; but here there were only two cases where a country scored zero points.

3. Covariates

Country *population* and *per_capita_gdp* were obtained from annual World Bank data, the latter measured at purchasing power parity in constant (2011) international dollars. A *host* dummy is conventionally included to capture home advantage but here we also include 'number of *additional_teams*' because hosts may accumulate more points simply because they are allowed to field extra teams.

We modify political regime dummies from Bernard and Busse (2004) because our data postdate the Cold War. We have separate dummies for *ex_Soviet_Bloc* countries according to whether they have joined the EU. Generally communist countries may have performed well in sport because the state could direct resources to delivering success. Countries which joined the EU may be less likely to continue such arrangements though they may still over-perform because of legacy institutional infrastructure. Another dummy signifies other *socialist* countries; *China* has its own category.

IHME provides country estimates of average number of years of *schooling* completed, for each five-year age/ gender band in the population, with the value capped at 18. From these data, we calculated a single figure for the whole population, deriving weights from population figures by age and gender provided by IHME.[1] The correlation between this statistic and log(*per_capita_gdp*) was +.745 (Figure 1 provides a scatter-plot).

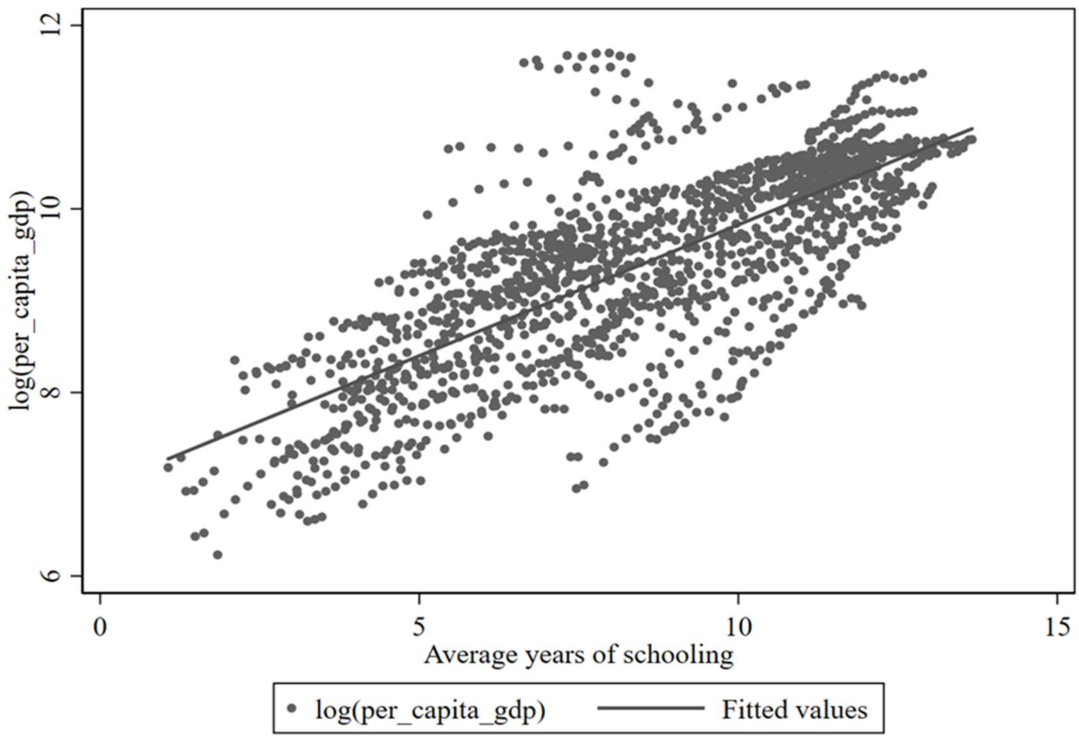

Figure 1. Schooling and log(per_capita_gdp)

[1] For discussion of methods and data sources employed by IHME, see Lim et al. (2018).

In the final version of our model, following Bernard and Busse (2004), we add a lagged dependent variable. Sometimes this took the value zero because the country had not participated before since it had been part of another (e.g. Czechoslovakia split). To avoid any resulting distortion, we employ dummies to distinguish between countries which had not participated because they are a *new_country* and those which had *another_reason*. Similarly, we include *additional teams(t-1)* since the preceding host will have had an inflated points share from fielding those extra teams.

We estimate on a data set from which observations were excluded if information was not available on all covariates (e.g. gdp estimates are unavailable for Andorra and Cuba).

4. Results

Table 1, column (1) reports a model where points share is regressed only on log(*population*) and log(*per_capita_ gdp*). As in Bernard and Busse (2004), the coefficient estimates are highly significant and similar in magnitude to each other, implying that it is the multiple of the two variables, GDP, which drives success.

In column (2), we add *host*, which is positive and significant. However, its effect disappears once it is taken into account that it fields more than one team (column (3)). There appears to be no home advantage in chess.

In column (4), we add political variables. All four country groups with past or present communist regimes tend to over-perform relative to their population and income levels. Post-Soviet countries, even if now westward facing in the EU, are particularly strong.

In column (5), we add *schooling*. The coefficient estimate is highly significant ($p<.0001$). The result on *population* is unchanged but the introduction of *schooling* renders *per_capita_gdp* non-significant ($p=.387$). Political variables exhibit diminished coefficients, implying that part of the enhanced performance of communist states derives from high investment in education (relative to their gdp).

Finally, we follow Bernard and Busse (2004) by presenting a dynamic model. Findings are unaffected but the lagged term demonstrates inertia in country performance.

We also estimated with the log instead of the level of schooling years. This model had lower goodness-of-fit. Qualitatively similar results were obtained except that log(*per_capita_gdp*) retained its statistical significance albeit with much reduced coefficient size. In another experiment, we estimated a Heckman two-step model to account for selection effects, employing additional variables (distance to host country, dummy for a country which had experienced deaths from conflict) at step 1. Here schooling was again strongly significant and log(*per_capita_income*) non-significant.

We find, then, that, in chess, any effect from per capita gdp is mediated mostly or entirely through investment in schooling. The effect size is non-trivial, e.g. four extra years of schooling (the difference between Taiwan and India in 2016) would increase expected points share by 0.128 pcp (where mean points share across all countries is only 0.763%). Such a role for education capital is perhaps to be expected if schooling aids cognitive development, given that chess is a cerebral sport. That there is little residual role for income perhaps reflects that chess is a game with negligible costs for equipment and facilities. Forrest et al. (2017) find that Olympic sports with lower resource inputs exhibit only a shallow relationship between country income and performance.

	(1)	(2)	(3)	(4)	(5)	(6)
log(population)	0.0573***	0.0531***	0.0539***	0.0558***	0.0554***	0.0390***
	(0.0090)	(0.0067)	(0.0067)	(0.0055)	(0.0049)	(0.0050)
log(per_capita_gdp)	0.0695***	0.0601***	0.0576***	0.0674***	0.0096	0.0137
	(0.0114)	(0.0099)	(0.0101)	(0.0078)	(0.0111)	(0.0088)
host		1.7282***	-0.0245	-0.0226	-0.0209	-0.0595
		(0.2262)	(0.1031)	(0.1033)	(0.1030)	(0.1116)
additional_teams			0.8486***	0.8471***	0.8461***	0.8774***
			(0.0458)	(0.0454)	(0.0469)	(0.0534)
ex_Soviet_bloc/non-EU				0.2734***	0.1788***	0.1316***
				(0.0246)	(0.0251)	(0.0193)
ex_Soviet_bloc/EU				0.2137***	0.1104***	0.0798***
				(0.0223)	(0.0301)	(0.0220)
socialist				0.1268***	0.0805***	0.0530***
				(0.0140)	(0.0166)	(0.0121)
China				0.1182***	0.0718***	0.0483***
				(0.0265)	(0.0269)	(0.0189)
schooling					0.0321***	0.0190***
					(0.0050)	(0.0042)
points_share(t-1)						0.2846***
						(0.0419)
additional_teams(t-1)						-0.2168***
						(0.0488)
new_country						0.3828***
						(0.0740)
another_reason						0.1703***
						(0.0287)
constant	-0.5830***	-0.4514***	-0.4422***	-0.6061***	-0.2819**	-0.2162**
	(0.2186)	(0.1674)	(0.1678)	(0.1327)	(0.1305)	(0.1069)
between-R^2	0.545	0.652	0.663	0.833	0.856	0.910
within-R^2	0.186	0.701	0.772	0.771	0.775	0.753
overall-R^2	0.285	0.625	0.671	0.786	0.804	0.830
rho	0.300	0.495	0.558	0.383	0.349	0.0183

observations=1,515, estimated with year dummies, data period 1992-2016, 158 countries

standard errors, clustered by country, in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 1. Random-effects model. Dependent variable: country_points_share

5. The Olympics

Might education capital also play some role in determining success in physical sports? We applied our model to medal shares at the Olympics over the period for which *schooling* was available. The steps in Table 2 are as before except that the *additional_teams* variable is no longer relevant, medal share is measured as a proportion rather than a percentage, to facilitate presentation and comparison with Bernard and Busse (2004), and the model is a tobit because many observations of the dependent variable are zero.

	(1)	(2)	(3)	(4)	(5)
log(population)	0.0081***	0.0080**	0.0075***	0.00072***	0.0043***
	(0.0008)	(0.0008)	(0.0008)	(0.0007)	(0.0004)
log(per_capita_gdp)	0.0070***	0.0066***	0.0066***	0.0018	0.0008
	(0.0010)	(0.0009)	(0.0009)	(0.0012)	(0.0008)
host		0.0165***	0.0165***	0.0161***	-0.0142
		(0.0024)	(0.0024)	(0.0024)	(0.0021)
ex_Soviet_bloc/non-EU			0.0167***	0.0061	0.0026
			(0.0039)	(0.0040)	(0.0023)
ex_Soviet_bloc/EU			0.0109**	-0.0023	-0.0017
			(0.0051)	(0.0051)	(0.0021)
socialist			0.0118	-0.0135	-0.0082
			(0.0126)	(0.0151)	(0.0075)
China			0.0437***	0.0399***	0.0253***
			(0.0165)	(0.0153)	(0.0083)
schooling				0.0036***	0.0023***
				(0.0006)	(0.0004)
medal_share (t-1)					0.4137***
					(0.0276)
new_country					0.0037**
					(0.0016)
another_reason					0.0022
					(0.0024)
constant	-0.1934***	-0.1870***	-0.1824**	-0.1561***	-0.0923***
	(0.2186)	(0.0156)	(0.0154)	(0.0154)	(0.0098)
log-likelihood	1535	1556	1570	1589	1710

observations=1,203, estimated with year dummies, data period 1992-2016, 158 countries

standard errors, clustered by country, in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2. Random-effects Tobit. Dependent variable: country_medal_share

Until *schooling* is introduced, results are strikingly similar to those reported in Bernard and Busse (2004). Once *schooling* is added (column (4)), political variables lose significance except that *China* remains a strong over-performer. As in the chess model, *schooling* is highly significant and *per_capita_gdp* becomes non-significant in its presence. Also as before, results where *schooling* was logged are less preferred from goodness-of-fit but we note that in that model *per_capita_gdp* retained significance though with much diminished effect size.

As with chess, it appears that, at minimum, effects on Olympic achievement from country wealth are substantially mediated through provision of schooling. Several explanations are possible. Schooling level could be a better proxy for level of development than GDP. On the other hand, it is plausible that schooling matters for all sports. First, even in physical sports, it might be that the very best secure their advantage over the merely very good from using superior cognitive ability, fostered by education investment. Second, sports and games are most widely played in education settings where there are facilities, organised teams and instruction available. The longer the population is in education, the greater the chance that potentially elite players will be revealed before they disappear into the world of work. Further insight into the mechanisms by which education capital feeds into national success might be gained from future research sport-by-sport.

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