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Creating and Testing a Production Function for Olympic Medals

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Almost every country competes in the Olympics, and while the relative importance of the Olympics differs by country, every country wants to do well on a stage of such global magnitude and focus. However, determining which country characteristics predict Olympic success is not easy. For example, while population is a major component in having Olympic talent, it is not the entire answer: one only needs to look as far as India, which has the second largest population of any country in the world but only won six medals in 2012 ("Historical Medals"). So what are all the major components for producing Olympic medals, and what is the relative importance of each component? To a large degree, this question has been investigated by numerous papers – the two that I focus my literature review on are Bernard and Busse (2004) who were one of the first people to devise an Olympic medal production function, and Forrest, Sanz, and Tena (2010) who added useful additions to the Bernard and Busse model. While my model and theoretical methodology resembles the work done by Bernard and Busse, I have added a proxy for a country's organizational ability, in the form of income inequality, to create a more accurate model. Additionally, Bernard and Busse's model and Forrest, Sanz, and Tena's model used medal data from before the collapse Soviet Union. However, I exclusively use post-Soviet Union data which should help create a more accurate predictive estimate for Olympic medals.

I. THEORY AND DEVELOPMENT OF THE EMPIRICAL MODEL

Winning Olympic medals requires athletic talent. I assume athletic talent is uniformly distributed, so bigger populations have a greater number of Olympic-level athletes. Thus, a nation's population is crucial in determining how many Olympic medals that nation wins. However, it is not the only factor that matters. Money must be spent creating training facilities and hiring coaches, for example. In addition, richer countries have the infrastructure such as an effective sewer system, or safe drinking water, which is necessary for developing a healthy young population. Thus, the ability and willingness of a country to invest in its athletes is also a major factor in Olympic medal production. I do not observe this effort directly. Instead I use a country's wealth to proxy for this effort, where I assume countries with greater wealth have greater ability and willingness to invest in athlete development. Finally, the organizational ability of a country can impact how well it does at an Olympics. Having the necessary wealth, or the athletic talent, to win many Olympic medals is unimportant if a nation does not have the organizational capability to invest its wealth in its athletic talent. Thus, my production function is a function of three factors: population, wealth, organizational ability.

$$(1) \quad P_{i,t} = f\left(POP_{i,t}, GDP_{i,t}, O_{i,t}\right)$$

where $POP_{i,t}$ is the population, $GDP_{i,t}$ is the GDP per capita, and $O_{i,t}$ is the organizational ability of country *i* at time *t*.

Unfortunately, there is no readily available statistic that measures a country's organizational ability. However, I proxy for organizational ability by looking at income inequality via a country's Gini coefficient. I justify using income inequality by referencing the relative power theory, which suggests that as a country becomes more unequal its citizens become less willing to buy into national policies. In particular, the relative power theory states that economic inequality should have a strong negative effect amongst the poor. The basic rationale is that as economic inequality rises, the rich obtain more political power and wield this power for their own benefit, ignoring many of the problems facing the poor. This only leads to positive feedback for the rich, as they become wealthier, gain more power, and use this power to become even wealthier. Eventually, poor citizens conclude that there is no possible improvement through the political system, and so disengage themselves from the political system. In "Economic Inequality and Political Engagement", Solt (2008) looks at the effects of inequality on political engagement in twenty-two developed countries. Solt finds that consistent with the relative power theory, income inequality reduced the frequency that citizens of all income levels discussed politics, and that this effect was statistically significant for all income levels except the top quintile (2008). Solt also finds that all else equal, the probability of voting for the poorest falls 12.9 percentage points over the observed ranges of income inequality within the twenty-two countries (2008). For all but the highest income quintile, the probability of voting decreases over the observed ranges of income inequality and this effect is statistically significant (Solt).

To develop the population and wealth variables that I use in my production function, I utilize the concept of Olympic medal share. The Olympic medal share that country *i* wins in time *t*, $M_{i,t}$, is a function of the Olympic athletes in it.

$$(2)\quad \frac{MEDALS_{i,t}}{\sum_{j=1}^{j} MEDALS_{j,t}} = M_{i,t} = h(P_{i,t})$$

where $MEDALS_{i,t}$ is the number of medals country *i* wins in time *t*, and $\sum_{j=1}^{j} MEDALS_{j,t}$ is the sum of the medals won by all *j* countries in time *t*.

Following Bernard and Busse (2004), I assume the country level production of medal is in the form of a Cobb-Douglas production function with organizational ability serving as the total factor productivity. As Bernard and Busse point out, there is no theoretical guidance on the precise form of the Olympic athlete production function.

$$(3)\quad P_{i,t} = O_{i,t} POP_{i,t}{}^{\gamma} GDP_{i,t}{}^{\lambda}$$

Since Olympic medal share is the relative production of Olympic medals in country *i* at time *t*, then medal share is also a function of the relative production of the Olympic athletes in country *i* at time *t*. Since there is no guidance on the precise form of the relative production of Olympic athletes in country *i* at time *t*, I will use the natural log function. That is to say,

$$(4)\quad \frac{MEDALS_{i,t}}{\sum_{j=1}^{j} MEDALS_{j,t}} = M_{i,t} = h\left(P_{i,t}\right) = ln \frac{P_{i,t}}{\sum_{j=1}^{j} P_{j,t}}$$

After some algebra, the basic production function can be estimated by Equation 6.[1]

[1] Since ln $\sum_{j=1}^{j} P_{j,t}$ is the total number of medals awarded in an Olympics, and is simply a constant, it is absorbed into the constant term.

$$(5) \quad M_{i,t} = \ln O_{i,t} + \gamma \ln (POP_{i,t}) + \lambda \ln (GDP_{i,t}) - \ln \sum_{j=1}^{j} P_{j,t}$$

$$(6) \quad M_{i,t} = \beta_0 + \beta_1 \ln (O_{i,t}) + \beta_2 \ln (POP_{i,t}) + \beta_3 \ln (GDP_{i,t}) + \mu_{i,t}$$

While I have estimated the basic production function, there are additional independent variables to supplement the basic production function. These additional variables are included due to their intuitive and theoretical importance as well as their estimated importance from previous literature. One of these variables is whether or not a country is the host nation. Both Bernard and Busse, and Forrest, Sanz, and Tena found that being the Olympic host significantly boosts medal totals. Intuitively, this makes sense as host nation athletes do not have to adjust to a different time zone or culture. In addition, these athletes also spend more time practicing and training in the same Olympic facilities they compete in. Also, host nations want to avoid being embarrassed at the Olympics so they invest more money in their athletes than they normally would. Finally, this host nation impact is not limited to nations that host the next Olympics. Forrest, Sanz, and Tena (2010) found that the nation that hosts, not the next Olympics, but the one after, actually has higher than expected medal totals. Since nations know seven years in advance that they will be hosting an Olympics (and they have an incentive to perform as well as they can when they host), this future host nation will begin investing in better coaches, facilities, and athletes right away. This immediate increase in investment will impact their Olympians' performances in the Olympics before they host.

Another variable is whether or not a country was formerly a part of the USSR. Empirically, Bernard and Busse found that "Soviet" countries had a medal share that was more than 6.1 percentage points higher than other countries. The economic intuition is that in these countries there is much more political significance placed on sporting success (Bernard, and Busse, 413-417). Thus, they might value their Olympians and invest in their Olympic training facilities more, relative to other countries. I follow the lead of Forrest, Sanz, and Tenna and extend this intuition to former Eastern Bloc nations (which were heavily influenced by the USSR) and current Communist countries. To account for these factors (host, Soviet, Eastern Bloc, Communist, and next host) I constructed dummy variables (1 representing that a country is a host, a former Soviet country, the next host, etc. and 0 otherwise) to add to the basic production function.

The final additions to my model are medal shares from previous Olympics. I include these variables because poor Olympic performances by a country tend to followed by poor future Olympic performances, while good Olympic performances tend to be followed by good future Olympic performances. This is because Olympic athletes are a durable good – quality Olympic athletes can win medals at more than one Olympic Game. Similarly, not having quality Olympic athletes can lead to medal droughts that last multiple Olympic Games. Thus, investing in producing good Olympic athletes can create payoffs not only in the next Olympics but also in future Olympics as well. To account for this effect, I add medal shares from the previous one, two, and three Olympics (or four, eight, and twelve years).

Thus, the estimated model looks like:

$$\text{(7)} \quad \widehat{M_{i,t}} = \widehat{\beta_0} + \widehat{\beta_1}\ln\left(GINI_{i,t}\right) + \widehat{\beta_2}\ln\left(GDP_{i,t}\right) + \widehat{\beta_3}\ln\left(POPULATION_{i,t}\right) + \widehat{\beta_4}M_{i,t-4} + \widehat{\beta_5}M_{i,t-8} + \widehat{\beta_6}M_{i,t-12} + \widehat{\beta_7}HOST_{i,t} + \widehat{\beta_8}NEXT\ HOST_{i,t} + \widehat{\beta_9}SOVIET_{i,t} + \widehat{\beta_{10}}EASTERNBLOC_{i,t} + \widehat{\beta_{11}}COMMUNIST_{i,t}$$

II. DATA

I use country population data, country GDP per capita data, and Gini coefficient data from the World Bank's Databank of Indicators. In addition, I include adjusted GDP per capita and population data. My adjusted GDP per capita is GDP per capita less governmental operating expenditures. I do not subtract military expenditures, health care, or social security expenditures as complete data was not available. Also, instead of using total population, I adjust my population to only include 15-65 year olds. This adjusted population eliminates those that would be too young to participate in the Olympics. Bernard and Busse (2004) do not consider that the inputs into an Olympian production function are not a country's entire population, nor its full GDP per capita, so these adjusted statistics should be a more accurate representation of the true inputs into the production function.[2]

All World Bank data is from 2008, and 2012. Finally, I did not have a list of all countries that participated in each of the past six Olympics so I assume that every country in the world participated in each Olympics. This is a relatively valid assumption as all of the 215 countries the World Bank recognizes participated in the 2012 Olympics.

III. EMPIRICAL MODEL

To obtain my estimates I use a tobit regression with robust standard errors. I use a tobit estimation because my data is bounded by zero, and violates one of the basic OLS assumptions. In other words, because winning negative medals does not happen practically, the tobit model corrects for this lower restriction. I run regressions for when *t* is 2012, and when *t* is 2008. In addition, endogeneity is not an issue because the number of medals a country wins does not determine its GDP. Multicollinearity, which could be an issue as many of the independent variables are highly correlated, has no real solution, and is a problem that I, like the relevant literature on medal forecasting, ignore[3]. Finally, I use robust standard errors to correct for heteroskedasticity. Thus, the two baseline regressions look like

$$\text{(8)} \quad \widehat{M_{i,2008}} = \widehat{\beta_0} + \widehat{\beta_1}\ln\left(GINI_{i,2008}\right) + \widehat{\beta_2}\ln\left(GDP_{i,2008}\right) + \widehat{\beta_3}\ln\left(POPULATION_{i,2008}\right) + \widehat{\beta_4}M_{i,2004} + \widehat{\beta_5}M_{i,2000} + \widehat{\beta_6}M_{i,1996} + \widehat{\beta_7}HOST_{i,2008} + \widehat{\beta_8}NEXT\ HOST_{i,2008} + \widehat{\beta_9}SOVIET_{i,2008} + \widehat{\beta_{10}}EASTERNBLOC_{i,2008} + \widehat{\beta_{11}}COMMUNIST_{i,2008}$$

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[2] For a list of host, next host, Soviet, Eastern Bloc, and Communist nations, and summary statistics for all variables, please see Appendix A.
[3] See Appendix B for independent variable correlation matrices

$$(9)\quad \widehat{M_{i,2012}} = \widehat{\beta_0} + \widehat{\beta_1}\ln\left(GINI_{i,2012}\right) + \widehat{\beta_2}\ln\left(GDP_{i,2012}\right) + \widehat{\beta_3}\ln\left(POPULATION_{i,2012}\right) + \widehat{\beta_4}M_{i,2008} + \widehat{\beta_5}M_{i,2004} + \widehat{\beta_6}M_{i,2000} + \widehat{\beta_7}HOST_{i,2012} + \widehat{\beta_8}NEXT\ HOST_{i,2012} + \widehat{\beta_9}SOVIET_{i,2012} + \widehat{\beta_{10}}EASTERN\ BLOC_{i,2012} + \widehat{\beta_{11}}COMMUNIST_{i,2012}$$

I run these two regressions to test if the effects of the dependent variables are robust over time. I suspect that the effects of the dependent variables are relatively robust over time, so I do not expect many differences in the coefficient or significance of variables from one regression to the next.

I alter each of the baseline regressions by varying adjusted GDP per capita, adjusted population, and Gini coefficients. I suspect that the adjusted variables only have a very marginal impact due to their high correlation with non-adjusted variables. In addition, I suspect that income inequality has little statistical or practical significance as it is probably not a very good predictor of organizational ability. To test these hypotheses I run three permutations of each of the previous baseline regressions[4]:

1. One without adjusted GDP per capita, adjusted population, and Gini coefficients.
2. One with adjusted GDP per capita, adjusted population, and no Gini coefficients.
3. One with adjusted GDP per capita, adjusted population, and Gini coefficients.

IV. RESULTS

As expected, both GDP and population are statistically significant and in the hypothesized direction (this is also true for adjusted GDP and adjusted population). In addition, there is little difference between the coefficients for the adjusted and non-adjusted GDP and population, suggesting that it does not matter which statistic is used. The coefficients for GDP and population indicate a relatively small effect on medal share, all else equal. For example, if a country doubles its GDP, it will only increase its medal share by roughly 0.06% to 0.1%, all else equal. Similarly, if a country doubles its population, it will only increase its medal share by around 0.06% to 0.09%, all else equal.

On the other hand, lagged medal share has a statistically significant and relatively large effect on medal share, as expected. If a country suddenly doubled its medal share from the previous Olympics, it would be expected to win around 50% to 70% more medals, all else equal. The impact of medal share from two or three Olympics ago is less clear, as some of the coefficients are negative. However, in all cases, the negative coefficients are not statistically significant, and all statistically significant coefficients are positive.

Being an Olympic host increases medal share by roughly 2% to 4% and being the next Olympic host boosts medal share by roughly 0.3%. Being an ex-Soviet nation increases medal share by roughly 0.2% to 0.4% while being an Eastern Bloc nation seems to decrease medal share. The Eastern Bloc effect could be due to the fact that the political impetus to perform well is outweighed by the lack of the necessary infrastructure to perform well. In addition, being a current Communist nation has no statistically significant effect on medal share.

As I thought, the Gini coefficient was not statistically significant, confirming my suspicion that using income inequality as a proxy for organizational ability was not effective. In the future,

[4] For the complete list of all regressions and their corresponding model number, please see Appendix B.

I hope that a more accurate measure of a country's organizational ability is found, and can be utilized in this sort of analysis[5].

V. PREDICTION

To test the value of the model, I evaluate its predictive power. Since the adjusted models did not deviate significantly from the baseline models, I only use the baseline models as my predictive model.

In their 2000 forecasts, Bernard and Busse reported a mean absolute error of 4.3 medals. In addition, Forrest, Sanz, and Tenna reported 4.33 medals for their 2008 forecasts. My mean absolute error was 2.57, and 2.82 for 2008 and 2012, respectively. The added accuracy of my model becomes more apparent when comparing my model's predictions with the Forrest, Sanz, and Tenna forecasts for the leading medal winners at the 2008 Olympics.

Table I.

Countries	Actual	Model Prediction	Forrest Prediction
United States	107	100	102
China	100	99	90
Russia	73	75	74
United Kingdom	47	47	44
Australia	46	42	39
Germany	41	55	43
France	39	33	32
South Korea	31	27	25
Italy	27	32	28
Ukraine	27	25	21
Japan	25	26	35
Belarus	19	17	13
Spain	18	19	18
Canada	18	17	13
Netherlands	16	18	19
Absolute Mean Error		3.4667	4.8
R-Squared		0.9699	0.9685

Though my model's absolute mean error was more than a medal lower than Forrest's absolute mean error, my model greatly overestimated the number of medals Germany was going to win. That being said, my model was relatively accurate – for example, my model predicted the top 15 medal winners at the 2012 Olympics reasonably well.

[5] For complete regression results, please see Appendix C.

Table II.

2012

Country	**Actual**	**Predicted**
United States	104	99
China	88	82
Russia	82	73
United Kingdom	65	62
Australia	35	41
Germany	44	39
France	34	34
Japan	38	31
South Korea	28	29
Italy	28	26
Ukraine	20	24
Spain	17	19
Belarus	12	16
Brazil	17	16
Canada	18	16
Average Absolute Error		3.80
R-Squared		0.98

For the 2012 Olympics, I found that the biggest overachiever, in absolute terms, was Russia, who won 82 medals when they were predicted to win 73. However, the biggest overachiever, relative to what they were predicted to win, was Colombia. Colombia was predicted to win only one medal, and they won eight. The biggest underachiever, in absolute terms, was Australia, who won 32 medals when they were predicted to win 41. The biggest underachiever, relative to what they were predicted to win, was Greece. Greece was predicted to win seven medals – instead Greece won two[6].

VI. CONCLUSION

Olympic medals can be predicted relatively accurately using a simple model based on per capita GDP and population. I have added medal shares from previous Olympics as explanatory variables, and found that these variables have very statistically significant and practical importance. My results emphasize that Olympic athletes are durable goods, and that Olympic performance in the past predicts Olympic performance in the future. My results also show that the effect of per capita GDP and population, while significant, is surprisingly small, and that being the host of the next Olympics, or the one after, actually has a larger impact on medal performance.

The predictive qualities of my model are generally stronger than previous models, and my mean absolute error is more than an error less than that of Bernard or Forrest. On average, my

[6] For all model predictions, see Appendix D.

predicted values were only 2.8 medals off the actual medal count. However, no model is perfect, and one of the flaws of my model is not having a variable that strongly explains a country's organization ability. While I tried to proxy organizational ability by using income inequality, my results were not conclusive. I hope that in the future, better and more creative data can be used to better estimate the effect that organizational ability has on medal output.

VII. REFERENCES

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VIII. APPENDIX

Appendix A

List of Soviet, Eastern Bloc and Communist Countries

Soviet	Eastern Bloc	Communist
Armenia	Poland	China
Azerbaijan	Czech Republic	Cuba
Belarus	Hungary	Lao PDR
Estonia	Romania	Vietnam
Georgia	Bulgaria	
Kazakhstan	Yugoslavia	
Kyrgyzstan	Albania	
Latvia		
Lithuania		
Moldova		
Russia		
Tajikistan		
Turkmenistan		
Ukraine		
Uzbekistan		

Summary Statistics for All Variables

2012

Variables	Mean	Median	Standard Deviation
Medal Share	0.0054	0.0000	0.0149
GDP	13212.1539	4873.0026	19735.5537
Population	38216120.9375	7760193.5000	141872809.0996
Adjusted GDP	9645.9471	4150.7208	13997.9336
Adjusted Population	25079547.8393	5030386.2278	97682824.0243
ln(GDP)	8.4962	8.4914	1.5028
ln(Population)	15.6545	15.8645	2.0892
ln(Adjusted GDP)	8.2996	8.3310	1.4040
ln(Adjusted Population)	14.6453	15.4309	3.8484
Gini	34.5534	37.4483	17.1677
ln(Gini)	3.1176	3.6230	1.3477
Medal Share - 1 Lag	0.0054	0.0000	0.0150
Medal Share - 2 Lag	0.0054	0.0000	0.0147
Medal Share - 3 Lag	0.0053	0.0000	0.0144
Host	0.0057	0.0000	0.0754

Next Host	0.0057	0.0000	0.0754
Soviet	0.0852	0.0000	0.2800
Eastern Bloc	0.0341	0.0000	0.1820
Communist	0.0170	0.0000	0.1298

2008

Variables	**Mean**	**Median**	**Standard Deviation**
Medal Share	0.0051	0.0000	0.0144
GDP	15603.4101	4791.1929	25326.3431
Population	33945707.9692	6206623.0000	131559029.4053
Adjusted GDP	12268.9850	3970.0563	21836.5723
Adjusted Population	22133912.3290	3900725.0000	89691646.2252
ln(GDP)	8.5298	8.4745	1.6173
ln(Population)	15.3873	15.6411	2.2191
ln(Adjusted GDP)	8.3398	8.2865	1.5485
ln(Adjusted Population)	14.0578	15.1767	4.5665
Gini	32.4925	36.1467	18.5665
ln(Gini)	2.9288	3.5876	1.5054
Medal Share - 1 Lag	0.0051	0.0000	0.0141
Medal Share - 2 Lag	0.0050	0.0000	0.0139
Medal Share - 3 Lag	0.0051	0.0000	0.0144
Host	0.0051	0.0000	0.0716
Next Host	0.0051	0.0000	0.0716
Soviet	0.0769	0.0000	0.2672
Eastern Bloc	0.0308	0.0000	0.1731
Communist	0.0205	0.0000	0.1421

2004

Variables	**Mean**	**Median**	**Standard Deviation**
Medal Share	0.0050	0.0000	0.0141
GDP	15517.0145	4309.5226	25287.4763
Population	32048194.1686	5667055.0000	126021210.8490
Adjusted GDP	12419.9119	3788.1344	21827.1970
Adjusted Population	20558033.1670	3488020.3690	84115881.7554
ln(GDP)	8.4692	8.3686	1.6486
ln(Population)	15.2878	15.5502	2.2383
ln(Adjusted GDP)	8.2949	5667055.0000	126021210.8490
ln(Adjusted Population)	13.8970	15.0648	4.6374
Gini	32.1626	36.0300	18.7579
ln(Gini)	2.8991	3.5844	1.5264
Medal Share - 1 Lag	0.0050	0.0000	0.0138
Medal Share - 2 Lag	0.0050	0.0000	0.0143

Medal Share - 3 Lag	0.0049	0.0000	0.0172
Host	0.0051	0.0000	0.0712
Next Host	0.0051	0.0000	0.0712
Soviet	0.0761	0.0000	0.2659
Eastern Bloc	0.0305	0.0000	0.1723
Communist	0.0203	0.0000	0.1414

Appendix B

2012 - Correlation Matrix

2012	LN(GDP)	LN(Population)	LN(Adjusted GDP)	LN(Adjusted Population)	LN(Gini)	Medal Share - 1 Lag	Medals Share - 2 Lag	Medal Share - 3 Lag	Host	NextHost	Soviet	Eastern Bloc	Current Communist
LN(GDP)	1												
LN(Population)	-0.093	1											
LN(Adjusted GDP)	0.9915	-0.1187	1										
LN(Adjusted Population)	-0.0474	0.8365	-0.0749	1									
LN(Gini)	-0.2106	0.5352	-0.2326	0.5697	1								
Medal Share - 1 Lag	0.299	0.4075	0.2857	0.2794	0.1167	1							
Medals Share - 2 Lag	0.337	0.4012	0.3201	0.2771	0.1147	0.9553	1						
Medal Share - 3 Lag	0.3374	0.387	0.3171	0.2699	0.1113	0.9405	0.9833	1					
Host	0.1044	0.0834	0.0894	0.0569	0.0262	0.2217	0.1442	0.1309	1				
NextHost	0.0477	0.1249	0.0449	0.08	0.0533	0.0522	0.0333	0.0401	-0.0057	1			
Soviet	-0.012	0.032	-0.0305	0.0676	0.0996	0.1338	0.1298	0.1376	-0.0231	-0.0231	1		
Eastern Bloc	0.0881	0.0527	0.0681	0.0602	0.0377	0.0179	0.0827	0.1138	-0.0142	-0.0142	-0.0573	1	
Current Communist	-0.0717	0.1686	-0.0619	0.1131	0.0463	0.2632	0.1545	0.1456	-0.01	-0.01	-0.0402	-0.0247	1

2008 - Correlation Matrix

	LN(GDP)	LN(Population)	LN(Adjusted GDP)	LN(Adjusted Population)	LN(Gini)	Medal Share - 1 Lag	Medals Share - 2 Lag	Medal Share - 3 Lag	Host	NextHost	Soviet	Eastern Bloc	Current Communist
LN(GDP)	1												
LN(Population)	-0.2339	1											
LN(Adjusted GDP)	0.9925	-0.2633	1										
LN(Adjusted Population)	-0.2364	0.8525	-0.2713	1									
LN(Gini)	-0.3483	0.5848	-0.3765	0.6167	1								
Medal Share - 1 Lag	0.2709	0.4002	0.2565	0.2689	0.1212	1							
Medals Share - 2 Lag	0.2724	0.3864	0.2555	0.2625	0.1157	0.9836	1						
Medal Share - 3 Lag	0.2785	0.3862	0.2631	0.2607	0.1191	0.9608	0.9718	1					
Host	-0.0175	0.1822	-0.0095	0.1043	0.0353	0.3189	0.2981	0.2946	1				
NextHost	0.0951	0.0826	0.0819	0.0546	0.0313	0.1438	0.1305	0.0619	-0.0052	1			
Soviet	-0.0305	0.0615	-0.0425	0.0896	0.1206	0.1339	0.1414	0.0899	-0.0207	-0.0207	1		
Eastern Bloc	0.0783	0.0687	0.0615	0.0712	0.0544	0.0854	0.1159	0.1392	-0.0128	-0.0128	-0.0514	1	
Current Communist	-0.0809	0.1563	-0.0694	0.1058	-0.0228	0.1962	0.1955	0.1834	0.4961	-0.0104	-0.0418	-0.0258	1

Model I

$$
\begin{aligned}
\widehat{M_{i,2012}} = \widehat{\beta_0} + \widehat{\beta_1}\ln\,(GDP_{i,2012}) + \widehat{\beta_2}\ln\,(Population_{i,2012}) + \widehat{\beta_3}M_{i,2008} + \widehat{\beta_4}M_{i,2004} \\
+ \widehat{\beta_5}M_{i,2000} + \widehat{\beta_6}Host_{i,2012} + \widehat{\beta_7}Next\ Host_{i,2012} + \widehat{\beta_8}Soviet_{i,2012} \\
+ \widehat{\beta_9}Eastern\ Bloc_{i,2012} + \widehat{\beta_{10}}Communist_{i,2012}
\end{aligned}
$$

Model II

$$\widehat{M_{i,2008}} = \widehat{\beta_0} + \widehat{\beta_1}\ln(GDP_{i,2008}) + \widehat{\beta_2}\ln(Population_{i,2008}) + \widehat{\beta_3}M_{i,2004} + \widehat{\beta_4}M_{i,2000} + \widehat{\beta_5}M_{i,1996} + \widehat{\beta_6}Host_{i,2008} + \widehat{\beta_7}Next\ Host_{i,2008} + \widehat{\beta_8}Soviet_{i,2008} + \widehat{\beta_9}Eastern\ Bloc_{i,2008} + \widehat{\beta_{10}}Communist_{i,2008}$$

Model III

$$\widehat{M_{i,2012}} = \widehat{\beta_0} + \widehat{\beta_1}\ln(Gini_{i,2012}) + \widehat{\beta_2}\ln(GDP_{i,2012}) + \widehat{\beta_3}\ln(Population_{i,2012}) + \widehat{\beta_4}M_{i,2008} + \widehat{\beta_5}M_{i,2004} + \widehat{\beta_6}M_{i,2000} + \widehat{\beta_7}Host_{i,2012} + \widehat{\beta_8}Next\ Host_{i,2012} + \widehat{\beta_9}Soviet_{i,2012} + \widehat{\beta_{10}}Eastern\ Bloc_{i,2012} + \widehat{\beta_{11}}Communist_{i,2012}$$

Model IV

$$\widehat{M_{i,2008}} = \widehat{\beta_0} + \widehat{\beta_1}\ln(Gini_{i,2008}) + \widehat{\beta_2}\ln(GDP_{i,2008}) + \widehat{\beta_3}\ln(Population_{i,2008}) + \widehat{\beta_4}M_{i,2004} + \widehat{\beta_5}M_{i,2000} + \widehat{\beta_6}M_{i,1996} + \widehat{\beta_7}Host_{i,2008} + \widehat{\beta_8}Next\ Host_{i,2008} + \widehat{\beta_9}Soviet_{i,2008} + \widehat{\beta_{10}}Eastern\ Bloc_{i,2008} + \widehat{\beta_{11}}Communist_{i,2008}$$

Model V

$$\widehat{M_{i,2012}} = \widehat{\beta_0} + \widehat{\beta_1}\ln(Adjusted\ GDP_{i,2012}) + \widehat{\beta_2}\ln(Adjusted\ Population_{i,2012}) + \widehat{\beta_3}M_{i,2008} + \widehat{\beta_4}M_{i,2004} + \widehat{\beta_5}M_{i,2000} + \widehat{\beta_6}Host_{i,2012} + \widehat{\beta_7}Next\ Host_{i,2012} + \widehat{\beta_8}Soviet_{i,2012} + \widehat{\beta_9}Eastern\ Bloc_{i,2012} + \widehat{\beta_{10}}Communist_{i,2012}$$

Model VI

$$\widehat{M_{i,2008}} = \widehat{\beta_0} + \widehat{\beta_1}\ln(Adjusted\ GDP_{i,2008}) + \widehat{\beta_2}\ln(Adjusted\ Population_{i,2008}) + \widehat{\beta_3}M_{i,2004} + \widehat{\beta_4}M_{i,2000} + \widehat{\beta_5}M_{i,1996} + \widehat{\beta_6}Host_{i,2008} + \widehat{\beta_7}Next\ Host_{i,2008} + \widehat{\beta_8}Soviet_{i,2008} + \widehat{\beta_9}Eastern\ Bloc_{i,2008} + \widehat{\beta_{10}}Communist_{i,2008}$$

Model VII

$$\widehat{M_{i,2012}} = \widehat{\beta_0} + \widehat{\beta_1}\ln(Gini_{i,2012}) + \widehat{\beta_2}\ln(Adjusted\ GDP_{i,2012}) + \widehat{\beta_3}\ln(Adjusted\ Population_{i,2012}) + \widehat{\beta_4}M_{i,2008} + \widehat{\beta_5}M_{i,2004} + \widehat{\beta_6}M_{i,2000} + \widehat{\beta_7}Host_{i,2012} + \widehat{\beta_8}Next\ Host_{i,2012} + \widehat{\beta_9}Soviet_{i,2012} + \widehat{\beta_{10}}Eastern\ Bloc_{i,2012} + \widehat{\beta_{11}}Communist_{i,2012}$$

Model VIII

$$\widehat{M_{i,2008}} = \widehat{\beta_0} + \widehat{\beta_1}\ln(Gini_{i,2008}) + \widehat{\beta_2}\ln(Adjusted\ GDP_{i,2008}) + \widehat{\beta_3}\ln(Adjusted\ Population_{i,2008}) + \widehat{\beta_4}M_{i,2004} + \widehat{\beta_5}M_{i,2000} + \widehat{\beta_6}M_{i,1996} + \widehat{\beta_7}Host_{i,2008} + \widehat{\beta_8}Next\ Host_{i,2008} + \widehat{\beta_9}Soviet_{i,2008} + \widehat{\beta_{10}}Eastern\ Bloc_{i,2008} + \widehat{\beta_{11}}Communist_{i,2008}$$

Appendix C

Tobit without Adjusted GDP, Adjusted Population, and Gini coefficients

Independent Variables	**Model I**	**Model II**
Log GDP per Capita	0.00111***	0.000683***
	(0.000222)	(0.000234)
Log Population	0.000667***	0.000886***
	(0.000207)	(0.000187)
Log Adjusted GDP per Capita		
Log Adjusted Population		
GINI		
Medal Share - 1 Olympic Lag	0.707***	0.537***
	(0.0755)	(0.139)
Medal Share - 2 Olympic Lag	0.458***	-0.164
	(0.156)	(0.128)
Medal Share - 3 Olympic Lag	-0.229	0.497***
	(0.143)	(0.150)
Host	0.0230***	0.0436***
	(0.00121)	(0.00183)
Next Host	0.00322***	0.0266***
	(0.000743)	(0.00176)
Soviet	0.00226**	0.00502***
	(0.000886)	(0.000773)
Eastern Bloc	0.00212	-0.00547***
	(0.00156)	(0.00171)
Communist	-0.00171	0.00143
	(0.00213)	(0.000994)
Constant	-0.0223***	-0.0219***
	(0.00448)	(0.00467)
Year	2012	2008
Adjusted GDP and Population	No	No
Proxy Organizational Ability	No	No
Observations	176	195

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Tobit without Adjusted GDP, and Adjusted Population

Independent Variables	**Model III**	**Model IV**
Log Gini	-0.0004313	-0.0018214
	-0.0017306	0.0014072
Log GDP per Capita	0.00114***	0.000670**
	(0.000267)	(0.000269)
Log Population	0.000679**	0.000790***
	(0.000279)	(0.000229)
Log Adjusted GDP per Capita		
Log Adjusted Population		
Medal Share - 1 Olympic Lag	0.709***	0.539***
	(0.0763)	(0.144)
Medal Share - 2 Olympic Lag	0.461***	-0.169
	(0.155)	(0.133)
Medal Share - 3 Olympic Lag	-0.234	0.496***
	(0.142)	(0.154)
Host	0.0229***	0.0448***
	(0.00123)	(0.00259)
Next Host	0.00327**	0.0265***
	(0.00137)	(0.00176)
Soviet	0.00226**	0.00459***
	(0.000989)	(0.000865)
Eastern Bloc	0.00209	-0.00606***
	(0.00159)	(0.00182)
Communist	-0.00179	0.000673
	(0.00216)	(0.00145)
Constant	-0.0226***	-0.0182***
	(0.00692)	(0.00617)
Year	2012	2008
Adjusted GDP and Population	No	No
Gini	Yes	Yes
Observations	149	155

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Tobit with Adjusted GDP and Adjusted Population and without Gini coefficients

Independent Variables	**Model V**	**Model VI**
Log Gini		
Log GDP per Capita		
Log Population		
Log Adjusted GDP per Capita	0.00106***	0.000628***
	(0.000236)	(0.000235)
Log Adjusted Population	0.000606***	0.000781***
	(0.000220)	(0.000190)
Medal Share - 1 Olympic Lag	0.703***	0.540***
	(0.0735)	(0.139)
Medal Share - 2 Olympic Lag	0.459***	-0.164
	(0.156)	(0.126)
Medal Share - 3 Olympic Lag	-0.220	0.500***
	(0.144)	(0.149)
Host	0.0234***	0.0437***
	(0.00118)	(0.00181)
Next Host	0.00340***	0.0269***
	(0.000765)	(0.00170)
Soviet	0.00216**	0.00483***
	(0.000876)	(0.000766)
Eastern Bloc	0.00217	-0.00547***
	(0.00159)	(0.00171)
Communist	-0.00196	0.00117
	(0.00211)	(0.000970)
Constant	-0.0204***	-0.0192***
	(0.00453)	(0.00440)
Year	2012	2008
Adjusted GDP and Population	Yes	Yes
Gini	No	No
Observations	167	179

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Tobit with Adjusted GDP, Adjusted Population, and Gini coefficients

Independent Variables	**Model VII**	**Model VIII**
Log Gini	-0.0009007	-0.0020212
	0.0016985	0.0013678
Log GDP per Capita		
Log Population		
Log Adjusted GDP per Capita	0.00110***	0.000636**
	(0.000275)	(0.000266)
Log Adjusted Population	0.000658**	0.000787***
	(0.000274)	(0.000224)
Medal Share - 1 Olympic Lag	0.704***	0.535***
	(0.0748)	(0.144)
Medal Share - 2 Olympic Lag	0.459***	-0.164
	(0.154)	(0.133)
Medal Share - 3 Olympic Lag	-0.225	0.497***
	(0.142)	(0.153)
Host	0.0233***	0.0447***
	(0.00120)	(0.00256)
Next Host	0.00357***	0.0267***
	(0.00134)	(0.00170)
Soviet	0.00215**	0.00450***
	(0.000970)	(0.000849)
Eastern Bloc	0.00204	-0.00608***
	(0.00161)	(0.00181)
Communist	-0.00209	0.000427
	(0.00214)	(0.00140)
Constant	-0.0209***	-0.0172***
	(0.00652)	(0.00577)
Year	2012	2008
Adjusted GDP and Population	Yes	Yes
Gini	Yes	Yes
Observations	148	154

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix D

Medal Predictions

2008			2012		
Country	**Actual**	**Predicted**	**Country**	**Actual**	**Predicted**
Afghanistan	1	0	Afghanistan	1	0
Algeria	2	0	Algeria	1	0
Argentina	6	4	Argentina	4	6
Armenia	6	3	Armenia	3	3
Australia	46	42	Australia	35	41
Austria	3	5	Azerbaijan	10	7
Azerbaijan	7	6	Bahamas	1	0
Bahamas	2	0	Belarus	12	16
Belarus	19	17	Belgium	3	2
Belgium	2	4	Botswana	1	0
Brazil	15	14	Brazil	17	16
Bulgaria	5	6	Bulgaria	2	6
Cameroon	1	0	Canada	18	16
Canada	18	17	China	88	82
Chile	1	1	Colombia	8	1
China	100	99	Croatia	6	4
Colombia	2	0	Cyprus	1	0
Croatia	5	2	Czech Republic	10	7
Cuba	24	23	Denmark	9	7
Czech Republic	6	3	Dominican Republic	2	0
Denmark	7	6	Egypt	2	2
Dominican Republic	2	0	Estonia	2	2
Ecuador	1	0	Ethiopia	7	3
Egypt	1	2	Finland	3	3
Estonia	2	3	France	34	34
Ethiopia	7	2	Gabon	1	0
Finland	4	2	Georgia	7	4
France	39	33	Germany	44	39
Georgia	6	4	Greece	2	7
Germany	41	55	Grenada	1	0
Greece	4	10	Guatemala	1	0
Hungary	10	12	Hong Kong	1	0
Iceland	1	0	Hungary	17	12
India	3	2	India	6	2
Indonesia	5	4	Indonesia	2	3
Iran	2	4	Ireland	5	2
Ireland	3	1	Italy	28	26

Israel	1	1
Italy	27	32
Jamaica	11	2
Japan	25	26
Kazakhstan	13	13
Kenya	14	5
Kyrgyzstan	2	1
Latvia	2	5
Lithuania	5	4
Malaysia	1	0
Mauritius	1	0
Mexico	3	2
Moldova	1	2
Mongolia	4	0
Morocco	2	1
Netherlands	16	18
New Zealand	9	4
Nigeria	4	4
Norway	9	5
Panama	1	0
Poland	10	7
Portugal	2	2
Romania	8	11
Russia	73	75
Serbia	3	0
Singapore	1	0
Slovakia	6	3
Slovenia	5	1
South Africa	1	5
South Korea	31	27
Spain	18	19
Sudan	1	0
Sweden	5	6
Switzerland	7	6
Tajikistan	2	1
Thailand	4	5
Togo	1	0
Trinidad and Tobago	2	0
Tunisia	1	0
Turkey	8	8
Ukraine	27	25
United Kingdom	47	47
United States	107	100

Jamaica	12	5
Japan	38	31
Kazakhstan	13	12
Kenya	11	8
Kuwait	1	0
Latvia	2	3
Lithuania	5	4
Malaysia	2	0
Mexico	7	3
Moldova	2	0
Mongolia	5	0
Montenegro	1	0
Morocco	1	0
Netherlands	20	16
Norway	4	7
Poland	10	10
Portugal	1	2
Qatar	2	0
Romania	9	9
Russia	82	73
Saudi Arabia	1	0
Serbia	4	0
Singapore	2	1
Slovakia	4	5
Slovenia	4	3
South Africa	6	2
South Korea	28	29
Spain	17	19
Sweden	8	4
Switzerland	4	8
Tajikistan	1	0
Thailand	3	5
Trinidad and Tobago	4	0
Tunisia	3	0
Turkey	5	9
Uganda	1	0
Ukraine	20	24
United Kingdom	65	62
United States	104	99
Uzbekistan	4	5
Venezuela	1	1

Uzbekistan	6	6
Venezuela	1	1
Vietnam	1	0
Zimbabwe	4	0