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Marcus Noland is executive vice president and director of studies at the Peterson Institute for International Economics. He is also senior fellow in the Research Program at the East-West Center.

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Publications Office| East-West Center
1601 East-West Road | Honolulu, Hawai'i 96848-1601

Tel: 808.944.7145 | Fax: 808.944.7376
EWCBooks@EastWestCenter.org

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From its European aristocratic origins, the modern Olympic Games have grown to be the most global organized sporting event on earth, with more than 10,000 competitors from over 200 national delegations participating. A small cottage industry has developed modeling national medal performance at the Olympics as a function of such correlates as population size, income per capita, women's labor force participation, and host status, to name a few.[1]

In light of these socio-economic correlates, it is not surprising that Asia's rise over the last century has been paralleled by growing success at the Olympic Games. In 1912, Japan became the first Asian country to make an appearance at the Games, followed by the Philippines in 1924, and Burma (Myanmar), China, Singapore, and South Korea in 1948 (Noland and Stahler 2015a Appendix Table 1).[2] In the post-War period, Asian athletic prowess continued to rise along with its growing economic power. Since the early 1980s, Asian competitors have made up roughly 11 – 15 percent of the total participating athletes at the Summer Games, and between 7 – 12 percent at the Winter Games. Asian competitors have achieved even greater success reaching the medal stand: at Los Angeles 1984 Asian athletes accounted for 12 percent of medals (and 14 percent of gold medals), but by 2008 they seized 19 percent of total medals and 27 percent of the

[1] See for example 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), Otamendi and Doncel (2014), and Noland and Stahler (2015a, b).

[2] During the period of Japanese colonialism, some Korean athletes competed for Japan (see Ok and Ha 2011).

gold medals. The improvement is even more striking in the Winter Games, with Asian athletes going from earning only a single medal in 1988 to a peak of 30 medals (12 percent of the total) in 2010. Asian female athletes have since made enormous strides from the first post-War Games, where only a single woman from an Asian country (South Korea) competed athletically at London 1948. Women have become a prominent and extremely successful component of Asia's overall performance at the Olympics. Indeed, there is evidence that with Asian male athletes underperforming in Olympic competition, Asian success is driven by its female competitors (Noland and Stahler 2016).

This note presents forecasts of Asian medal counts at the upcoming Rio Games, subject to ongoing uncertainties about the status of Russian participation, and the possible impact of the zika virus. The models indicate that Northeast Asia is likely to continue to dominate medaling by Asian delegations. The United States is likely earn the greatest number of medals, but that China is closing medal gap. Japan (6th place) and South Korea (10th place) should remain in the top 10.

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). It also appears to be the case that Russian doping in London predominately affected women's competitions (Noland 2016). In response, a second forecast is obtained by modeling men's and women's performance separately and then combining the gender-specific forecasts.

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 these differences are ignored in this forecasting exercise. 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 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).

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; and in some specifications female educational attainment, labor force participation, and foreign-born population shares.

Unfortunately, doping, particularly as practiced 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 created by the large-scale boycotts the 1980 Moscow and 1984 Los Angeles Games.

[3] Noland and Stahler (2015b) conclude that at its peak the East German doping program accounted for 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.

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 with overestimate Russian medal counts by the margin that would have been won by "clean" competitors and the medal totals of other countries would rise accordingly.

Missing data precluded generating a true forecast for North Korea. The country has recently put success in international sport competitions at the center of a propaganda campaign, put a general in charge of the sports program, hired some formers 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 5-6 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.

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 (for example golfers Jason Day (US), Rory McIlroy (Northern Ireland), Shane Lowry (Ireland) and Vijay Singh (Fiji), and

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

American cyclist Tejay van Garderen) or, worse, some athletes could contract zika and be unable to compete, at least at their full potential.[5]

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. (Though one could argue the opposite case: the Brazilians are inured to the chaos and it will be the visiting foreigners thrown off balance.) The negative interpretation is reinforced, however, by the observation that the Brazilian team under-performed miserably at the last mass event the country hosted, the 2014 World Cup.

There is also evidence 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 is has not been particularly competitive in judged events, and as a consequence, may 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 would rise

[5] Charlotte Wilder, "17 athletes who are skipping the 2016 Olympics," http://ftw.usatoday.com/2016/06/17-athletes-not-going-to-rio-so-far-2016 Accessed 13 June 2016.

commensurately. China, Japan, and South Korea would be the most likely Asian beneficiaries of Brazil's woes.

Finally, there is the issue of doping. Performance-enhancing drugs (PEDs) have long been part of Olympic competition, 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 the out-performance 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 the actual medal counts of Asian countries at the London Games along with four forecasts are presented in table 1. The first column displays the actual results from 2012. The next two columns report two sets of forecasts: one from 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. The two sets of forecasts are highly correlated, though the models based on total medal counts tend to generate slightly higher forecasted figures compared to the results obtained from the models derived from estimating male and female results separately (which tend to yield lower forecasts for Asian males). Only in the case of Taiwan (officially Chinese Taipei) is there much of a difference in the results obtained from the two forecasting methods.

The United States is expected to earn the largest number of medals, and may even pick up an additional medal or two relative to the previous Games as a result of Russia reverting back to its normal level of competitiveness after its PED-enhanced performance in London. China is expected to increase its medal count, closing the gap on the US. Japan and South Korea both are forecast to bring home a few more medals. This pattern would be in keeping with the historical record of Northeast Asia accounting for the bulk of Asian medals.

The results are plausible but close 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 well as others such as Vietnam which seem to underperform.

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. This approach in effect creates "convergence" as the expected medal counts of rapidly developing countries are boosted at the expense of slower growing rich countries, mirroring growing dispersion of medals across national delegations observed in recent decades (Noland and Stahler 2015a). The results derived from the total medal count model and then aggregation of separate male and female results are presented in the fourth and fifth columns, respectively.

The forecasted medal counts for the US, China, Japan and South Korea all fall relative to their performances at the London Games. Using this forecasting approach, a few countries that won no medals at London including Cambodia, Laos, Myanmar, the Philippines, and Vietnam, make it over the threshold, and are predicted to win a single medal each. In the cases of Cambodia, Laos, and Myanmar, if they were to medal, it would be for the first time in history.

Conclusion

Assuming that issues relating to the zika virus or PEDs do not significantly distort outcomes, the United States should remain at the top of the medals table, but China is closing the gap. Japan and South Korea should retain their places in the top 10, and some Southeast Asian countries may medal for the first time.

Let the Games begin.

Appendix

To forecast these outcomes, we compile projections on GDP per capita (in PPP) and population growth for all available countries in 2016, the year of the next Summer Games in Brazil, from the October 2014 update of the IMF's World Economic Outlook (WEO) database (IMF 2014a, 2014b).[6] 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 post-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; 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 add 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

[6] In a January 2015 update of the WEO, the IMF reported significant downward revisions to Russian GDP growth in 2015 and 2016 (IMF 2015). However, applying updated forecasts for Russia do not affect our overall rankings forecasts.

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 full 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.

[7] In our case, 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 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.

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 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' 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 regressions are then run without the Russia 2012 estimator. Male and female forecasts are then aggregated. As with the previous forecasting model, assuming that Russia reverts back 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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Asia Medal Forecasts

Country	Medals won in 2012	Total Medals	Aggregate M & F	Marginal Changes Model Total Medals	Marginal Changes Model M & F Aggregate
Cambodia	0	0	0	1	1
China	88	94	92	85	84
Hong Kong	1	1	0	1	1
Indonesia	2	2	1	2	2
Japan	38	42	42	37	37
Laos	0	0	0	1	1
Malaysia	2	3	1	3	2
Mongolia	5	0	0	5	5
Myanmar	0	0	0	1	1
Nepal	0	0	0	1	0
Philippines	0	1	0	1	1
Singapore	2	0	0	2	2
South Korea	28	31	30	27	26
Taiwan	2	5	2	2	2
Thailand	3	3	1	3	3
United States	104	106	105	100	100
Vietnam	0	4	3	1	1