WORKING PAPER

Coming to Play or Coming to Win: Participation and Success at the Olympic Games

By

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Abstract

This paper investigates the post-War Summer Olympic Games in order to determine the economic and political determinants of national participation, and of female participation in particular. Success at the Games (i.e., medal counts) is then analyzed in two ways, from the individual level and the national level, showing similar results. Female participation is rising over time, augmented primarily by larger nations. There is a significant and measurable advantage to larger nations (both in GDP per capita and in population) in terms of participation and success at the Games. Furthermore, there are undeniable advantages to being the hosting nation, and to being a neighbor to the host. Equally striking is the fact that while there is no evidence of a bias of Communist and single-party governments to send more athletes to the Games, once there, the athletes of these nations perform exceptionally well. There is support for the hypothesis that colonial links make a difference, imparting a mixed blessing from the past. Predictions for participation and gold, silver and bronze medal counts by nation for the 2000 Sydney Games conclude the paper. JEL O10, Z10.

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Coming to Play or Coming to Win:
Participation and Success at the Olympic Games

I. Introduction

As the torch approaches the opening ceremonies of the Summer Olympics in Sydney in September of 2000, the world anticipates an international event, with participants from around the world, from nations large and small, developed and less developed. Yet the Olympic games have not always attracted athletes from all continents. In fact, global participation is a relatively recent phenomenon. At the inaugural modern Olympic Games in Athens in 1896, there were only 245 participants, representing 14 nations. A century later there were over forty times as many athletes (almost 11000) representing 271 nations or territories.

This paper investigates some of the factors that encourage or discourage nations from sending athletes to participate in the Summer Olympics, and continues on to analyze similar determinants of their success. It is an economic analysis, so focuses on economic and political variables. As such, it does not intend to explain away athletic excellence as a function of national systems, but rather offers some insight into the variables that affect an athlete's ability to participate and to succeed at their chosen event.

Most recent academic and journalistic papers have concentrated their energy on the importance of hosting the Olympics, with emphasis on the financial impact of the celebration on the local economy[1]. This work redirects attention back to the athletes, offering another reason to bid for the opportunity to host the Games--- an opportunity to send more athletes, each with a better chance of attaining a medal.

Intuition suggests that several political and economic variables have an important impact on national participation and success. High productive capacity (measured by GDP per capita) shows ability to pay the costs necessary to send athletes to the Games, and may be associated with a higher quality of training for success. A large population may mean a larger number of people to share the costs of training and transportation for athletes, and a larger pool of potential athletes from which to select successful contenders. Obviously, the home (or hosting) nation, along with geographic neighbors, has advantages in the lower transportation costs to participate, and climatic and training advantages in the competitions themselves.

The analysis also hypothesizes that political structure and international historical linkages have an effect on participation and success. Monarchies and single-party or Communist systems may have a different approach to participation, training and incentives for success so may show different results.

[1] As this draft was being finalized, Bernard and Busse (2000) released a working paper addressing very similar issues. We have responded to them here as well as possible without delaying our own research paper.

In addition, nations with colonial linkages to a strong nation (either economically or Olympically) may have different norms of participation or success.

Section II describes the data and some salient characteristics of the post-War Games. Section III contains the analysis of participation (Part A) and medal-winning success (Part B). Success is investigated in two fashions, from the individual level and from the national level. Section IV summarizes and offers some thoughts about future research directions.

II. Data

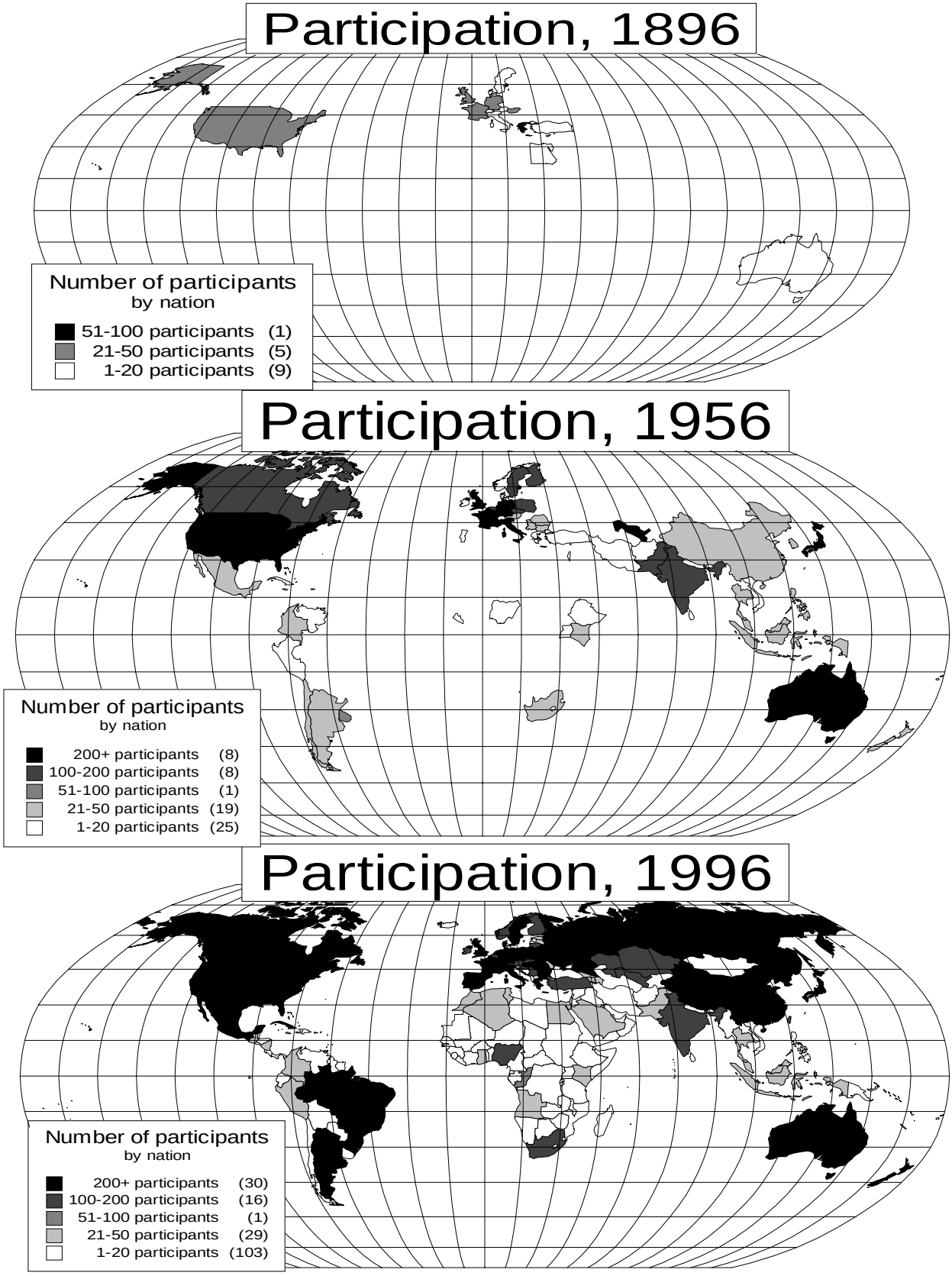
This work is restricted to the Summer Olympics from 1952 to the present, including predictions for the 2000 Games. Work on earlier Summer Games faces difficult data issues, primarily in economic data definitions, which must wait for a future paper. The Winter Games involve far fewer nations as participants (for obvious climatic reasons) and so also pose a different set of issues, to be investigated separately. Analysis of several individual events is possible, but clouds the immediate issue so presentation of those will be in a separate, later paper.

Significant political boycotts occurred in three recent Games: 1976 (many African nations), 1980 (many Western nations) and 1984 (Eastern and Central Europe with the Soviet Union). In order to retain use of existing data from these Games, the analysis does not include participation data for nations which for political reasons chose not to participate in a given year. Likewise, data are omitted for nations that were not fully independent at the time of a Games (e.g. Guam) or were precluded from competition (e.g. South Africa or Libya for several Games).

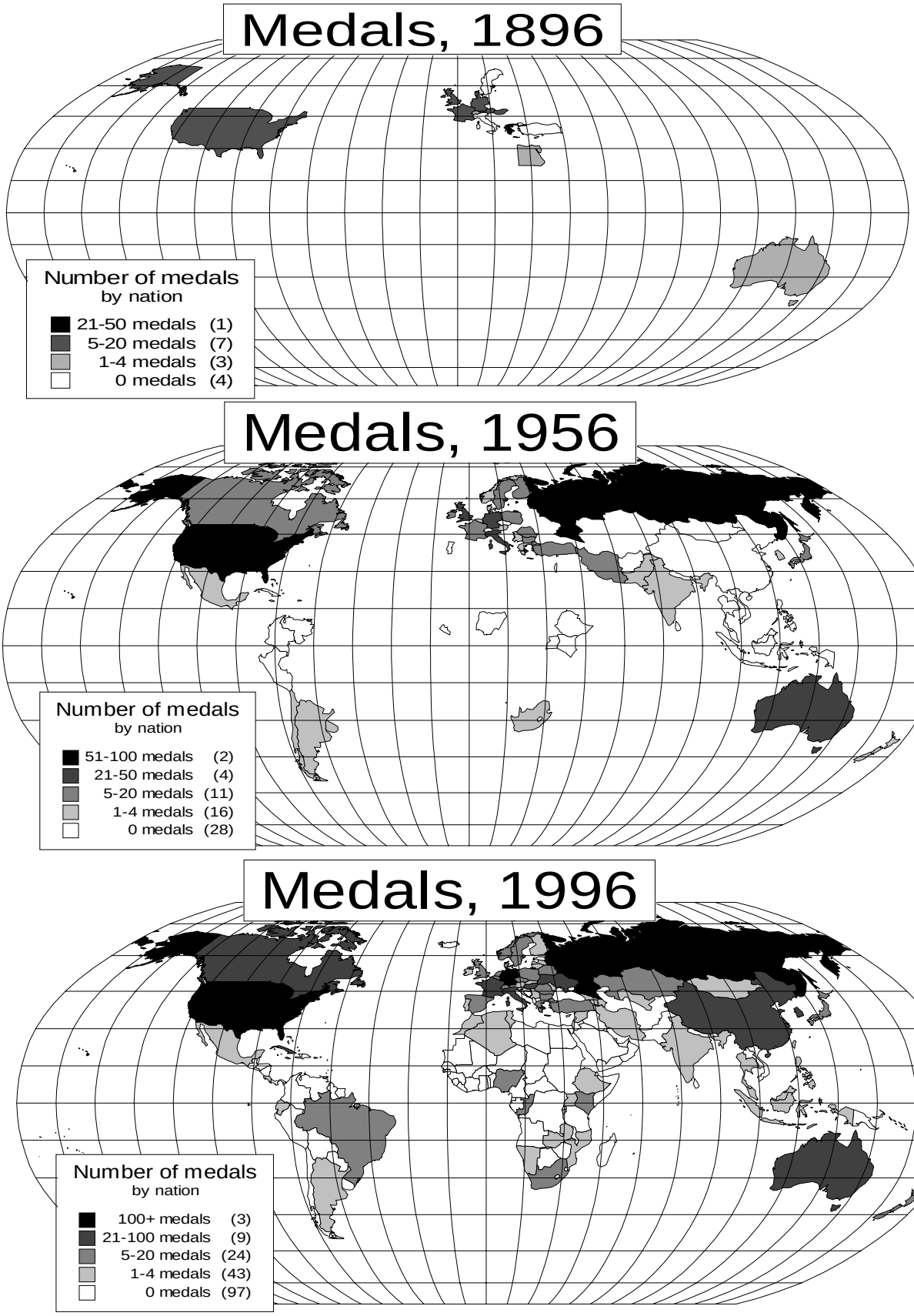
GDP per capita data are from the Penn World Tables for the year preceding the Games in question. Thus, they control for differences in international purchasing power, and are in constant 1985 international prices for all years. Extrapolations were made to extend the analysis to 1996 and for out-of-sample predictions for the 2000 Games. While this adds an extra degree of error into the predictions, it provides an interesting test for the precision of our coefficient estimates.

As indicated earlier, global participation in the Olympic Games is really a very recent phenomenon. The early Games (see Maps 1 to 6 below) showed limited participation, and no participation at all from nations outside of the most developed. This has changed in the post-War period, but while geographic diversity of participants has increased dramatically, the concentration of athletes from developed nations (with high GDP per capita) has been increasing over time as well. In 1952, if all nations were listed by GDP per capita, 19.1 percent of the participants represented nations in the top ten percent of the GDP list. In the 1996 Games, almost double that proportion, or 37.9 percent, came from nations in the top ten percent of the list. The pool of athletes has been widening, but the concentration has been getting tighter simultaneously.

Maps 1-3

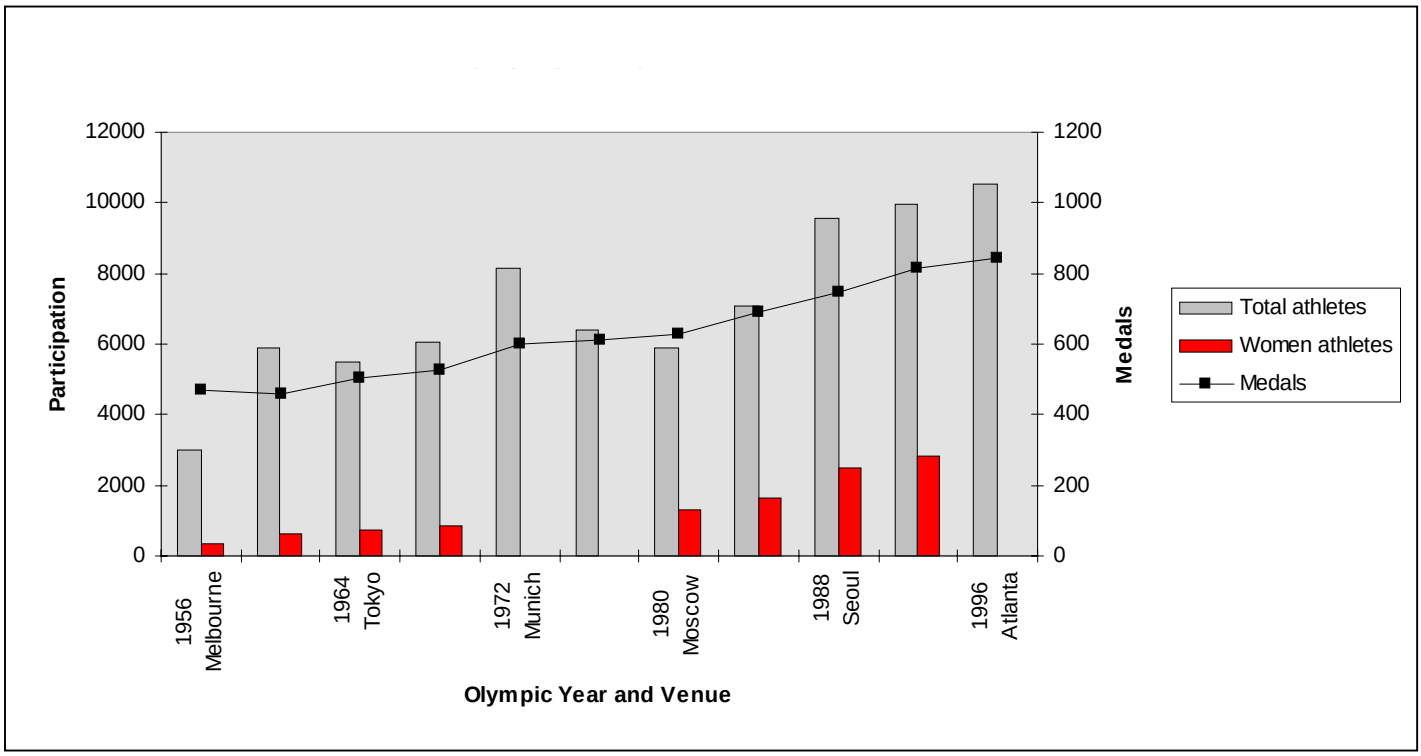

Participation, 1896
Number of participants
by nation
51-100 participants (1)
21-50 participants (5)
1-20 participants (9)
Participation, 1956
Number of participants
by nation
200+ participants (8)
100-200 participants (8)
51-100 participants (1)
21-50 participants (19)
1-20 participants (25)
Participation, 1996
Number of participants
by nation
200+ participants (30)
100-200 participants (16)
51-100 participants (1)
21-50 participants (29)
1-20 participants (103)

Maps 4-6


Medals, 1896
Number of medals
by nation
21-50 medals (1)
5-20 medals (7)
1-4 medals (3)
0 medals (4)
Medals, 1956
Number of medals
by nation
51-100 medals (2)
21-50 medals (4)
5-20 medals (11)
1-4 medals (16)
0 medals (28)
Medals, 1996
Number of medals
by nation
100+ medals (3)
21-100 medals (9)
5-20 medals (24)
1-4 medals (43)
0 medals (97)

The gender balance among athletes has been growing closer over time, from a post-War high of over 8 male athletes for each female athlete, to a ratio in Barcelona 1992 of less than 2.5 male-to-female (Atlanta data are still unavailable). Figure 1 shows a combination of data on participation by gender where available, along with medal counts over time.

Figure 1: Olympic Participation and Medals, 1956-1996



With the exception of the Melbourne Games in 1956, the participant-to-medal ratio has varied in the range of 10 to 13 (and between 12.2 and 12.8 in the last three Games). In 1956, the ratio was less than 6.5, making it a good year to be a competitor!

Although it is obviously the initial intent to have an equal number of gold, silver and bronze medals presented, in every post-War Games there have been more bronze than gold medals awarded. In the 1992 Barcelona Games there were a full 14 percent more bronze medals awarded than their gold counterparts.

Success in terms of medals earned is still very concentrated. Of the record-breaking 241 nations and territories attending the 1996 Games, less than half (119) have *ever* won a medal in any Olympic event. All African nations combined share a little over two percent of all medals ever bestowed. Because the developed nations host the Games, they benefit from the "homefield advantage". Furthermore, the introduction of new events seems to favor

developed nations, although this issue will be explored more fully in a subsequent study.

There is an obvious relationship between nation size and success at the Olympic Games, as is shown descriptively in Table 1. In 1956, nations that won at least one medal averaged six times the population and over twice the GDP per capita of participant nations that won no medals. By 1996, those differences had both decreased, but medal-winning nations still average five times the population and 1.6 times the GDP per capita. The standard deviations of population and GDP per capita are naturally wider for the larger, medal-winning nations, but the differences between groups are striking enough to warrant further investigation.

Table 1: Summary Statistics for GDP per capita and Population

Year	Medal status	Population		GDP per capita	
		average	st. dev.	average	st. dev.
1956	no	6873.54	7332.28	1766.27	1479.51
	yes	41011.00	78294.98	4015.04	2352.94
1996	no	15921.07	27816.92	4697.35	4827.85
	yes	78615.46	209508.50	7767.25	5695.97

Note: Summary statistics include only those nations for whom data were available. Medal status indicates whether the nations earned one or more medals in the Games.

III. Analysis

A. Participation

Part of the spirit of the Olympic movement is the celebration of international community, fostered by participation by many nations. Yet not all nations are similarly able or willing to send athletes to the event.

Consider a simple linear function to assess the determinants of participation:

$$part_i = \alpha + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 POP + \beta_4\ POP^2 + \beta_5\ HOME + \beta_6 NEIGH + \sum_{j=7}^{10} \beta_j POL_j + \beta_{11} COLGDP + \beta_{12} COLPOP + \beta_{13} COLMED + u_i + e$$

where *part* is the number of participants from nation i
GDP is GDP per capita of nation i in constant 1985 international prices
POP is the population of nation i
HOME is a dummy variable to indicate the hosting nation
NEIGH is a dummy variable to indicate immediate geographical proximity to the hosting nation
POL_j is a series of dummy variables to indicate a monarchy, single-party, military or other political environment (compared to a republic)
COLGDP is the GDP per capita of the primary nation colonizing nation i
COLPOP is the population of the primary nation colonizing nation i
COLMED is the Olympic medal count of the primary nation colonizing nation i

and where u_i is a nation-specific error term and e is the unexplained error.

Use of a log-linear functional form showed results similar to those below. While it has the benefit of a parallel with Cobb-Douglas production functions (with GDP per capita as "capital" and population as "labor") it offered no better fit to the data and could be slightly misleading. The objective here is not to estimate a production function but to examine the structural determinants of participation. Omission of fixed or random effects (group effects by nation) made no substantial difference to any coefficient. Results below therefore use random effects, suggesting that the nation-specific error terms are normally distributed among nations of the world.

Other variables were originally included but revealed no change in the significance of the variables above. Examples included dummy variables for each colonial power, a dummy variable for the presence of a political structure involving voting, the importance of government and consumer spending in GDP, and interactions between political structures and GDP. All were found to offer minimal (if any) improvement on the existing explanation.

Unlike Bernard and Busse (2000), our analysis excludes lagged performance variables (i.e., past Olympic success) because of a different choice in analysis type. Although lagged performance variables are highly effective explanations and predictors, the interest here is in purely economic and political variables. Under our interpretation, if unraveled, past medal counts would be explained by previous GDP per capita and previous medal counts, which would in turn be explained by previous variables devolving down to GDP per capita several periods ago. However, due to the serial correlation of GDP per capita over time, lagged GDP variables are not included in our analysis either.

The regression results are unsurprising, but interesting to quantify. Table 2 presents the results of this regression for the number of all athletic participants sent by a nation, and for the number of female athletic participants sent by a nation. Following it, Table 3 shows the same specification, estimated only for the post-boycott Games (1988-1996). The only differences of statistical significance are the more positive effect of population (and its square) in the later Games, and the negative time trend for all participants.

Nations with higher GDP per capita send more participants and more female participants, with an effect that is nonlinear for total participants in particular. Richer nations send more athletes, at the rate of roughly 8 more for each thousand dollars of GDP per capita at the average. They also send more female athletes than poorer nations, although the impact is vanishingly small.

Nations with larger populations also send more athletes, although that effect tapers off with extreme size. This is a natural result of the finite number of events at any Games. Since there is a limitation on the number of teams that any nation may send in one sport, large nations will not be able to send as many athletes as their populations would suggest. An extra 10000 citizens has an average effect of 4 extra participants at the Games, but it takes an average of 30000 more citizens to support an additional female athlete.

Table 2: National Participation in all Games
Effects of economic and political variables on participation in the Summer Olympic Games, 1952-1996

Variable	Coeff. (β_i)	t-statistic		Coeff. (β_i)	t-statistic	
	All participants			**Female participants**		
Constant	22.45	3.65	***	-1.36	0.60	
GDP per capita (1985 prices)	8.23e-3	5.15	***	3.19e-4	0.50	
GDP per capita squared	-1.10e-8	0.13		1.71e-7	4.98	***
Population (000's)	3.77e-4	5.44	***	4.79e-5	1.90	*
Population squared	-1.59e-10	2.62	**	3.48e-11	1.46	
Home nation	209.40	17.13	***	64.09	12.91	***
Neighboring nation	48.12	7.17	***	14.44	5.37	***
Political system						
(compared to republic or parl. democracy)						
Monarchy	-21.99	2.42	**	-8.95	2.86	***
Single party or Communist	10.15	0.58		0.15	0.03	
Military	-12.89	0.74		-0.83	0.14	
Other system	-44.06	2.23	**	-16.82	2.50	**
Characteristics of former colonial power						
GDP per capita (1985 prices)	-3.91e-3	5.64	***	-1.32e-3	4.87	***
Population (000's)	-9.61e-6	0.25		4.06e-6	0.31	
Medal success	0.35	2.90	***	9.15e-2	2.15	**
Time trend	1.57	1.99	**	1.63	5.47	***
Adjusted R^2		0.56			0.49	
Number of groups (nations)		138			137	
Number of observations		1095			830	

Notes: Dependent variable = number of athletic participants from a nation in a specific year.
Significance indicated as * for 10 percent, ** for 5 percent, *** for 1 percent

The overwhelmingly large populations of China and India cause a nonlinear effect of population (with their relatively low participation-to-population ratios lowering the effects of squared population). Removing them from the sample does not appreciably affect any estimated coefficient except for that of squared population (making it positive but insignificant). Omitting China and India also somewhat artificially boosts the explanatory power of the regressions by truncating variation in the variables.

The "home nation" and "neighboring nation" effects are very significant, both statistically and in numerical importance. The hosting nation sends an average of 209 more athletes than it would given its other characteristics, 64 of which are female. Nevertheless, remember that host nations are always among the most developed in the world, so hosting in a less developed nation would not necessarily increase domestic participation by that nation as dramatically. Neighboring nations send 48 more participants than expected due to other national attributes, of which 14 are female. For the Games in our sample, this represents almost a *doubling* of participation by the home nation compared to

Table 3: National Participation in the post-boycott Games
Effects of economic and political variables on participation in the "post-boycott" Summer Olympic Games, 1988-1996

Variable	Coeff. (β_i)	t-statistic		Coeff. (β_i)	t-statistic	
	All participants			Female participants		
Constant	104.60	4.70	***	-5.32	0.48	
GDP per capita (1985 prices)	6.94e-3	3.21	***	8.69e-4	0.68	
GDP per capita squared	-4.03e-8	0.36		1.66e-7	2.25	**
Population (000's)	7.60e-4	5.45	***	2.51e-4	4.66	***
Population squared	-5.08e-10	4.11	***	-1.69e-10	3.23	***
Home nation	203.49	13.11	***	86.97	14.06	***
Neighboring nation	17.46	1.66	*	13.09	3.27	***
Political system (compared to republic or parl. democracy)						
Monarchy	-12.77	0.76		-11.45	2.08	**
Single party or Communist	-5.33	0.16		9.67	0.89	
Military	-44.41	1.37		-10.76	1.03	
Other system	-51.20	1.45		-17.86	1.61	
Characteristics of former colonial power						
GDP per capita (1985 prices)	-1.66e-3	2.18	**	-1.21e-3	2.70	***
Population (000's)	2.11e-6	0.03		5.59e-6	0.27	
Medal success	0.17	0.83		6.69e-2	0.85	
Time trend	-7.34	3.06	***	1.48	1.30	
Adjusted R^2		0.59				
Number of groups (nations)		134			133	
Number of observations		293			219	

Notes: Dependent variable = number of athletic participants from a nation in a specific year.
Significance indicated as * for 10 percent, ** for 5 percent, *** for 1 percent

other Games, and a *25 percent increase* in participation by neighboring nations. Aside from the obvious impact on the tenor of competition in the Games and the role of the crowd, this offers a numerical advantage towards winning events, assuming that each participating athlete has some probability of winning.

Political systems have some small effect on participation levels, as compared with the (omitted) comparison case of republics and parliamentary democracies. While monarchies and "other political systems" (those in transition to democracies, those with ill-defined power structures) send fewer athletes than democracies do, military, single-party and Communist nations send no more than expected. The same pattern holds for both male and female athletes.

The economic and Olympic prowess of former colonial powers are also potent indicators of participation by former colonies. Former colonies or protectorates of wealthy nations (e.g. Britain, France and Germany) participate less than would be predicted by other variables, but that is offset by a tendency to participate more if the former colonial power is a successful Olympic medallist (most notably the USA and Russia, but including most of Western Europe as well). A strong athletic tradition in a former colonial power may mean better access to training facilities and expertise, but the negative impact of colonial

economic power is a surprising commentary that might explain African as compared to Latin American participation levels.

Finally, the results show that the number of total participants per nation has been rising significantly with time, even after analysis has controlled for other factors (i.e., real GDP per capita and population have been rising over time, lifting the participation numbers with them). Female participation accounts for roughly all of the increase, rising over and above the combined effect of other factors, by one-and-a-half female athletes per nation per Games.

For the sake of testing robustness (and pure interest), curious readers may want to know the results of a simple Cobb-Douglas function constrained to display constant returns to scale in capital (GDP per capita) and labor (population) with additive elements for the other characteristics above:

$$part_i = \alpha + GDP^{\beta_1} POP^{\beta_2} + \beta_3\ HOME + \beta_4 NEIGH + \sum_{j=5}^{8} \beta_j POL_j + \beta_9 COLGDP + \beta_{10} COLPOP + \beta_{11} COLMED + e$$

where the coefficients of GDP and POP are constrained to sum to unity. The results are similar to those reported above, with a coefficient on GDP per capita of 0.93 (with 0.07 on population). That value does not change if China and India are omitted from the sample, nor is it substantially different for post-boycott Games.

As a test of the estimated coefficients from the unconstrained linear model, an in-sample prediction of participants of the 1996 Games was performed, using regression coefficients from the post-boycott Games only. Results are very close to the actual data, overestimating aggregate participation by three percent (among those nations with complete data for estimation and prediction). Nation-by-nation estimates fall close to the correct order, with the obvious omissions due to data limitations. Japan, Eastern and Central Europe, Russia, Korea, Brazil and the Netherlands (along with a number of smaller participant nations) were omitted from nation-level predictions for that reason.

It is difficult to predict total participation at the 2000 Games for several additional reasons. First, travel from most regular participant nations to Australia is farther than for any Games since the 1956 Games (also in Australia). Participation numbers may therefore be generally lower than predicted here. In addition, in order to predict future participation, current GDP for all nations and current medal standings for colonial powers are needed, and since neither one is available, forecasts (involving potentially large errors) had to be used instead.

With those caveats, some out-of-sample predictions for the 2000 Games are presented in Table 4. While the overall composition of the list of largest participant nations has not changed, nations closer to the site of the Games (Australia, Japan and Korea) have moved up the list to higher participation. While estimates at the national level were again impossible for a number of important regular participants (due to data constraints), predictions for those

Table 4: Participation in Sydney 2000
out-of-sample predictions
(with in-sample predictions for the Atlanta Games, 1996)

Nationality of participants	2000 predicted	(rank)	1996 predicted	1996 actual	(rank)
United States of America	590	(1)	784	767	(1)
Australia	532	(2)	330	436	(3)
Russia*	467	(3)	n/a	402	(4)
Germany	433	(4)	438	476	(2)
Korea*	364	(5)	n/a	313	(8)
Japan*	360	(6)	n/a	310	(11)
Great Britain	352	(7)	350	325	(6)
France	313	(8)	317	315	(7)
Italy	306	(9)	311	341	(5)
Canada	302	(10)	328	312	(9)
Netherlands*	278	(11)	n/a	239	(13)
Spain	276	(12)	279	300	(12)
Ukraine*	271	(13)	n/a	233	(14)
People's Republic of China	261	(14)	267	312	(9)
Cuba*	205	(15)	n/a	176	(17)
Total of nations with data	7553		6198	6000	
Total of all participants	12237		10870	10523	

Notes: Ranks are based on nations with nation-level predictions, which are only possible where economic and political data are available. Nations annotated with an asterisk were estimated based on trend instead of regression. See the text for details.

nations were calculated by trend instead, inferring their participation relative to other nations using their relative participation in 1996. An estimate of global participation puts the 2000 Games at over 12200 athletes if transportation costs and recent economic crises in Southeast Asia, East Asia and Russia do not curtail participation.

B. Medal-Winning Success

Naturally, in addition to the joy of participating in the Games, nations would like to succeed, as measured by the medal count. Analysis here uses two different methods: success at the individual level by estimating the probability of winning given an athlete's national affiliation, and at the national level by counting medals won.

B.1. Individual-level Success Probabilities

The quest for medals can also be analyzed at the level of the individual, where the characteristics of interest are still national in scope. No personal characteristics are used here, but as an athlete, each participant in the Games has

some probability of winning a medal, a probability affected by the nature of the national support offered to him or her.

From this viewpoint, the problem becomes an ordered probit model, with characteristics of each athlete affecting the probability of achieving any medal, and subsequently affecting the probability of reaching higher medals. An ordered probit simply recognizes that each successive medal is more difficult to obtain, so that in order to win a silver medal the athlete must also have been able to win a bronze medal in that same Games.

As above, consider a simple linear function to assess the determinants of medal-winning or success:

$$\Pr(WinStatus)_{ki} = \alpha + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 POP + \beta_4\ POP^2 + \beta_5\ HOME + \beta_6 NEIGH + \sum_{j=7}^{10} \beta_j POL_j + \beta_{11} COLGDP + \beta_{12} COLPOP + \beta_{13} COLMED + \beta_{14} MED + \beta_{15} TIME + u_i + e$$

where *Pr(WinStatus)*$_{ki}$ is the probability that an athlete k from nation i attains the medal status that she or he does (3=gold, 2=silver, 1=bronze, 0=participant with no medal)

GDP is GDP per capita of nation i in constant 1985 international prices

POP is the population of nation i

HOME is a dummy variable to indicate the hosting nation

NEIGH is a dummy variable to indicate immediate geographical proximity to the hosting nation

POL_j is a series of dummy variables to indicate a monarchy, single-party, military or other political environment (compared to a republic)

COLGDP is the GDP per capita of the primary nation colonizing nation i

COLPOP is the population of the primary nation colonizing nation i

COLMED is the Olympic medal count of the primary nation colonizing nation i

MED is the total number of medals available to be won at this Games

TIME is the period of the Games (1952=1, 1996=12)

u_i is a nation-specific error term

e is the unexplained error

The results of this regression for 67652 Olympic athletes over eleven Games are presented in Table 5.

Unsurprisingly, a high GDP per capita is associated with success at the Games, since it is (among other things) indicative of high-quality training facilities. The squared term is negative, probably because of the obvious limitations on medal winning imposed by participation limits (e.g. nations cannot enter multiple teams in every sport). Population has the same general effect, because larger populations allow for a greater chance of outstanding athletes

Table 5: Individual success

Effects of economic and political variables on medal achievement in the Summer Olympic Games, 1952-1996

Variable	Coeff. (β_i)	t-statistic	
GDP per capita (1985 prices)	1.11e-4	15.99	***
GDP per capita squared	-4.19e-9	11.16	***
Population (000's)	3.02e-6	19.72	***
Population squared	-2.40e-12	-18.65	***
Home nation	0.12	4.77	***
Neighboring nation	-9.13e-3	-0.39	
Political system			
(compared to republic or parl. democracy)			
Monarchy	-0.18	-8.26	***
Single party or Communist	0.52	13.76	***
Military	-5.52e-2	-0.69	
Other system	0.13	1.43	
Characteristics of former colonial power			
GDP per capita (1985 prices)	-2.1e-5	-9.74	***
Population (000's)	-4.85e-7	-2.47	**
Medal success	7.31e-3	12.02	***
Total medals available	1.84e-3	5.80	***
Time trend	-9.63e-2	-7.96	***
Log-likelihood		22289	
Number of observations		62629	

Notes: Dependent variable = probability of success (gold=3, silver=2, bronze=1, no medal=0) by a given athlete in a specific year. Significance indicated as * for 10 percent, ** for 5 percent, *** for 1 percent

in the nation, but not all athletic teams from a nation are permitted to participate.

The "homefield advantage" is enormous, adding a twelve percent chance of success (measured as a move from bronze to silver, or from silver to gold) to the probability as measured by other attributes. This effect alone might be enough to encourage a nation to host the Games. At the average income level, this advantage is equivalent in medal-winning effect to an extra edge of $1123 in GDP per capita or roughly 40 million extra citizens.

Even more amazing is the overwhelming effect of the single party or Communist political system on success. Although there was no distinguishable effect of this regime on participation rates, the effect on success rates is undeniable, indicating a difference in incentives to succeed, effectiveness of training, mobilization of economic resources or some other institutional attribute.

Former colonial powers have effects similar to those on participation, with former colonies of large nations lowered and former colonies of medal-winning nations raised in their medal hopes. Once again, the intuition of access to training facilities and expertise of other successful Olympians fits the data well.

Naturally, the probability of an individual athlete winning rises with the number of medals available to be won. Finally, over time it appears to be more

difficult to win a medal (individual probability shows a negative impact of time) holding other effects constant. Since there has been no systematic rise in the number of athletes competing for each medal, this result is slightly unusual.

To test the estimates, Table 6 presents a comparison of actual medals won at the 1996 Games with medal-winners predicted by the individual-level model. Unfortunately, lack of key data makes prediction of the winners in 2000 impossible via this estimation route.

Table 6: Individual Medal Performance in Atlanta 1996
in-sample predictions by medal type

Nation	Total medals		Gold medals		Silver medals		Bronze medals	
	actual	predicted	actual	predicted	actual	predicted	actual	predicted
United States of America	101	119	44	37	32	38	25	44
Australia	41	29	9	11	9	10	23	8
Germany	65	49	20	17	18	16	27	16
Great Britain	15	21	1	8	8	7	6	6
France	37	31	15	11	7	10	15	10
Italy	35	34	13	12	10	11	12	11
Canada	22	21	3	8	11	7	8	6
Spain	17	18	5	7	6	6	6	5
People's Republic of China	50	51	16	16	22	16	12	19
Bulgaria	15	7	3	3	7	2	5	2
Korea	27	31	7	11	15	10	5	10
Total of nations with data	524		176		175		173	
Total of all medals	634	642	206	225	206	210	222	207

Notes: Estimates are based on individual-level predictions, which are only possible where economic and political data are available. See the text for notable nations omitted.

B.2. Nation-level Medal Counts

From a national perspective instead of an individual perspective, in order to win medals, a nation must send participants to the Games. Therefore, the number of national participants could be used to explain the number of medals won, but it would forsake the knowledge gleaned in Section A above about the relationship between participation and underlying economic variables. Therefore, the effect of the number of national participants will be seen here only indirectly, via (for example) the indirect effect of GDP on national participation which then leads to success.

However, there is one new consideration included here that did not limit the number of participants--- the total number of medals available to be won. As before, consider a simple linear function to assess the determinants of medal-winning or success:

$$medals_i = \alpha + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 POP + \beta_4\ POP^2 + \beta_5\ HOME + \beta_6 NEIGH$$

$$+ \sum_{j=7}^{10} \beta_j POL_j + \beta_{11} COLGDP + \beta_{12} COLPOP + \beta_{13} COLMED$$

$$+ \beta_{14} MED + \beta_{15} TIME + u_i + e$$

where *medals* is the number of medals won by nation i
GDP is GDP per capita of nation i in constant 1985 international prices
POP is the population of nation i
HOME is a dummy variable to indicate the hosting nation
NEIGH is a dummy variable to indicate immediate geographical proximity to the hosting nation
POL_j is a series of dummy variables to indicate a monarchy, single-party, military or other political environment (compared to a republic)
COLGDP is the GDP per capita of the primary nation colonizing nation i
COLPOP is the population of the primary nation colonizing nation i
COLMED is the Olympic medal count of the primary nation colonizing nation i
MED is the total number of medals available to be won at this Games
TIME is the period of the Games (1952=1, 1996=12)
u_i is a nation-specific error term
e is the unexplained error

Table 7 presents the results of this regression for the number of all medals earned by a nation, including a breakdown for gold medals in particular. Similar coefficients are obtained for estimation using only for the post-boycott Games (1988-1996).

GDP per capita and population again both have a positive impact but both show decreasing returns to scale (a smaller positive impact at higher levels of GDP per capita). The effect is more pronounced for gold medals than for all medals, with much larger nations seeing very little increase in gold medal counts for each successive increase in size.

The home nation shows a strong advantage, taking home 25 more medals than expected, including 12 gold medals. Neighboring nations share in the prize, earning 3.5 more medals than anticipated. This may be a strong reason to negotiate for upcoming Olympic host privileges, and suggests a reason for neighboring nations to support the bid (if it does not compete with a similar bid they are proposing!). However, this quantifying of the "homefield advantage" may also help in setting the record straight on the exact athletic advantages of hosting privileges.

Table 7: National success

Effects of economic and political variables on medal achievement in the Summer Olympic Games, 1952-1996

Variable	Coeff. (β_i)	t-statistic		Coeff. (β_i)	t-statistic	
	All medals			**Gold medals**		
Constant	-2.60	0.87		-1.16	0.91	
GDP per capita (1985 prices)	9.52e-4	3.55	***	4.61e-4	4.07	***
GDP per capita squared	-1.71e-8	1.26		-1.32e-8	2.28	**
Population (000's)	5.20e-5	3.97	***	2.40e-5	4.47	***
Population squared	-1.15e-11	1.11		-1.06e-11	2.45	***
Home nation	24.87	13.59	***	12.21	15.50	***
Neighboring nation	3.51	3.48	***	0.81	1.87	*
Political system (compared to republic or parl. democracy)						
Monarchy	-3.98	2.07	**	-1.58	2.06	**
Single party or Communist	12.10	3.30	***	5.13	3.50	***
Military	-2.87	0.77		-1.04	0.70	
Other system	-3.89	0.92		-1.21	0.72	
Characteristics of former colonial power						
GDP per capita (1985 prices)	-4.00e-4	3.34	***	-1.50e-4	3.02	***
Population (000's)	-2.01e-6	0.26		-1.54e-6	0.50	
Medal success	2.23e-2	1.09		7.99e-3	0.93	
Total medals available	1.25e-2	1.62		4.21e-3	1.27	
Time trend	-0.39	1.25		-0.14	1.06	
Adjusted R^2		0.35			0.35	
Number of groups (nations)		138			138	
Number of observations		1095			1095	

Notes: Dependent variable = number of medals earned by a nation in a specific year.
Significance indicated as * for 10 percent, ** for 5 percent, *** for 1 percent

As seen earlier at the individual level, monarchies perform worse than expected while single party and Communist systems outperform expectations by an average of 12 medals (5 of them gold). The effects of former colonial powers mirror those explained above.

Again for the sake of testing robustness (and pure interest), a simple Cobb-Douglas function was estimated, constrained to display constant returns to scale in capital (GDP per capita) and labor (population) with additive elements for the other characteristics:

$$medal_i = \alpha + GDP^{\beta_1} POP^{\beta_2} + \beta_3 HOME + \beta_4 NEIGH + \sum_{j=5}^{8} \beta_j POL_j + \beta_9 COLGDP + \beta_{10} COLPOP + \beta_{11} COLMED + e$$

where the coefficients of GDP and POP are constrained to sum to unity. Again, the results are similar to those reported above and similar to the Cobb-Douglas specification for participation, with a coefficient on GDP per capita of 0.93 (with

0.07 on population). That result is insensitive to the inclusion of China and India, or use of only the post-boycott Games as a sample.

While the unconstrained linear regressions for all medal types (gold, silver and bronze) are not shown, they display similar results, allowing predictions of specific numbers of each type of medal by nation. Table 8 shows those predictions in-sample for the 1996 Atlanta Games, using the post-boycott coefficient estimates. Nations with insufficient data were omitted from these calculations.

Table 8: National Medal Performance in Atlanta 1996
in-sample predictions by medal type

Nation	Total medals		Gold medals		Silver medals		Bronze medals	
	actual	predicted	actual	predicted	actual	predicted	actual	predicted
United States of America	101	103	44	42	32	33	25	27
Australia	41	26	9	6	9	8	23	11
Germany	65	58	20	19	18	16	27	20
Great Britain	15	20	1	4	8	7	6	8
France	37	26	15	9	7	6	15	11
Italy	35	22	13	8	10	6	12	8
Canada	22	17	3	5	11	5	8	8
Spain	17	11	5	4	6	4	6	3
People's Republic of China	50	42	16	11	22	19	12	10
Bulgaria	15	21	3	5	7	8	5	6
Korea	27	30	7	9	15	11	5	10
Total of nations with data	524	524	176	176	175	175	173	173
Total of all medals	634		206		206		222	

Notes: Totals may not add due to rounding. Estimates are based on nations with nation-level predictions, which are only possible where economic and political data are available. See the text for notable nations omitted.

Although always dangerous to perform, out-of-sample predictions for medal standings at the Sydney Games are presented in Table 9. Since data were not available for all nations, medal counts for nations marked with an asterisk were inferred as a share of the remaining medals to be won (based on their performance in 1996).

It is impossible to precisely predict out-of-sample here for the same reasons as were explained in the section on participation. In addition, there is a reliance upon the actual number of medals awarded, in order to predict their distribution among nations. Since the precise number is unknown (due to ties in which several medals of one rank are presented, or occasional cancellations) the totals are based on an estimate of 900 awarded medals. Naturally, if there are a different number of medals awarded, the estimates could be rescaled to mirror the true total.

Table 9: Nation-level Predicted Medal Performance in Sydney 2000
out-of-sample predictions by medal type
(including only nations predicted to win more than ten medals)

Nation	Predicted Sydney 2000 medal counts				Actual Atlanta 1996 medal counts			
	Total	Gold	Silver	Bronze	Total	Gold	Silver	Bronze
United States of America	90	33	21	26	101	44	32	25
People's Republic of China	85	28	32	25	50	16	22	12
Germany	61	21	18	21	65	20	18	27
Australia	54	19	17	18	41	9	9	23
Russia*	29	11	8	10	63	26	21	16
France	28	10	6	12	37	15	7	15
Bulgaria	26	7	10	9	15	3	7	5
Italy	25	9	7	9	35	13	10	12
Great Britain	23	5	8	10	15	1	8	6
Spain	16	6	5	5	17	5	6	6
New Zealand	15	4	5	7	6	3	2	1
Korea*	12	3	6	3	27	7	15	5
Cuba*	12	4	3	5	25	9	8	8
Canada	12	2	5	5	22	3	11	8
Ukraine*	12	4	1	7	23	9	2	12
Hungary*	11	3	2	6	21	7	4	10
Romania*	11	2	3	6	20	4	7	9
Sweden	11	2	5	4	8	2	4	2
Hungary*	11	3	2	6	21	7	4	10
Total of nations with data	660	218	208	231				
Total of all medals	900	287	275	332	842	271	273	298

Notes: Totals may not add due to rounding. Estimates are based on predictions which are only possible where economic and political data are available. Nations annotated with an asterisk were estimated based on trend instead of regression. See the text for details.

The medal predictions have some anomalies hidden in a list that otherwise conforms well to historical precedent, and therefore to the predictions of Bernard and Busse (2000). While the same twenty nations top the list, China and Bulgaria are here predicted to perform unusually well compared to past standards, at the expense of Russia and most of Eastern Europe. The United States once again tops the list at ninety medals, and Australia leaps in the final rankings to 54, thirteen medals more than in Atlanta, largely because of the homefield advantage.

IV. Conclusion

Regardless of the precise medal outcome of this particular incarnation of the Olympic Games, several facts can be clearly stated. Female participation is rising over time, augmented primarily by larger nations. There is a significant and measurable advantage to larger nations (both in GDP per capita and in population) in terms of participation and success at the Games. Furthermore, there are undeniable advantages to being the hosting nation, and to being a

neighbor to the host. In particular, not only does hosting double the average national participation level but it increases each individual's probability of medal success by twelve percent. Equally striking is the fact that while there is no evidence of a bias of Communist and single-party governments to send more athletes to the Games, once there, the athletes of these nations perform exceptionally well. There is support for the hypothesis that colonial links make a difference, imparting a mixed blessing from the past. The broad uniformity in the regressions, whether estimated on the individual level or the national level, whether estimated for participation or success, add to the power of the results.

Work is already in progress to investigate whether the aggregate findings hold for particular events, and whether the results are stable across time. Another obvious extension would be to compare the Winter Games. If data were available on national funding for athletes or the location of training facilities (on a detailed basis) there would be interesting work to explore the importance of expenditures and training expertise on participation and success.

Hopefully, this analysis will encourage further reflection on the nature of international competition and the tilt of the playing field, given economic and political variables. Larger nations have a distinct advantage, and also have a greater chance of hosting the Games, thereby accruing an additional advantage.

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