# Who Wins the Olympic Games: Economic Development and Medal Totals

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**Abstract**

This paper examines determinants of Olympic success at the country level. Does the U.S. win its fair share of Olympic medals? Why does China win 6% of the medals even though it has 1/5 of the world's population? We consider the role of population and economic development in determining medal totals from 1960-1996. We also provide out of sample predictions for the 2000 Olympics in Sydney.

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# 1 Introduction

Every four years it begins anew, the hand-wringing and finger-pointing over a poor showing at the Olympics. The only real uncertainty is which countries will feel the sharpest disappointment over their poor performances. After the Barcelona Olympics, a headline in the New York Times read "Despite its 108 medals, U.S. rates mixed success." In 1996, headlines in London trumpeted "Olympic shame over Britain's medal tally" and "Britain in danger of being left at the starting line,"[1] while in Mexico, Japan, Singapore, Colombia and Egypt, medal totals below expectations led to national self-examinations. In this paper, we ask the straightforward question of how many medals countries should be expected to win by considering what factors influence national Olympic success.[2]

One possible avenue of inquiry would be to assess sport by sport the athletic talent in each country and predict the likelihood of success in each event. We then could then generate a prediction for a national medal total by summing across sports. We suspect this is the method employed by most national Olympic committees when offering predictions about how many medals their countries will win. We follow a different path by generalizing from individual sports. While this has the disavantage of missing nation-specific expertise in a particular event, it has what we believe is the larger advantage of averaging over the random component inherent in individual competition, enabling us to make more accurate predictions of national medal totals.

Even the most ardent xenophobes would not suggest that a single country should win all the medals, or even all the gold medals, at a given Olympic Games. The real question is how many medals qualify as a successful performance by a national team. There have been several attempts to put national medal totals in some sort of perspective.[3] In 1996 after the At-

[1] The first paragraph of the subsequent editorial in The Times of London began, "John Major wants a successful sporting nation, rightly believing that it reflects a healthy nation. He needs to direct urgent attention to the somnolent government administration if Great Britain is not to become an international laughing stock. The British Olympic Association (BOA) today holds its annual meeting with a debriefing from Craig Reedie, the chairman, on the Games in Atlanta, where Britain's tally of 15 medals was perceived at home as being unsatisfactory."

[2] We look only at performance in the summer Games. All references to the Olympics or Games refer to the summer Games.

[3] While there is nothing in the recent academic literature on national Olympic performance, it was an active area of research in the early 1970's. See Ball (1972), Levine

lanta Games, Eurostat announced that the European Union had "won" the Olympic Games since the 15 member countries had both more medals and more medals per capita than the United States (08/15/1996 USA Today ). The United Nations Population Information Network went a step further by declaring Tonga the winner of the Games with a medal to population ratio more than twice as high as the nearest competitor (9.4 medals per million inhabitants).[4]

Population should play a role in determining country medal totals. Larger countries have a deeper pool of talented athletes and thus a greater chance at fielding medal winners. We present and test a simple theory of medal success based on population coupled with assumptions about the distribution of Olympic calibre athletic talent. We consider both the probability that a country wins at least one medal, as well as their share of total medals.

Pure population levels are not sufficient to explain national totals. If they were, China, India, Indonesia, and Bangladesh with 43+ percent of the world's population would have won more than the 6+ percent of total medals in 1996 that they actually won. We recognize the importance of available resources in enabling gifted athletes to train for, attend, and succeed in the Games. To this end, we extend the population based model to include a measure of resources per person in the form of GDP per capita.

The addition of per capita GDP dramatically improves the ability of the model to fit the data. While China, India, Indonesia, and Bangladesh have a huge share of world population, together they account for under 5 percent of world GDP in 1996, roughly equal to their share of medals. The main results are quite sharp. Over time, a country's real GDP remains the single best predictor of Olympic performance. Population and per capita GDP contribute equally at the margin implying that two countries with identical levels of GDP but different populations and per capita GDP levels will win the same number of medals.

While GDP is most of the story, it is not the whole story. Host countries typically win an additional 1.5 percent of the medals beyond what would be predicted by their GDP alone. The forced mobilization of resources by governments clearly can also play a role in medal totals. On average, the Soviet Union and Eastern Bloc countries won a share of medals higher by 6+

(1974), and Grimes, Kelly, and Rubin (1974).

[4]See http://www.undp.org/popin/popis/journals/poptoday/today0996.html for details.

percentage points than predicted by their GDP.[5]

The rest of the paper is organized as follows. Section 2 describes the data employed in the empirical analysis. Section 3 presents a population-based model of Olympic success. Section 4 presents a national production function for Olympic medals. Section 5 presents some extensions to the production function model of Section 4. Section 6 predicts medal-winning in the Sydney 2000 Olympics, and Section 7 concludes.

## 2 Data

The data for this project consist of two main components: Olympic medal counts and socio-economic indicators. We obtained the medal data from Wallechinsky (1992) and direct correspondence with the International Olympic Committee (IOC). For our socio-economic indicators, we would ideally like to have a range of indicators including population, income per capita, income inequality and government spending. However, the difficulty of obtaining such measures for more than 150 countries over 30 years precludes us from considering anything but GDP and population. Our primary source for both these measures was the World Bank and the U.N. (see the Appendix for a more complete description).[6]

## 3 A simple theory of population and Olympic success

To organize our thinking about the sources of Olympic success, we start by considering the underlying distribution of athletic talent. As with most physical attributes, athletic talent is most likely distributed normally in the world's population. If we think of countries as being arbitrary divisions of the world population, then we should expect to find medal-caliber athletes in proportion to the population share of the country. If medals are proportional to athletic talent, then we would expect to find the following relationship in

[5] Shughart and Tollison (1993) argue that the change in the structure in economic incentives in the former Soviet countries is responsible for their lower medal totals in the 1992 Olympics.

[6] There are numerous judgement calls required in assembling real GDP data for countries in the former Soviet Union, China, and many protectorates.

the distribution of Olympic medals. For country $i$

$$\text{medalshare}_i = \frac{\text{medals}_i}{\sum_i \text{medals}_i} = \frac{\text{olympic talent}_i}{\sum_i \text{olympic talent}_i} = \frac{\text{population}_i}{\text{world population}}. \quad (1)$$

Of course, this "pure talent" theory need not hold as not every country participates in the Olympics (more on this below). The actual relationship predicted by the talent distribution is that the share of medals accruing to a country should be equal to its share of the total population of countries participating in the Olympics,

$$\text{medalshare}_i = \frac{\text{medals}_i}{\sum_i \text{medals}_i} = \frac{\text{population}_i}{\sum_i \text{population}_i} = \text{popshare}_i. \quad (2)$$

One interesting implication of this hypothesis is that every country with a share of the total participating population greater than 1/M, where M is the number of medals, should win at least one medal,

$$\begin{aligned} \Pr(\text{med}_i > 0) &= 1 \quad \text{if popshare}_i \geq \frac{1}{\sum_i \text{medals}_i} = \frac{1}{\text{M}} \\ &= 0 \quad \text{if popshare}_i < \frac{1}{\text{M}}. \end{aligned} \quad (3)$$

These simple relationships give us two testable propositions. First the rank correlation between winning a medal and having a population share greater than 1/M should be one. Second the share of total medals a country wins should be increasing one-for-one in that country's share of the total participating population.

There are several reasons related to the structure of the Olympics themselves to think that these linear relationships will not hold in practice. First, countries cannot send athletes in proportion to their population to compete in each event. This is most easily seen in the team competitions where each country has at most one entrant. Second, in medal counts, team events count as one medal even though a country must provide a number of athletes. This means that even if a country is able to send athletes in proportion to its size, it may still win a smaller share of medals than its size would predict. Finally, and perhaps most important for our analysis, the number of athletes that a country may send to the Olympics is determined by the IOC in negotiation with the country's Olympic committee. As a result, not all the

| | Medal winner | Medal non-winner | Total |
|---|---|---|---|
| Population share $> \frac{1}{M}$ | 400 | 313 | 713<br>55.6% |
| Population share $< \frac{1}{M}$ | 95 | 475 | 570<br>44.4% |
| Total | 495<br>38.6% | 788<br>61.4% | 1283<br>100% |

Table 1: Medal winners and population shares, 1960-96

Olympic calibre athletes from a large country are able to participate.[7] We allow for these nonlinearities in our empirical work by considering both the level of the population share and the log-level of population as determinants of medal shares.

## 3.1 Results

This section empirically tests the talent hypothesis as specified in Equations 2 and 3. We begin with the specification in Equation 3, in which the probability of winning at least one medal should be proportional to population share. In Table 1[8], we report the predictive power of the specific prediction of Equation 3 that countries with population shares greater than 1/M should win medals. From 1960-1996, on average in each Olympics just over 38% of the countries won medals. However, on average 55% of the participating countries had populations large enough to suggest that they should be medal winners. In all, the simple proportionality model mispredicts over 31% of the results during the period, and as expected, overpredicts medal winning more than 3 times as often as it fails to correctly identify winning countries.

We use a probit model to test the more general implication of Equation 3, namely that the probability of winning a medal should be increasing in population share. The results of this estimation, reported as marginal probability

[7]For example, qualifying to be a member of the US Olympic team in track and field is considered to be as difficult as winning a medal; former medalists regularly fail to qualify. In the 2000 Olympic trials two record-holders, Michael Johnson and Maurice Green, failed to qualify for the 200 meter dash.

[8]Standard errors are reported in parentheses in all tables.

effects, are reported in Table 2. As predicted by the model, the probability that a country will win at least one medal is increasing in its population share. However, the fit of the model seems quite poor. Using a 50 percent cutoff, i.e. a predicted probability of 50 percent or greater is counted as a positive prediction, the model correctly predicts the medal status 65 percent of the time. However, almost all these correct predictions come from the pool of countries that do not win medals. The model actually predicts that only 6 percent of the countries would win medals instead of the actual 38 percent.

| | **I** | **II** |
|---|---|---|
| Population share | 6.561<br>(2.247) | |
| Log population share | | 0.127<br>(0.009) |
| Log likelihood | -814.671 | -707.037 |
| Observations | 1278 | 1278 |

Table 2: Probit of medal winning on population share

As mentioned above, we have reason to believe that medal winning will not be proportional to population shares because of the structure of the Olympics themselves. The nature of the deviation from the simple theory is one-sided in that larger countries will win fewer medals than predicted by their population shares while smaller countries will win more. There are an infinite number of possible alternative specifications that we could implement to account for these deviations but for the sake of simplicitiy we will limit ourselves to log-levels.[9]

The results of estimating a probit in log-levels of population shares are given in Table 2. Again using the 50 percent cutoff, the fit of the specification is now dramatically improved. Over 72 percent of the observations are predicted correctly, and the model predicts that 31 percent of the countries will win medals. Mispredictions are still more likely in the direction of missing an actual medal winner. The coefficient estimate in Table 2 can be interpreted approximately to mean that if a typical country were to double its population, it would see its probability of winning a medal increase by 12.7 percentage points.

[9]This will apply for the rest of the paper as well.

| | I | II |
|---|---|---|
| Population share | 0.590<br>(0.050) | |
| Log population share | | 0.015<br>(0.001) |
| Constant | -0.024<br>(0.002) | 0.074<br>(0.005) |
| Log likelihood | 463.919 | 581.047 |
| Observations | 1278 | 1278 |

Table 3: Tobit of medal share on population share

Next we turn to the medal shares themselves. Equation 2 predicts that medal shares will be increasing one for one in population shares. Results from a tobit regression estimating this specification are reported in Table 3. While population share is positive and significant, the estimated coefficient is significantly below one. The second column of Table 3 reports the same tobit in log levels of the population share. The fit is substantially improved with a big increase in the log-likelihood. The coefficient estimate in the second column indicates that if a typical country were to double its population, it would win an additional 1.5% of the medals awarded.

Figure 1 gives a visual depiction of the fit of the estimation. The number of medals actually won by each country in 1996 is plotted along the horizontal axis, with the the predicted values from the tobit specification in log levels of population share is plotted on the vertical axis.[10] If the model fit the data perfectly, all observations would fall on the 45 degree line. The figure shows that the specification does particularly poorly in capturing the countries with the largest medal totals. The simple population model needs help to fit the data.

[10]Figure 1 omits countries that did not win a medal in 1996 to make the image less cluttered.

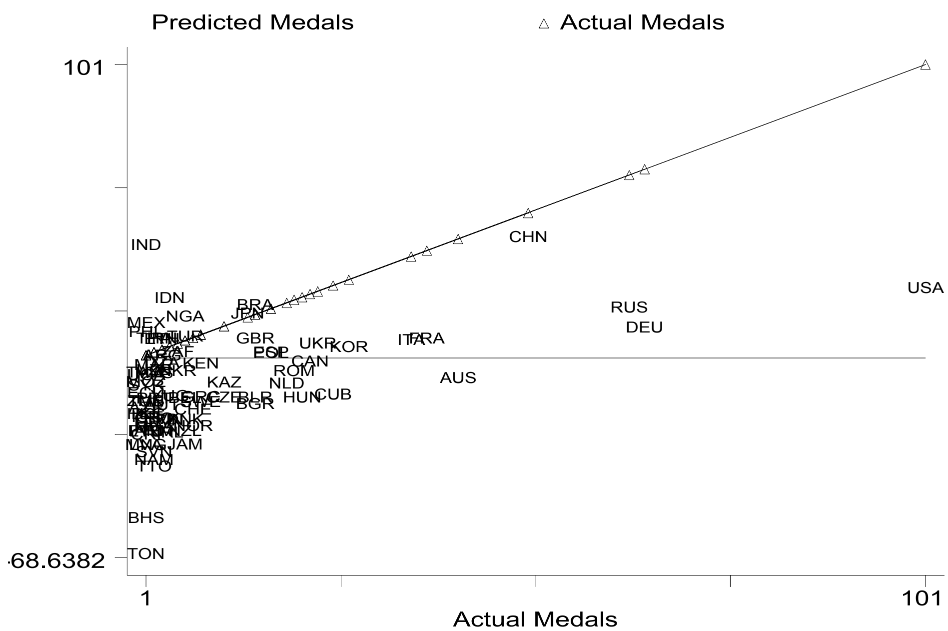


Figure 1: Predicted and actual medal totals for 1996 from the population tobit

# 4 A production function for Olympic medals

To augment our model we now turn to the role of economic resources in generating Olympic medals. We choose to frame our analysis in terms of a production technology. In the previous section, we assumed that talented athletes were randomly distributed in the world population. However, there is a large and lengthy process involved in becoming an Olympic athlete and this process involves the allocation of resources, either by individuals or by an organization, most likely the central government.

Our production function for generating Olympic calibre athletes for a country $i$ in year $t$ requires people, money, and some organizational ability.[11]

$$T_i = f\left(N_i, Y_i, A_i\right) \tag{4}$$

The share of Olympic medals, $M_i$, won by a country is a function of the talent in a given country.

$$\begin{aligned} \frac{\text{medals}_i}{\sum_i \text{medals}_i} &= M_i = g\left(T_i\right) \qquad \text{if } T_i \geq T^* \\ &= 0 \qquad\qquad\quad \text{if } T_i < T^* \end{aligned} \tag{5}$$

There is no theoretical guidance on the precise form of either $f\left(\cdot\right)$ or $g\left(\cdot\right)$. We choose a Cobb-Douglas production function in population and national income for the production of Olympic talent and a log function for the translation of relative talent to medal shares.

$$\begin{aligned} T_i &= A_i N_i^{\gamma} Y_i^{\theta} \\ M_i &= \ln\left(\frac{T_i}{\sum_j T_j}\right) \qquad \text{if } T_i \geq T^* \end{aligned} \tag{6}$$

This yields the following specification for medals

$$\begin{aligned} M_{it} &= \ln A_{it} + \gamma \ln N_{it} + \theta \ln Y_{it} - \ln\left(\sum_j T_{jt}\right) \quad \text{if } T_i \geq T^* \\ &= 0 \qquad\qquad \text{if } T_i < T^* \end{aligned} \tag{7}$$

with the properties that increases in medals are less than one for one in both people and resources and there may exist country-specific organizational

[11] Time subscripts are suppressed for notational simplicity.

| | I | II |
|---|---|---|
| Log population | 0.493<br>(.051) | 0.702<br>(0.062) |
| Log GDP per capita | 0.494<br>(0.055) | 0.763<br>(0.086) |
| Random effects | No | Yes |
| Log likelihood | -546.391 | -438.955 |
| Observations | 1254 | 1254 |

Table 4: Probit of medal winning on population and per capita GDP

abilities that will increase or decrease the total medals won.[12] Since national income can be expressed as the product of population and per capita income, we will actually estimate a specification of the form

$$\begin{aligned} M_{it} &= C + \alpha \ln N_{it} + \beta \ln \left(\frac{Y}{N}\right)_{it} + \delta_t + \nu_i + \epsilon_{it} \quad \text{if } T_i \geq T^* \\ &= 0 \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{if } T_i < T^* \end{aligned} \tag{8}$$

where $\delta_t$ is year dummy included to capture changes in the total pool of talent and in the number of countries participating, as well as the changing number of sports, $\nu_i$ is a country random effect, and $\epsilon_{it}$ is a normally distributed error term.

## 4.1 Results from the production function

In this section, as in Section 3, we report results for both the probability of winning a medal and the medal shares themselves. For the probability of winning a medal, we estimate a probit in log population and log per capita income with and without country random effects. Year dummies are included in all specifications reported in this section.

The estimated marginal probabilities for the probits are reported in Table 4. Both log population and log GDP per capita enter with positive and significant coefficients. The addition of a measure of national income dramatically improves the fit over the univariate specification with log population only,

[12]The term 'organizational' is merely a shorthand for all the possible reasons that countries may have high or low medal counts.

| | I | II |
|---|---|---|
| Log population | 0.016<br>(0.001) | 0.013<br>(0.000) |
| Log GDP per capita | 0.014<br>(0.001) | 0.009<br>(0.001) |
| Random effects | No | Yes |
| Log likelihood | 723.933 | 1075.051 |
| Observations | 1254 | 1254 |

Table 5: Tobit of medal share on population and per capita GDP

reported in Table 2. Interestingly, the coefficients on the two variables are almost identical, indicating that log GDP itself is the relevant determinant of the probability that a country wins at least one medal. This result suggests that countries with the same GDP have the same probability of winning a medal even if one is more populous with lower per capita incomes than the other. The second column of Table 4 reports the results including country random effects. We find again that the coefficients on the two explanatory variables are positive and significant, and that they are statistically identical, maintaining the argument for total GDP as the primary determinant of Olympic success. One difference from the previous specification is that, with country random effects, the estimated coefficients are significantly larger on both log population and log GDP per capita.

In Table 5, we report the results for the tobit specification with the share of medals won by a country as the dependent variable. Both log population and log GDP per capita are positive and significant in both specifications. Including random effects reduces both estimates.

The results of this section can be loosely interpreted to mean that if a typical country were to double its total GDP, it could expect the probability of winning a medal to rise by 50-70 percentage points, and the number of medals it wins to rise by 1-1.5% of the total awarded.

## 4.2 Additions to the model

The empirical specification given in Equation 8 shifts all country-specific information not included in GDP and population into the error term. In this section we explore some of the additional factors that might augment or diminish medal shares including the advantages of hosting, the medal premium enjoyed by the former Soviet Union and its satellites, and the role of large scale boycotts.

Hosts have several potential advantages over other Olympic participants. First, the cost of attending the Olympics for individual athletes is minimized. In addition, host countries can tailor facilities to meet the needs of their athletes and may gain an edge if home crowd enthusiasm sways judges.[13] Individual athletes may be more motivated to achieve Olympic fame when the events are conducted in front of friends and family. Finally, host countries are influential in the addition of new sports to the Games themselves. All these factors suggest that hosts should enjoy supranormal medal shares when the Games are in their country.

One of the most interesting questions regarding Olympic medal totals over the past 40 years concerns the ability of countries to 'manufacture' gold medals. Concern about this process stems from the apparent success of the former Soviet Union and Eastern European countries. These countries clearly accumulated large quantities of Olympic gold, silver, and bronze over the years. However, the unconditional medal totals cannot tell us how successful they were at mobilizing resources. We create two dummies variables to capture these effects. The first covers countries distinctly inside the Soviet sphere of influence while the second includes other non-market, typically communist, countries.[14] We consider the additional medals for these groups after controlling for income and population to provide a first estimate of the power of central planning in the Olympic race.[15]

Two Olympics in the era we examine were subject to large scale boycotts, that in 1980 and again in 1984. Heretofore all our results have included those Olympics.[16] The coefficients on the host dummy and the dummies for the centrally planned economies are likely to be particularly sensitive to the inclusion of these Games and so we provide some evidence on the robustness

[13]This was certainly the US perception of the results for selected boxing matches in the 1988 Olympics.

[14]The 'soviet' dummy includes Bulgaria, Czechoslovakia, Poland, the USSR, East Germany, Hungary, and Romania from 1960-1988, the Unified Team in 1992 and Cuba throughout the period. The other 'planned' dummy include China, Albania, Yugoslavia (through 1988), and North Korea.

[15]We should caution again that our GDP per capita numbers for these countries are far from perfect.

[16]All the results of the previous sections are robust to the omission of these boycotted Olympics.

of our results excluding the 1980 and 1984 Games.

The resulting specification is

$$M_{it} = C + \alpha \ln N_{it} + \beta \ln \left( \frac{Y}{N} \right)_{it} + \text{Host}_{it} + \text{Soviet}_{it} + \text{Planned}_{it} + \epsilon_{it} \quad (9)$$

Table 6 reports the tobit specification for medal shares with and without the boycotted years. The results for population and GDP per capita are largely unchanged. Both are positive, significant and of the same magnitude as each other and as reported in Table 5. The 'Soviet' countries do successfully increase their medal totals with shares higher by more than 3 percentage points than other countries. The group of other planned economies also have higher medal shares, higher by roughly 2% than the benchmark non-communist countries after controlling for income and population. Neither of these effects is sensitive to the exclusion of the boycotted Games.

The host effect on medal totals is also positive and significant. The bump in medal share from hosting in a non-boycotted Olympics is almost 1.5%.[17] During the boycotted Games the host effects were enormous, on the order of 18%, suggesting that the US and USSR were the prime beneficiaries in terms of medal counts from each other's boycotts.[18]

We finish by considering the adequacy of our sparse specification for the purposes of prediction. Given the lack of adequate summary statistics for the tobit, we instead present the results visually. Figure 2 shows the relationship between the predicted medal shares and actual medal shares for 1996 from our augmented tobit excluding the boycotted years. If the prediction were perfect all the country codes would line up on the 45 degree line. Predictions below (above) the 45 degree line are low (high) relative to the actual number of medals.[19]

The model underpredicts medal shares at both the low and high ends of the range and overpredicts in the middle. While the additions of log GDP per capita and several dummies have improved the fit substantially, the overall predictive power of the current model is lacking. In the next section, we consider the inclusion of additional variables to improve the fit and add predictive power.

[17] In 1996, this host effect amounted to 13 additional medals.

[18] The US won 174 of 688 medals awarded in 1984, almost twice what it won in 1976 and 1988.

[19] Figure 2 omits countries that did not win a medal in 1996 to make the image less cluttered.

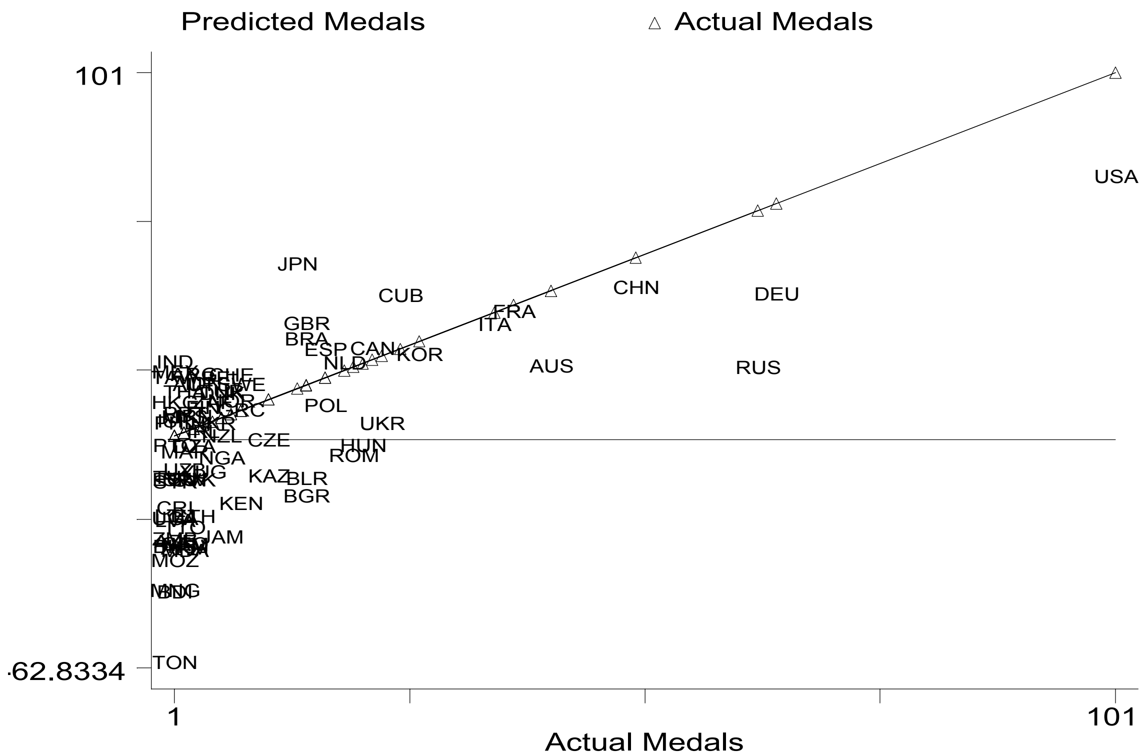


Figure 2: Predicted and actual medal totals for 1996 from the population and GDP tobit

| | I | II | III |
|---|---|---|---|
| Log population | 0.0128<br>(.0007) | 0.0127<br>(0.0007) | 0.0075<br>(0.0004) |
| Log GDP per capita | 0.0124<br>(0.0007) | 0.0122<br>(0.0008) | 0.0076<br>(0.0006) |
| 1 if host country | 0.0609<br>(0.0090) | 0.0246<br>(0.0096) | 0.0148<br>(0.0043) |
| 1 if Soviet sphere of influence | 0.0662<br>(0.0039) | 0.0607<br>(0.0041) | 0.0330<br>(0.0022) |
| 1 if non-Soviet planned economy | 0.0170<br>(0.0067) | 0.0151<br>(0.0072) | 0.0208<br>(0.0039) |
| Constant | -0.3157<br>(0.0139) | -0.3106<br>(0.0145) | -0.1868<br>(0.0083) |
| Boycott years included | Yes | No | No |
| Random effects included | No | No | Yes |
| Log likelihood | 854.869 | 731.015 | 963.703 |
| Observations | 1254 | 1036 | 1036 |

Table 6: Tobit of medal share on expanded explanatory set

# 5 Predicting Medal Totals

Until this point we have tried to keep our empirical specifications as close to our simple theoretical models as possible. However, the results from the tobits, while sensible, consistently underpredict medal totals for countries that win the bulk of the medals. Also, as shown in Figure 3, the distribution of medal shares has changed from 1960 to 1996 with more countries winning a small number of medals. This leads us to suspect that the underlying relationships are also changing. In Table 7, we report the coefficients on the specification run year by year with and without the host dummy (which will obviously perfectly fit the medal share for the host).

Two patterns are apparent in the results. The equality of the coefficients on log population and log GDP per capita is stable over time. However, the marginal effects of both variables has been systematically declining over time. The coefficients on both variables are less than half their 1960 values by 1996. This is probably a result of two major trends, one an increase in participation as the number of countries has more than doubled in the same

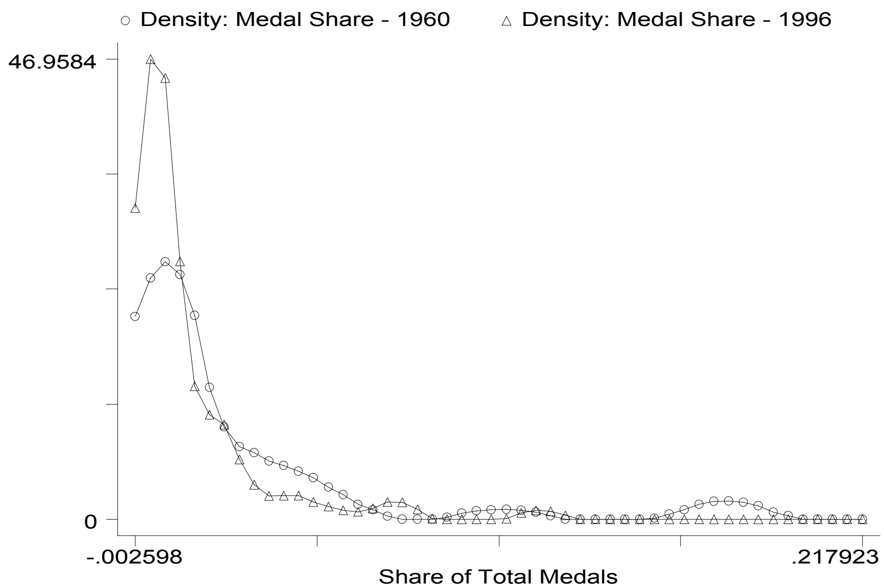


Figure 3: Density of medal shares in 1960 and 1996

time period, and the second, growth in GDP for a substantial number of countries.[20]

One item of interest are the cutoffs for guaranteed success and failure and how they have changed over time. From our sample, we create two measures, one is the level of income needed to "guarantee" at least one medal in a given Olympics, and the other is the level of GDP that "guarantees" failure.

Figure 4 plots the log levels of these variables and log GDP over time. While the 'guaranteed winner' cutoff has been quite stable over time, there has been a slight downward drift in the 'no medal' cutoff. More countries are above the upper threshhold in recent years and fewer below the bottom contributing to the increase in medaling countries and the lower share of medals among the wealthier countries, i.e the declining coefficient on GDP.

[20] We are not arguing that GDP levels have become more equal (converged) over the period but rather that more countries have GDP levels close to those of the richest and largest countries.

| | 1960 | 1964 | 1968 | 1972 | 1976 |
|---|---|---|---|---|---|
| Log pop. | 0.0194* | 0.0187* | 0.0158* | 0.0135* | 0.0132* |
| Log GDP percap | 0.0172* | 0.0157* | 0.0155* | 0.0121* | 0.0225* |
| Soviet | 0.0546* | 0.0510* | 0.0542* | 0.0586* | 0.0860* |
| Planned | 0.0055 | 0.0078 | 0.0166 | 0.0090 | 0.0266 |
| Log pop. | 0.0187* | 0.0187* | 0.0157* | 0.0130* | 0.0132* |
| Log GDP percap | 0.0167* | 0.0157* | 0.0155* | 0.0117* | 0.0226* |
| Host | 0.0340 | -0.0022 | 0.0073 | 0.0301 | -0.0039 |
| Soviet | 0.0551* | 0.0509* | 0.0544* | 0.0591* | 0.0859* |
| Planned | 0.0060 | 0.0078 | 0.0167 | 0.0093 | 0.0266 |
| Log pop. | | 0.0043* | 0.0032* | 0.0034* | 0.0016* |
| Log GDP percap | | 0.0036* | 0.0029* | 0.0032* | 0.0038* |
| Soviet | | 0.0079 | 0.0202* | 0.0229* | 0.0191* |
| Planned | | 0.0084 | 0.0135 | 0.0052 | 0.0084 |
| Lagged medal share | | 0.8585* | 0.8720* | 0.7789* | 1.0314* |

| | 1980 | 1984 | 1988 | 1992 | 1996 |
|---|---|---|---|---|---|
| Log pop. | 0.0133* | 0.0196* | 0.0109* | 0.0102* | 0.0086* |
| Log GDP percap | 0.0125* | 0.0186* | 0.0112* | 0.0100* | 0.0073* |
| Soviet | 0.1069* | 0.0838* | 0.0676* | 0.0814* | 0.0344* |
| Planned | 0.0249 | 0.0164 | 0.0215 | 0.0249 | 0.0192 |
| Log pop. | 0.0064* | 0.0104* | 0.0106* | 0.0102* | 0.0070* |
| Log GDP percap | 0.0081* | 0.0109* | 0.0109* | 0.0100* | 0.0060* |
| Host | 0.2220* | 0.2017* | 0.0359 | 0.0033 | 0.0841* |
| Soviet | 0.0745 | 0.0772* | 0.0681* | 0.0814* | 0.0329* |
| Planned | 0.0189 | 0.0230* | 0.0224 | 0.0250 | 0.0211* |
| Log pop. | 0.0012* | 0.0199* | 0.0077* | 0.0060* | 0.0018* |
| Log GDP percap | 0.0007 | 0.0191* | 0.0075* | 0.0061* | 0.0016* |
| Soviet | 0.0005 | 0.0935* | 0.0687* | 0.0874* | -0.0001 |
| Planned | 0.0031 | 0.0174 | 0.0155 | 0.0178 | -0.0016 |
| Lagged medal share | 1.4644* | -0.2613 | 0.3550* | 0.8145* | 0.8435* |

Table 7: Year by year tobit of medal share on expanded explanatory set

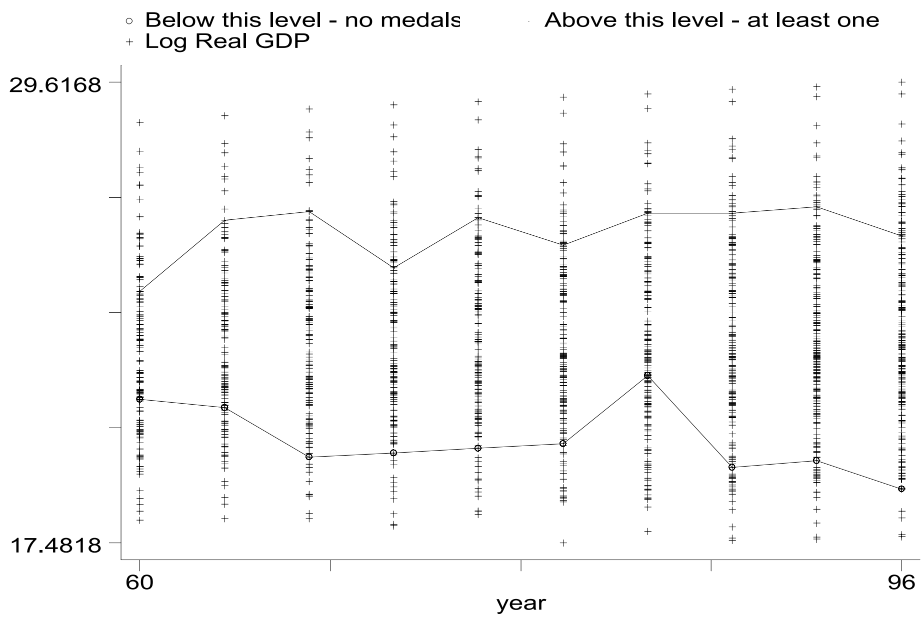


Figure 4: Income levels for 'guaranteed' winners and losers

## 5.1 Persistence

We suspect that there is a substantial degree of persistence in the characteristics that are associated with Olympic success. To capture this persistence, we include the medal share from the previous Olympics in our specification. The third panel of Table 7 contains the specification with lagged medal share by year. Lagged medal share is positive and significant in all the non-boycott years with a stable coefficient around 0.8. Log GDP remains an important determinant of medal share and again the decline in the coefficients is substantial.

Including lagged medal share improves the fit of the specification substantially especially for countries with large medal totals. Figure 5 shows predicted and actual medals for 1996 from a tobit specification with lagged medal shares estimated on the post-boycott Olympics.[21]

The model does quite well in predicting totals for a number of countries

[21]Figure 3 omits countries that did not win a medal in 1996 to make the image less cluttered.

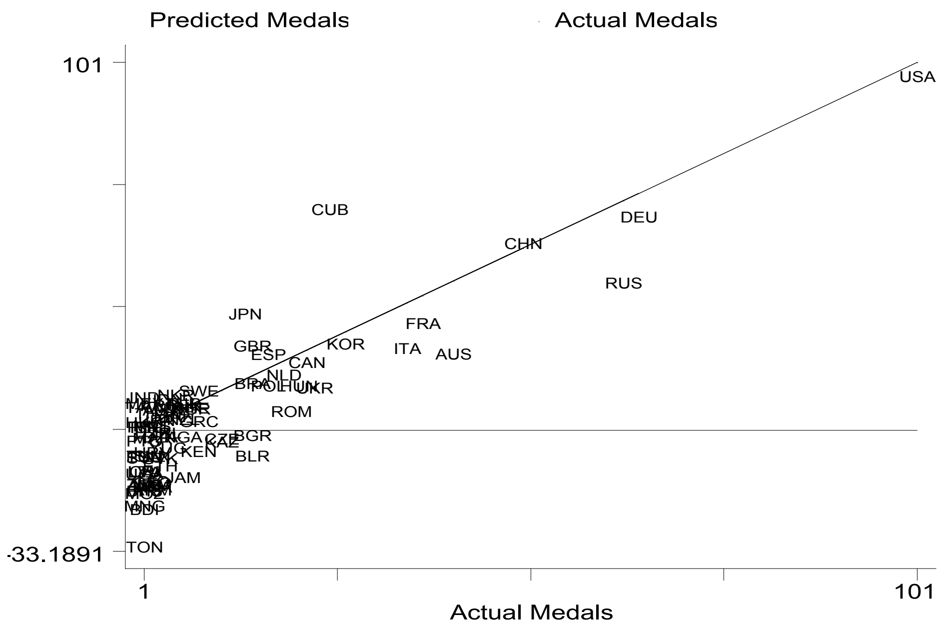


Figure 5: Predicted and actual medal totals for 1996 from the enhanced tobit

including the USA, Germany, and China. However, Russia wins more medals than predicted while Cuba wins far fewer than predicted. Table 8 has a list of medals won and the predictions from the model.

We can ask ourselves, based on this specification which countries did worse, or better, than expected in Atlanta. The biggest underperformers in terms of total medals were Germany, Japan and the United Kingdom, perhaps verifying the sense of anguish felt in Britain and Japan after the Atlanta Games. On the positive side, Italy, Australia, the Czech Republic and Brazil, among others, all overachieved according to our simple model.[22]

Did the EU win the Games as claimed by Eurostat. Well, the sum total of medals for the 15 countries, 229, was 11 more than predicted by the model. As for the US, the prediction of 101 medals was exactly correct.

[22] The large discrepancy for Belarus is most likely due to the difficulty in assigning lagged medals to former members of the Soviet Union.

# 6 Medals in Sydney

To answer the burning question of how many medals will be won in Sydney during the 2000 Games, we extend our data as best we can using recent numbers on population and GDP growth for a subset of countries. The most recent, most complete data we have available are from the IMF for 1998 population and GDP. We predict the medal winnings for the 36 countries that won at least five medals in 1996.

The occurence of the Sydney Games in the near future gives us the opportunity to do true out of sample predictions. In the first column of Table 9, we present the prediction of the 1996 tobit coefficients presented in the last column of Table 7. The specification predicts medal share, which we convert to a medal prediction using the announced 888 medals to be awarded in Sydney.

For comparison, 1996 medal totals are presented in the last column of the table. Several things are of note. First, the estimates here may well be underestimates. In the last two Olympics, the countries on this list have among them taken home about 90% of the Olympic medals. These estimates cumulatively predict them to garner 82% of the total.

Second, Australia, the Olympic host may well be under-predicted in this table. The year by year regression on which these predictions are made cannot estimate a host effect (the variable simply removes the host from the sample), but previous specifications found a host effect of 1.5%. Thus Australia could be expected to win as many as 13 additional medals beyond what is reported in the table.

Finally, there are particular countries worth noting. The biggest improvement predicted is for Japan, which is predicted to increase its medal total to 19 from its 1996 performance of 14. The predictions are most pessimistic, relative to previous performance, for Bulgaria, Cuba, and Jamaica, each of which are predicted to win 5 fewer medals than they did in 1996. The US is predicted to win 97 medals, four fewer than it did in 1996. This is not out of line with its medal decrease of 7 from 1992 to 1996.

The second column of Table 9 contains an alternative prediction for 2000 medal winning based on the post-boycott tobit which is presented graphically in Figure 4. These coefficients used in this prediction weight population and per capita GDP relatively more, and lagged medal share relatively less, than in the prediction presented in the first column.

These predictions may well not be as accurate in terms of forecasting actual 2000 medal winning as the first column's predictions. Certainly the second column predicts some medal totals that are dramatically different from 1996 performance. Instead, the results in this column are meant to answer the question of how many medals a country "ought" to earn on the basis of its population and income resources. Using observations for the entire post-boycott period, instead of 1996 alone, allows us to more generally predict of what kind of performance one might reasonably expect from a country of a given size and income based on the historical role of those factors.

The first thing to notice is that many of the Eastern Bloc and former Soviet countries (Belarus, Bugaria, Czech Republic, Kazakhstan, Romania) are predicted to win 0 or very few medals if the prediction weights population and income. These countries are, in some sense, too small to win as many medals as they do, which may be evidence of the lingering Soviet effect.

There are also countries who, judging by their resources, should see a big improvement from 1996 to 2000, including Australia, Brazil, Japan, and the U.K.[23] Finally, there are a number of countries who, even if they merely match their 1996 performance, will outperform the second column's more resource based prediction. These include many of the Eastern Bloc and former Soviet countries, and also Germany, Jamaica, Kenya, New Zealand, Nigeria, South Korea, and the U.S.

## 6.1 Gold medals in Sydney

Finally, we use the specification in Equation 9 to predict the number of gold medals each country will win in Sydney.[24] Table 10 contains the predictions for the 2000 games as well as the gold medal totals from Atlanta.

Several countries are predicted to win substantially more gold medals including Canada (5), Germany (5), and the United Kingdom (5). In addition, Australia is predicted to increase its gold medal total to 14 even before accounting for a possible host country bounce of as many as 8 additional golds. Countries with the biggest expected decreases in gold medals include the U.S. (-5), Russia (-4) and Cuba(-3).

[23] We do not include Cuba in this list. It has a very large prediction in this case, but that comes from it being still under the Soveit sphere of influence. While this is true, it is unlikely that there are large Olympic resources flowing from Russia to Cuba.

[24] The host effect is not included in this set of predictions. On average over the past 40 years the host has won an extra 3 percent of the total gold medals.

## 7 Conclusions

In this paper, we examine the question of how many Olympic medals a country should win. We begin with a simple hypothesis that athletic talent is randomly distributed and that therefore medal winning should be proportional to population. We also consider a production function for Olympic medals that encompasses resources, population and other national characteristics.

While the simple population hypothesis does have explanatory power, it fails to adequately explain the distribution of medals across countries. We find significant evidence that the other resources, national income in particular, are important for producing Olympic athletes. Interestingly, per capita income and population have identical effects at the margin suggesting that total GDP is the best predictor of national Olympic performance.

While GDP is most of the story, it is not the whole story. Host countries typically win an additional 1.5 percent of the medals beyond what would be predicted by their GDP alone. This host bounce could bolster the Australian medal total in the 2000 games by as many as 13 medals. The forced mobilization of resources by governments clearly can also play a role in medal totals. On average, the Soviet Union and Eastern Bloc countries won a share of medals higher by 3+ percentage points than predicted by their GDP during the 1960-1996 period. Howver, the Soviet 'bounce' was largely gone by the end of the sample. Finally, we find that over time, medal winning has become less concentrated, with large and prosperous nations winning a smaller share of medals, and with more smaller and less prosperous nations among the regular medal winners.

We finish by exposing our simple specification to an out of sample test and predict medal totals for the 2000 summer games in Sydney.

# 8 Appendix

Our primary source for population and GDP data was the World Bank. We also used United Nations data sources, and for a few observations, the CIA Factbook, The Economist magazine, and the Taiwan Statistical Planning Book. Population figures could be found fairly readily; GDP measures were more difficult. For some countries, especially less developed countries, it was necessary to interpolate or extrapolate using either reported or imputed growth rates. Also, there is an ever-present concern about GDP figures from the Soviet Union and its satellites, China, and protectorates. We do our best to compile comparable and reasonable data. All GDP figures are converted to 1995 US dollars.

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| Country | Actual | Pred. | Country | Actual | Pred. | Country | Actual | Pred. |
|---|---|---|---|---|---|---|---|---|
| United States | 101 | 101 | Puerto Rico | 1 | 0 | Guyana | 0 | 0 |
| Germany | 65 | 77 | Azerbaijan | 1 | 0 | Cayman Islands | 0 | 0 |
| Russian Federation | 63 | 59 | Mongolia | 1 | 0 | Paraguay | 0 | 0 |
| China | 50 | 50 | Uganda | 1 | 0 | Panama | 0 | 0 |
| Australia | 41 | 26 | Philippines | 1 | 1 | Sierra Leone | 0 | 0 |
| France | 37 | 30 | Mozambique | 1 | 0 | Niger | 0 | 0 |
| Italy | 35 | 20 | Hong Kong | 1 | 1 | Mauritius | 0 | 0 |
| South Korea | 27 | 28 | Lithuania | 1 | 0 | Tanzania | 0 | 0 |
| Cuba | 25 | 25 | India | 1 | 3 | Kuwait | 0 | 0 |
| Ukraine | 23 | 20 | Zambia | 1 | 0 | Nepal | 0 | 0 |
| Canada | 22 | 19 | Tunisia | 1 | 0 | Peru | 0 | 1 |
| Hungary | 21 | 25 | Burundi | 1 | 0 | Guatemala | 0 | 0 |
| Romania | 20 | 15 | Latvia | 1 | 0 | Vietnam | 0 | 0 |
| Netherlands | 19 | 15 | Syrian Arab Rep | 1 | 0 | Botswana | 0 | 0 |
| Spain | 17 | 22 | Israel | 1 | 2 | Liechtenstein | 0 | 0 |
| Poland | 17 | 18 | Cameroon | 0 | 0 | Cyprus | 0 | 0 |
| Brazil | 15 | 6 | Barbados | 0 | 0 | Comoros | 0 | 0 |
| United Kingdom | 15 | 21 | Turkmenistan | 0 | 0 | Vanuatu | 0 | 0 |
| Belarus | 15 | 0 | Iceland | 0 | 0 | Sudan | 0 | 0 |
| Bulgaria | 15 | 11 | Zimbabwe | 0 | 0 | Ghana | 0 | 0 |
| Japan | 14 | 25 | Grenada | 0 | 0 | Singapore | 0 | 0 |
| Czech Rep. | 11 | 0 | Congo, Dem. Rep. | 0 | 0 | Maldives | 0 | 0 |
| Kazakhstan | 11 | 4 | Bermuda | 0 | 0 | Equatorial Guinea | 0 | 0 |
| Sweden | 8 | 12 | Egypt, Arab Rep. | 0 | 0 | St. Lucia | 0 | 0 |
| Greece | 8 | 2 | Colombia | 0 | 1 | Belize | 0 | 0 |
| Kenya | 8 | 4 | Bangladesh | 0 | 0 | Liberia | 0 | 0 |
| Switzerland | 7 | 3 | Swaziland | 0 | 0 | Cape Verde | 0 | 0 |
| Norway | 7 | 7 | El Salvador | 0 | 0 | British Virgin Islands | 0 | 0 |
| Belgium | 6 | 4 | Pakistan | 0 | 1 | Malta | 0 | 0 |
| Turkey | 6 | 7 | St. Vincent | 0 | 0 | UAE | 0 | 0 |
| Denmark | 6 | 6 | Chile | 0 | 0 | Aruba | 0 | 0 |
| Jamaica | 6 | 0 | Fiji | 0 | 0 | Chad | 0 | 0 |
| Nigeria | 6 | 3 | Uruguay | 0 | 0 | Angola | 0 | 0 |
| New Zealand | 6 | 8 | Burkina Faso | 0 | 0 | Suriname | 0 | 0 |
| North Korea | 5 | 5 | Cambodia | 0 | 0 | Mali | 0 | 0 |
| South Africa | 5 | 3 | Jordan | 0 | 0 | Libya | 0 | 0 |
| Indonesia | 4 | 6 | Benin | 0 | 0 | Afghanistan | 0 | 0 |
| Yugoslavia | 4 | 1 | Nicaragua | 0 | 0 | Cote d'Ivoire | 0 | 0 |
| Ireland | 4 | 1 | Brunei | 0 | 0 | Yemen, Rep. | 0 | 0 |
| Finland | 4 | 5 | Albania | 0 | 0 | Lesotho | 0 | 0 |
| Iran, Islamic Rep. | 3 | 3 | Rwanda | 0 | 0 | Dominican Rep. | 0 | 0 |
| Argentina | 3 | 3 | Saudi Arabia | 0 | 1 | Lao PDR | 0 | 0 |
| Slovak Republic | 3 | 0 | Togo | 0 | 0 | Haiti | 0 | 0 |
| Algeria | 3 | 1 | Malawi | 0 | 0 | Luxembourg | 0 | 0 |
| Austria | 3 | 3 | Oman | 0 | 0 | Guinea-Bissau | 0 | 0 |
| Ethiopia | 3 | 0 | Central African Rep. | 0 | 0 | Bosnia | 0 | 0 |
| Malaysia | 2 | 1 | Macedonia | 0 | 0 | Bhutan | 0 | 0 |
| Georgia | 2 | 0 | Samoa | 0 | 0 | Tajikistan | 0 | 0 |
| Armenia | 2 | 0 | Sao Tome Principe | 0 | 0 | San Marino | 0 | 0 |
| Portugal | 2 | 0 | Cook Islands | 0 | 0 | Congo, Rep. | 0 | 0 |
| Moldova | 2 | 0 | Guam | 0 | 0 | Gabon | 0 | 0 |
| Uzbekistan | 2 | 7 | Estonia | 0 | 0 | Gambia, The | 0 | 0 |
| Morocco | 2 | 2 | Honduras | 0 | 0 | Solomon Islands | 0 | 0 |
| Namibia | 2 | 0 | Papua New Guinea | 0 | 0 | Venezuela | 0 | 0 |
| Thailand | 2 | 2 | Qatar | 0 | 0 | Mauritania | 0 | 0 |
| Trinidad Tobago | 2 | 0 | Antigua Barbuda | 0 | 0 | Myanmar | 0 | 0 |
| Slovenia | 2 | 0 | Iraq | 0 | 0 | Bahrain | 0 | 0 |
| Croatia | 2 | 1 | Somalia | 0 | 0 | Senegal | 0 | 0 |
| Ecuador | 1 | 0 | Guinea | 0 | 0 | Bolivia | 0 | 0 |
| Taiwan | 1 | 3 | Djibouti | 0 | 0 | Madagascar | 0 | 0 |
| Costa Rica | 1 | 0 | Sri Lanka | 0 | 0 | Dominica | 0 | 0 |
| Bahamas | 1 | 0 | St. Kitts and Nevis | 0 | 0 | Monaco | 0 | 0 |
| Tonga | 1 | 0 | Netherlands Antilles | 0 | 0 | Lebanon | 0 | 0 |
| Mexico | 1 | 3 | Kyrgyz Republic | 0 | 0 | Seychelles | 0 | 0 |

Table 8: Actual and predicted medal totals for 1996

| | **Predicted 2000 medals (1)** | **Predicted 2000 medals (2)** | **Actual 1996 medals** |
|---|---|---|---|
| Australia | 39 (52*) | 47 | 41 |
| Belarus | 12 | 0 | 15 |
| Belgium | 7 | 8 | 6 |
| Brazil | 17 | 19 | 15 |
| Bulgaria | 10 | 0 | 15 |
| Canada | 23 | 21 | 22 |
| China | 49 | 51 | 50 |
| Cuba | 20 | 59 | 25 |
| Czech Republic | 9 | 2 | 11 |
| Denmark | 7 | 6 | 6 |
| France | 38 | 33 | 37 |
| Germany | 63 | 50 | 65 |
| Greece | 8 | 5 | 8 |
| Hungary | 18 | 7 | 21 |
| Italy | 35 | 31 | 35 |
| Jamaica | 1 | 0 | 6 |
| Japan | 19 | 28 | 14 |
| Kazakhstan | 8 | 0 | 11 |
| Kenya | 5 | 0 | 8 |
| Netherlands | 19 | 17 | 19 |
| New Zealand | 5 | 0 | 6 |
| Nigeria | 5 | 0 | 6 |
| North Korea | 3 | 7 | 5 |
| Norway | 7 | 5 | 7 |
| Poland | 16 | 11 | 17 |
| Romania | 17 | 4 | 20 |
| Russia | 59 | 40 | 63 |
| South Africa | 6 | 5 | 5 |
| South Korea | 27 | 22 | 27 |
| Spain | 18 | 18 | 17 |
| Sweden | 9 | 8 | 8 |
| Switzerland | 8 | 9 | 7 |
| Turkey | 7 | 7 | 6 |
| UK | 18 | 20 | 15 |
| Ukraine | 21 | 11 | 23 |
| US | 97 | 75 | 101 |

Table 9: Total medal predictions for Sydney

| | **Predicted 2000 Gold medals (1)** | **Actual 1996 gold medals** |
|---|---|---|
| Australia | 14 | 3 |
| Belarus | 3 | 1 |
| Belgium | 1 | 2 |
| Brazil | 6 | 3 |
| Bulgaria | 2 | 3 |
| Canada | 8 | 3 |
| China | 19 | 16 |
| Cuba | 6 | 9 |
| Czech Republic | 2 | 4 |
| Denmark | 1 | 4 |
| France | 14 | 15 |
| Germany | 25 | 20 |
| Greece | 1 | 4 |
| Hungary | 5 | 7 |
| Italy | 13 | 13 |
| Jamaica | 0 | 1 |
| Japan | 7 | 3 |
| Kazakhstan | 1 | 3 |
| Kenya | 0 | 1 |
| Netherlands | 6 | 4 |
| New Zealand | 0 | 3 |
| Nigeria | 0 | 2 |
| North Korea | 0 | 2 |
| Norway | 1 | 2 |
| Poland | 5 | 7 |
| Romania | 5 | 4 |
| Russia | 22 | 26 |
| South Africa | 1 | 3 |
| South Korea | 10 | 7 |
| Spain | 6 | 5 |
| Sweden | 2 | 2 |
| Switzerland | 2 | 4 |
| Turkey | 1 | 4 |
| UK | 6 | 1 |
| Ukraine | 7 | 9 |
| US | 39 | 44 |

Table 10: Gold medal predictions for Sydney