PIIE PETERSON INSTITUTE FOR INTERNATIONAL ECONOMICS

POLICY BRIEF

16-9 Converging on the Medal Stand: Rio 2016 Olympic Forecasts

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July 2016

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Author's note: I thank the International Olympic Committee for its provision of data used in this Policy Brief. *The Institute is grateful to EY for its ongoing support of the Institute's work on issues of gender, work, and inequality.*

While the modern Olympics have their origins in the milieu of European aristocratic sport, the Games have evolved into mass spectacle: At the 2012 London Summer Games, 10,500 athletes—including 4,700 women—from over 200 nations went head-to-head in sporting disciplines from aquatics to wrestling. The upshot has been a diffusion of medaling away from the rich countries of Western Europe and the lands of new settlement to a more diverse set of nations (figure 1).

This *Policy Brief* presents forecasts of medal counts at the 2016 Summer Olympics in Rio de Janeiro, Brazil. The underlying statistical models (described in the appendix) are derived from a series of papers that have addressed the growing pluralism in the Olympic movement, particularly the rise in female participation, and other aspects of the Games, including the recent Russian doping controversy at the 2012 London Games.[1] These models analyze the correlations between Olympic success going back to the 1960 Rome Games and socioeconomic variables, such as income per capita and educational attainment as well as host status, to name a few. One logical inference from these models parallels the economic growth literature: As less developed and emerging-market countries catch up in terms of these socioeconomic correlates, their shares of Olympic medals should rise as well.

But the models underlying the forecasts here go further, adjusting for the distortions in the historical record created by large-scale boycotts (Moscow 1980, Los Angeles 1984) and doping. The latter consideration is critical to forecasting success in Rio insofar as the forecasts are strongly influenced by performance at the immediately preceding Games. There is growing documentary and statistical evidence of widespread Russian doping in London (Noland 2016), and the forecast procedure adopted here explicitly recalibrates Russian performance in London to control for the impact of doping and effectively reallocates additional medals in Rio to Russia's competitors.

Subject to ongoing uncertainties about the status of Russian participation, and the possible impact of the Zika virus on competition, the forecasts indicate that the United States is likely to continue to earn the greatest number of medals but that China is closing the medal gap. Brazil should get a boost from hosting the Games, but their home field advantage may not be as great as experienced by prior hosts. Slumping performance in Rio could add to Britain's post-Brexit malaise.

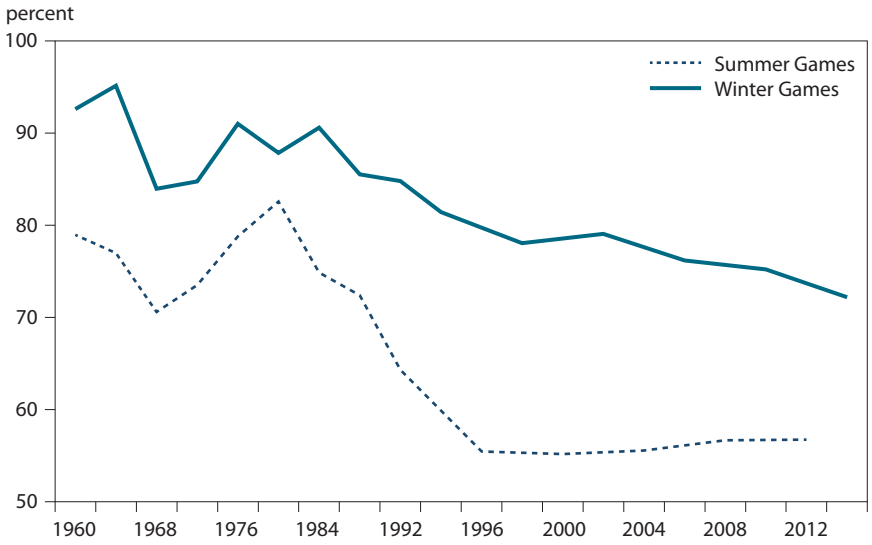
MODELING APPROACH

The forecast procedure is detailed in the appendix. The usual approach is to forecast from an equation that models overall medal performance. However, there is evidence that the correlates with women's success are somewhat distinct (Noland and Stahler 2015b). Also, Russian doping in London appears to have predominately affected women's competitions (Noland 2016). Hence, men's and women's performances were modeled separately and the resulting gender-specific forecasts then combined to obtain a second forecast. There is also evidence that the correlates with success differ across sport disciplines, but the sample size declines quickly when different events are disaggregated, and this forecasting exercise ignores these differences.[2]

1. See Noland and Stahler (2015a, b; 2016) and Noland (2016). See also Bernhard and Busse (2004), Johnson and Ali (2004), Klein (2004), Pfau (2006), Lui and Suen (2008), Leeds and Leeds (2012), Andreff (2013), Lowen, Deaner and Schmitt (2014), and Otamendi and Doncel (2014).

2. Investment in facilities and equipment create a barrier to entry for poor countries in events such as aquatics and equestrian, but per capita income is not a correlate with success in competitions

Figure 1 Share of total medals won by top 10 performers at the Olympics, 1960–2014



Note: "Top 10" refers to the top 10 ranked National Olympic Committees in terms of total medals won at each individual Olympic Games.

Source: International Olympic Committee.

The regressions take into account GDP, population size, status as the current host, status as host of the previous summer games, membership in the communist bloc, average years of schooling, distance from the equator, medal share from the previous Olympics, and in some specifications female educational attainment. Twelve different specifications underlie the forecasts. Evaluated at the sample means, previous Olympic games performance tends to have the biggest impact on the forecast, followed by population, host status, per capita income, education, and other variables.

Unfortunately, doping, particularly as practiced by East Germany in the 1970s and 1980s, and Russia at the London and Sochi Games, has distorted the historical record of competition.[3] The models explicitly take this history into account. For Russia, the forecasts assume that a full delegation of Russian athletes compete at Rio and perform according to the cross-national norm (which itself may embody some degree of doping—that is, if the Russians dope at Rio, it's no worse than the average). Controls are also included to account for distortions in the medal pattern created by weakened competition resulting from the large-scale boycotts of the 1980 Moscow and 1984 Los Angeles Games.

If, however, the entire Russian athletics (track and field) team is banned (as proposed by the International Association of Athletics Federations, the discipline's governing body), the forecasts will overestimate Russian medal counts by the margin that would have been won by "clean" competitors in track and field, and the medal totals of other countries will rise accordingly.

For a few countries, most notably Cuba, which won 14 medals in London, placing it 17th in the ranking, missing data precluded constructing an explicit forecast. In response, a "naïve" forecast of no change from 2012 is used.

Missing data also prevented generating a true forecast for North Korea. The country has recently put success in international sports competitions at the center of a propaganda campaign, put a general in charge of the sports program, hired some former East German coaches, and is promising to compete with "heated zeal." As leader Kim Jong-un put it, "Sports officials and coaches must implement the tactics of anti-Japanese guerilla-style attacks in each sport event in order to take the initiative in every game and triumph."[4]

Expect North Korea to garner 5 to 6 medals in Rio and an unknown number of doping violations. If North Korea comes away with, say, 8 or 9 medals, well, maybe those guerilla tactics are working.

such as athletics (track and field) and boxing. There is also some evidence that Asian countries fare better in certain culturally linked disciplines (cf. table tennis) and weight-stratified events (cf. judo) (Noland and Stahler 2016).

3. Noland and Stahler (2015b) conclude that at its peak the East German doping program was responsible for 17 percent of the medals awarded to female athletes, equivalent to the total women's medal share that the Soviet and American teams each earned in 1972, the last year the Summer Games were not marred by widespread doping. Noland (2016) finds evidence of a smaller, though notable, impact of Russian doping efforts at the 2012 London Games.

4. Marcus Noland and Kevin Stahler, "Sports, Legitimacy, and Heated Zeal," North Korea: Witness to Transformation blog, April 15, 2015, https://piie.com/blogs/north-korea-witness-transformation/sports-legitimacy-and-heated-zeal (accessed on June 14, 2016).

Table 1 2016 forecast results

2012 London Games results			Total medals forecast			Male and female aggregate medals forecast		
Rank	Country	Total	Rank	Country	Total	Rank	Country	Total
1	United States	104	1	United States	106	1	United States	105
2	China	88	2	China	94	2	China	92
3	Russia	82	3	Russia	66	3	Russia	66
4	Great Britain	65	4	Great Britain	55	4	Great Britain	50
5	Germany	44	5	Germany	48	5	Germany	43
6	Japan	38	6	Japan	42	6	Japan	42
7	Australia	35	7	France	37	7	France	36
8	France	34	8	Australia	36	8	Australia	35
9	Italy	28	9	Brazil	35	9	Brazil	32
9	South Korea	28	10	South Korea	31	10	South Korea	30
11	Ukraine	20	11	Italy	30	11	Italy	27
11	Netherlands	20	12	Canada	22	12	Canada	24
13	Hungary	18	13	Netherlands	21	13	Ukraine	20
13	Canada	18	14	Ukraine	20	13	Spain	20
15	Brazil	17	15	Spain	19	15	Netherlands	17
15	Spain	17	16	Hungary	17	16	Hungary	16
17	Cuba*	14	17	Cuba*	14	17	Cuba*	14
18	New Zealand	13	18	Kazakhstan	13	18	Kazakhstan	12
18	Kazakhstan	13	18	New Zealand	13	18	Poland	12
20	Jamaica	12	20	Iran	12	20	Iran	11
20	Iran	12	20	Belarus*	12	20	Belarus*	11
20	Belarus*	12	20	Poland	12	20	New Zealand	11

* Belarus and Cuba medals held constant from 2012 due to missing data.

Source: Author's calculations.

MEDALS FORECASTS

Three imponderables could confound the forecasts. The first is the Zika virus. Zika could affect the outcome either by discouraging some athletes from participating or, worse, some athletes could contract Zika and be unable to compete, at least at their full potential.[5] The men's golf competition has been particularly hard hit, with Jason Day (world ranked number 1), Dustin Johnson (number 2), Jordan Spieth (number 3), Rory McElroy (number 4), and others indicating that they would not compete in Rio because of Zika concerns.

The second issue is the impact of home field advantage. Historically, the host of the Games has experienced a statistically significant performance boost. But this year there is reason to believe that Brazil may not obtain the full effect. The country is experiencing political and economic turmoil. The impeachment trial of President Dilma Rousseff is expected to extend into the Games, creating protocol issues such as who should preside as host and raising the specter of mass protests during the competition. The crisis could adversely affect the performance of Brazilian athletes by disrupting their training or just creating an unwelcome distraction. One could argue the opposite case: The Brazilians are inured to the chaos, and it will be the visiting foreigners who are thrown off balance. The negative interpretation is reinforced, however, by the observation that the Brazilian team underperformed miserably at the last mass event the country hosted, the 2014 World Cup.

Evidence also shows that the host advantage is particularly pronounced in events that are judged, such as gymnastics, as opposed to more objectively assessed events, such as track or weightlifting (Balmer, Nevill, and Williams 2003; Noland and Stahler 2015a). Unfortunately for Brazil, historically it has not been particularly competitive in judged events and may therefore not be well placed to take advantage of "home cooking." If Brazil is unable to make full use of the home field advantage, the medal counts of other countries will rise commensurately.

Finally, there is the issue of doping. Performance-enhancing drugs (PEDs) have long been part of Olympic competition,

5. Charlotte Wilder, "17 athletes who are skipping the 2016 Olympics," *USA Today*, June 6, 2016, http://ftw.usatoday.com/2016/06/17-athletes-not-going-to-rio-so-far-2016 (accessed on June 13, 2016).

Table 2 2016 marginal changes forecast model results

Total medals forecast			Male and female aggregate medals forecast		
Rank	**Country**	**Total**	**Rank**	**Country**	**Total**
1	United States	100	1	United States	100
2	China	85	2	China	84
3	Russia	66	3	Russia	67
4	Great Britain	54	4	Great Britain	50
5	Germany	43	5	Germany	38
6	Japan	37	6	Japan	37
7	Australia	34	7	Australia	34
8	France	33	8	France	33
8	Brazil	33	9	Brazil	31
10	South Korea	27	10	South Korea	26
10	Italy	27	10	Italy	26
12	Netherlands	19	12	Ukraine	18
13	Ukraine	18	13	Spain	17
14	Canada	17	13	Hungary	17
14	Hungary	17	13	Canada	17
16	Spain	16	16	Netherlands	16
17	Cuba	14	17	Cuba	14
18	New Zealand	12	18	Kazakhstan	12
18	Kazakhstan	12	18	Iran	12
18	Belarus	12	20	New Zealand	11
18	Iran	12	20	Jamaica	11
			20	Kenya	11

Source: Author's calculations.

from the nadir of the East German program in the 1970s and 1980s to the more recent cheating by the Russian team at London and Sochi. These forecasts assume that the Russians regress back to their natural competitiveness after their outperformance in London, and PED use among other competitors is either detected or sufficiently minor and uniformly spread across national delegations that it does not systematically distort the competitions.

Data on actual medal counts at the London Games along with two forecasts are presented in table 1. The first column displays the actual results from 2012. The next two columns report two sets of forecasts for 2016: one derived from a statistical model of total medal counts, and a second set of forecasts derived from estimating male and female medal counts separately and then combining them. The two sets of forecasts are highly correlated and reproduce identical rankings for the top 10 countries, though there are some differences in the rankings from the 11th to 20th place.[6]

The United States is expected to earn the largest number of medals, and it may even pick up an additional medal or two relative to the previous Games as a result of Russia reverting to its normal level of competitiveness. China is expected to increase its medal count, closing the gap on the United States. Russian and British medal counts are expected to decline, as they lose the edges conferred by doping and the home field advantage, respectively. Conversely, Brazil is expected to jump from 15th place to 9th place due to the host advantage, though for reasons previously discussed, the statistical models may be overstating this effect in this particular instance. The models predict that Poland will crack the top 20 in Rio (at the expense of Jamaica), but I would think twice before betting against the Jamaican track team—even with sprinter Usain Bolt's injury—especially if Russia is excluded from athletics or reverts to its non-PED aided form.

The results are plausible, but closer inspection suggests that they might not fully capture the competitiveness of some national delegations that appear to have consistently exceeded expectations in recent Games, such as Jamaica (sprinting), Kenya (distance running), and Mongolia (combative sports such as judo, boxing, and wrestling).

As a response, the forecasts were recalculated taking the actual performance in London as a base and then factoring in expected marginal changes in the explanatory variables (table 2). This approach in effect creates "convergence," as the expected medal counts of rapidly growing emerging-market and developing countries are boosted at the expense of slower-growing rich countries, mirroring the growing dispersion of medals across national delegations observed in recent decades. Again, the forecasts derived from the total medal count model as well as the aggregation of separate male and female results are presented.

The composition of the top 20 countries remains largely the same, though the total number of medals captured by the top 20 falls from 708 in London to forecasts of 678 and 662 in the total and gender-specific models, respectively, as poorer countries converge on the leaders. The United States remains at the top of the table, but in contrast to the first set of forecasts, the US medal total falls relative to London as the rest of the world catches up. Jamaica and Kenya break into the top 20 in the male- and female-model aggregated medal count forecasts, tied at 20th place with 11 apiece, alongside New Zealand.

6. It is worth noting that there are 971 total medals to be awarded in Rio compared to 962 in London, and the aggregate male and female medal counts do not factor in mixed-gender events, which account for 27 of the 971 total medals to be awarded, or approximately three percent. Therefore, overall the male-female aggregate figures are likely to be slightly less than the total medal forecasts, particularly for countries that do well in mixed-gender events.

CONCLUSION

Assuming that issues relating to the Zika virus do not significantly distort outcomes, the United States should remain at the top of the medals table, but China is closing the gap. The American medal total could rise relative to its performance at the London Games if it successfully picks up medal opportunities created by Russia's reversion to form after its PED-aided bonanza in 2012. Brazil should get a boost from hosting the Games, though for a variety of reasons, it would not be surprising if Brazil falls short of the predictions in tables 1 and 2, while conversely Great Britain experiences a post-host slump, adding to its post-Brexit and post–2016 UEFA European Championship doldrums. And if, in retrospect, the Rio Games are marred by yet another large-scale PED scandal, all bets are off.

Let the Games begin.

APPENDIX

To forecast these outcomes, projections on GDP per capita (in purchasing power parity) and population growth are compiled for all available countries in 2016, the year of the next Summer Games in Brazil, from the April 2016 update of the International Monetary Fund's (IMF) World Economic Outlook (WEO) database (IMF 2016). Educational attainment is extrapolated from the average linear growth rate between 2000 and 2010 in Barro and Lee (2013) data. Status as a communist country and distance from the equator are held constant from 2012, and the status of current host and prior host is updated to reflect that this will be Brazil and Great Britain in 2016, respectively. The lagged dependent variable for 2016 forecasts is the country's total medal share at the 2012 Games.

Underlying the forecasts in tables 1 and 2 are six different regression specifications (see Noland and Stahler 2016 for specifics). The regressions differ by whether a lagged dependent variable is included or not and by whether the sample period is 1960–2012 or 1992–2012 (the latter permits the inclusion of a larger number of countries and additional regressors). Forecasts were generated for the 2016 Games using the Granger-Ramanathan (1984) method. Excluding an intercept, the in-sample predicted medal shares from the six models are regressed against the actual observed medal share values, placing the constraint that the coefficients sum to one.

Of the resulting coefficients that are negative, the most negative coefficient is removed, and the model is re-estimated iteratively until all remaining prediction models exhibit positive coefficients that sum to one. These estimated coefficient values are then used as the weights to form the forecasts.[7] In the case at hand, the process yielded a combined forecast using models for estimations on total medal and male medal shares, which were the lagged dependent variable Tobit variations from the full sample and "modern" sample, respectively. For the female medal share forecast, the lagged dependent variable modern sample model was used.

To estimate the effect that Russian doping will play in the 2016 Rio games, two separate models were used, one with the Russia 2012 dummy variable included and one where the Russia dummy variable is removed. According to this technique the estimate of the additional medals Russia earned from doping is the difference in Russian medal shares predicted between these two models. Under the assumption that Russia reverts to its normal level of competitiveness in Rio, those additional medals ascribed to doping are reallocated to the top 10 medal receiving countries (besides Russia) based on their weighted share amongst these top 10 countries. Russian performance at London is then recalibrated for the lagged dependent variable models, and again the additional medals are reallocated based on the weighted share amongst the top 10 countries. Medals are reallocated in this way as opposed to across the entire weighted sample to avoid a dispersion effect in which the extra percentage of medals would have little noticeable effect.

The estimation is then conducted using the same procedures with male and female medals separately, using gender-specific medal counts and education figures, and deriving gender-specific Russian doping estimates, which indicate that the impact of PED use was mainly in women's events. The estimated medals are then subsequently aggregated.

For the separate marginal changes calculations, the same weights on the variables from the Granger-Ramanathan method are again used. Separate regressions are conducted based on total medals, male medals, and female medals. The constant is removed, and instead 2012 medal shares are held constant (except for Russia, which is rebased to take into account the doping-related distortion of competitiveness in the London Games). The regressions take into account changes in log of population, log of GDP per capita, status as previous host and current host, average years of education (only applied to total medal specification), and a variable for the Russian team in 2012. As with the previous forecasting model, to estimate the effect of Russian doping in Russia's medal count, the regres-

7. In the case of this study, one issue with the "modern sample"–predicted values is that, when applied to the full sample, inclusive of observations before 1990, it amounts to assuming that the coefficients on the year dummies are zero prior to 1990. Imposing this assumption generates relatively large residuals for the pre-1990 observations and could thereby downwardly bias the weight put on "modern sample" specifications. Alternatively, one could go through the Granger-Ramanathan method using all specifications but produce predicted values only on post-1990 data. Doing this yielded a 100 percent weight on the "modern sample" lagged dependent variable Tobit estimation. Ultimately, however, differences across these two sets of forecasts were minimal, as are the differences in results if full weight is placed on the "full sample" lagged dependent variable specification. In the interest of brevity, these alternate results are not shown.

sions are then run without the Russia 2012 estimator. Male and female forecasts are then aggregated. Assuming that Russia reverts to a normal level of competitiveness, the Russian performance in London is rebased, and the additional PED-related medals are reallocated to the top 10 medal receiving countries besides Russia, weighted by their medal share within the top 10 countries.

This exercise was repeated for the gender-specific medal counts.

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