

What Country is the All-Time Best in the Worldcup?

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Ask this question of any football (or soccer, as it is called in the U.S.) aficionado, and you will likely get the same answer: Brazil! Their 5 victories are the most of any country, ahead of Germany and Italy with 4 each. But then ask the following: How do the Netherlands compare to (say) Canada? If all that matters is winning, then those two would be equal, although the Netherlands have reached (albeit lost) the Worldcup final 3 times whereas Canada has only been to the Worldcup once, in 1986. So maybe we should differentiate a little more and also take into account how the countries performed in the Worldcup.

This, then, brings us right away to the statistical theme of this article: In almost any statistical analysis we have to make subjective choices, that is choices that we can not justify on some theoretical grounds. The best we can argue is that our choice is reasonable. Moreover our choice does not have to be the same as someone else's. Likely any Brazilian statistician will feel strongly that victory is everything, whereas our colleagues in the Netherlands might beg to differ.

1 Subjectivity in Statistics

The issue of subjectivity in Statistics has been discussed on occasion, mostly though in the context of Frequentist vs Bayesian statistics. The main objection to Bayesian statistics is in fact the need for a prior, a necessarily subjective choice. The usual reply by Bayesian statisticians is that in any statistical analysis, Frequentist or Bayesian, subjective choices have to be made anyway, so one more such choice should not be too big a problem. The kinds of subjective choices usually mentioned are for example the choice of probability distribution and the choice of analysis method, say mean vs median. This last one is in fact akin to our issue of how to rank the countries in the Worldcup. A good example for the discussion of subjectivity in the Bayesian vs Frequentist debate can be found in "Statistical analysis and the illusion of objectivity" by James Berger and Donald Berry, published in American Scientist, 1988.

Of course statisticians just like all scientists strive for objectivity as much as possible. In many cases we even know what method is best, in the sense that it minimizes some optimality criterion. Often though that just changes the source of the subjectivity, because it is not

always clear what optimality criterion to use! Bayesians also have made great strides to make the choice of prior more objective, with the development of systems such as reference priors. Again, though, whether an objective prior is actually desirable is an ongoing debate.

2 The Football Worldcup

By any measure, football is the most widely played and watched game in the world. Even in the U.S., where it was ranked a distant fourth behind American football, baseball and even ice hockey not so long ago, it has in recent years grown in leaps and bounds. The most important competition in football is the Worldcup. In 2014 203 countries participated in the year-long qualifying process, with the best 32 countries going to the Worldcup finals held in Brazil.

This was the 20th playing of the Worldcup, which began in 1930 in Uruguay and has been held every four years since, with a 12 year break because of Worldwar II. Table 1 shows the host country, winner and runner-up of all the Worldcup finals.

As in many other sports statisticians have become increasingly involved in football as well, and the problem of predicting the winner of football games in the Worldcup was the subject of a recent CHANCE article, "Optimism and the Occult Octopus: Favorites Lose, Underdogs Triumph, and Spain

Finally Wins the World Cup" by Jason D. Mitchell and Li Lian Ong.

Table 1: Host country, winner and runner -up of all the Worldcup finals.

Year	Host	Winner	Runner Up
1930	Uruguay	Uruguay	Argentina
1934	Italy	Italy	Czechoslovakia
1938	France	Italy	Hungary
1950	Brazil	Uruguay	Brazil
1954	Switzerland	Germany	Hungary
1958	Sweden	Brazil	Sweden
1962	Chile	Brazil	Czechoslovakia
1966	England	England	Germany
1970	Mexico	Brazil	Italy
1974	Germany	Germany	Netherlands
1978	Argentina	Argentina	Netherlands
1982	Spain	Italy	Germany
1986	Mexico	Argentina	Germany
1990	Italy	Germany	Argentina
1994	United States	Brazil	Italy
1998	France	France	Brazil
2002	South Korea	Brazil	Germany
2006	Germany	Italy	France
2010	South Africa	Spain	Netherlands
2014	Brazil	Germany	Argentina

3 How to Rank the Countries

So, let's say we want to derive a ranking system that takes performance into account. How might we do this? Maybe we can

give points, the more points the further in the tournament a country progressed. The 2014 Worldcup was contested by 32 teams. In the first round they were put into 8 groups of 4, with each team in the group playing one match with each of the others. The winner got 3 points, a tie was worth 1 and 0 for the loser. At the end the two teams with the most points in the group moved on, with a number of tie breaker rules in place, a good thing for the US team as it allowed them to lose their last group match against Germany and still move on. Then came the knock-out stage, until the final match. So we could use the following scheme: each team that made it to the Worldcup finals at all gets 1 point, after all 203 countries had played in the qualifying stage, so just to make it to the Worldcup finals is quite an achievement. The 8 teams that made it to the knock-out stage but then lost in the round of 16 get a points, the losers in the quarterfinals get b , the losers of the semifinals get c , the runner up d and the winner gets e points.

The traditional "winner takes all" measure is somewhat similar, except that the only point given is for winning.

Now though, how to choose a, b, c, d and e ? The only obvious requirement is $1 \leq a \leq b \leq c \leq d \leq e$. Let's start with the last two. How much more is winning worth than second place? Again, almost any answer is defensible. I would not be surprised if the Dutch would be quite happy to trade their three second place finishes for a single

win. Maybe we can look at other sports to get an idea. In Tennis and in Golf the winner usually gets double the prize money of the runner-up, so maybe we can give double the points to the winner of the Worldcup as well. If we keep this scheme we get 2 points for the losers in the round of 16 and so on, with the winner getting 32 points. In the following we shall call this the "double rule".

There is another justification for this point scheme: in each round the number of teams moving on is cut in half, so doubling the points sounds reasonable.

Another idea would be to look at the way the FIFA world rankings work. This is a system that ranks the countries based on a four year window, with all the games that a country plays included. Every time two countries play against each other, the winner gets points. How many depends on a number of factors such as the strength of the opponent (essentially their current ranking), what part of the world they are from, the circumstances of the game (for example a friendly counts for 25% of a match during the Worldcup) and a number of other factors. For the details of the ranking formula see http://en.wikipedia.org/wiki/FIFA_World_Rankings#Current_calculation_method. For our purpose what matters most is that all the games played during the Worldcup finals count (almost) the same. Both finalists will generally have won 6 matches (they might have tied or even lost a match early on but that won't change things much)

and a win is worth 3 points, so the winner will get about $7*3=21$ points and the runner-up $6*3=18$. I am quite certain that most people would consider this difference between winning the Worldcup and coming in second to small. Also, under this rule the third place finisher would get the same 18 points as the runner-up! Let's call this the "FIFA rule".

Now we have three basic point schemes, as shown in the table 2.

Table 2: Points for different ranking methods.

Points	Double	Winner	Fifa
Finalist	1	0	0
a	2	0	9
b	4	0	12
c	8	0	15
d	16	0	18
e	32	32	21

Applying the "winner takes all" rule Brazil is of course ahead with 5 wins, followed by Germany and Italy with 4 each. Using the "double rule" though we actually have a tie! Both Brazil and Germany have 249 points followed by Italy with 191 points. Finally under the "FIFA rule" Brazil is ahead with 325 points with Germany second (314) and again Italy third (224).

Table 3 shows the top 10 countries according to the "double rule" system.

Rank	Country	Points
1	Brazil	249

2	Germany	249
3	Italy	191
4	Argentina	142
5	Uruguay	101
6	France	84
7	England	79
8	Netherlands	79
9	Spain	69
10	Sweden	55

Of course we might consider any number of other ranking systems. How about one that takes the actual result of the games into account? In such a scheme the 7:1 trouncing of Brazil by Germany in the 2014 semifinals would count for much more than the comparatively pauly win of Argentina over the Netherlands by penalty shootout. In fact actual game outcomes used to be part of the formula used by FIFA for the world rankings. This was changed though in 2006 because it was considered to complicated.

4 Issues with the Data

There are a number of issues, though. They all stem from the fact that our data has changed over time. To begin with, until 1982 there were fewer teams playing in the Worldcup, and as a consequence there was no round of 16! Teams winning in the early round made it straight to the quarter finals. Is it really fair to award them 4 points anyway, even though they won one match less? On the other hand, they are listed in the record books as a Worldcup

quarter finalists, so maybe they should be treated as such!

A special case is the third place. Most unusual in any sport, the losers in the semifinal play again for third place. So rather than giving equal points to the semifinal losers, we could give more points to the winner of the third place match. Doubling the points seems excessive because there is not so much prestige in winning third versus fourth, so maybe we could give the third place finisher 12 points, halfway between 8 and 16. I have to admit to being partial to this points system, because with this change to the "double rule" Germany moves to the top as they have one third place finish than Brazil, and as a native born German I find this quite acceptable!

If this all sounds very ad-hoc and subjective, then that's because it is! And that of course is my point, i do not see a way to do this that is not subjective. But wait, it get's worse:

We had previously agreed that every team that makes it to the Worldcup deserves 1 point. But maybe not: first of, the very first Worldcup held in 1930 in Uruguay actually did not have a qualifying round. In fact the tournament had a tough time attracting enough teams, with many of the football powerhouses from Europe deciding that South America was too far away. (No jet airplanes in 1930!). Secondly, until the 2006 tournament the defending champion and until today the host country are automatically

qualified. But then, most tournaments have been held in countries that have strong teams which would likely have qualified anyway. So maybe we should just ignore this one.

Actually, there maybe a bit of a general principle lurking here: unless there is a good reason to make an adjustment to the general procedure, we probably shouldn't make one at all.

As is often the case with sporting events, they start slow and get bigger as time goes by. As we just saw, the first Worldcup took a bit of work to put together, with many European teams choosing to stay home. In retaliation the winner of the 1930 tournament, Uruguay, chose not to attend the 1934 tournament held in Italy, because Italy had not come to their tournament. Then FIFA gave the 1938 tournament to France, which upset a lot of South American teams who felt it should have been their turn again. So maybe we should not consider these three early tournaments at all, and begin counting from 1950 on? I will not do so, in part because i have many Italian friends who would consider this completely unreasonable (it would cut their winning total in half!)

As in many sports soccer also has a home-field advantage. In fact 6 of the 20 worldcup champions won on home soil. On the other hand, Brazil has now failed to win the tournament at home for the second time. So maybe we leave this one alone as well.

Historically it has been very difficult for a team from Europe to win a tournament held in South America, and vice versa. This feat has been accomplished only twice, in 1958 by Brazil in Sweden and in 2014 by Germany when the tournament was held in Brazil. So maybe we should give bonus points for this?

Then there is the issue with countries. Over the last 84 years a number of countries have ceased to exist and others have come into being. For example, Czechoslovakia was quite successful in the Worldcup, with runner-up finishes in both 1934 and 1962. Then in the 1980s after the fall of the Soviet Union the country broke up into Slovakia and the Czech Republic. So what should happen to the points of Czechoslovakia? We could credit each of the successor states with those points, split them up in some fashion, or simply have each successor country start from 0.

Another case like this is Yugoslavia, with fourth place finishes in both 1930 and in 1962. Yugoslavia broke up into (eventually) six different countries.

There is also Germany, which played as East and West Germany from 1950 to 1986, with West Germany winning the Worldcup twice, in 1954 and in 1974. Germany is of course one of the contenders for "best of all time", so this issue is important. Luckily for us, East Germany never did better than West Germany in any Worldcup, so we can just equate Germany with West Germany.

The issues discussed above essentially come about because our data has changed over time. So we need to adjust our ranking formulas to fit those somewhat different records from the past. Such adjustments for unusual cases is again something we have to do in many statistical analyses. In our case what is a reasonable choice depends of course on the history of the Worldcup. And there we find another guideline: as much as possible these choices should be made by the experts in the field, not by the statistician. This is of course not a grand revelation, the same is true for many steps in a statistical analysis.

5 Stars

If you look closely at the outfit worn by a national team you can see that they all have the national crest over the heart. Also some countries have some stars over the crest. This is explained in the FIFA's equipment regulations, where section 18.2 states: 'Those Member Associations that have won the FIFA World Cup may put a symbol on the playing shirt representing this accomplishment and the number of times won.' So Brazil has 5 stars, Germany and Italy have four and so on. But then check out the jersey of Uruguay, it actually has 4 stars, although they won the Worldcup only twice, in 1930 and 1950.

Well, not quite. The history of the Worldcup actually begins 10 years earlier, when FIFA decided to accept the football competition

in the Olympic games as an official Worldcup. The first tournament in 1920 ended in disaster, when Czechoslovakia walked off the pitch in the middle of the final game against Belgium because they felt the umpire was treating them unfairly. They may not have been wrong considering th the games were held in Antwerp, Belgium! The tournaments in 1924 and 1928 were both won by Uruguay, the best team in the world at that time. Then FIFA and the International Olympic committee could not agree on the use of professionals in the Olympics, and so in 1930 FIFA organized its own Worldcup. In 1950 FIFA revised its constitution and formally recognised that Uruguay were four-time world champions. It is not clear why Belgium did not get recognized for their win in 1920, after all it was not their fault that Czechoslovakia didn't finish the game and they did get the gold metal. Maybe they should get a star (and in our ranking the points) as well?

6 Sensitivity Analysis

So we see that even for as simple a questions as how to rank the teams participating in the Worldcup we have to make many choices, most of which can not be justified on any theoretical grounds. One thing we can do, though, is to see what effect these choices have on the outcome. So let's do the following "sensitivity analysis". We will consider the following variations, some of which do not change all of

our three ranking formulas: winner gets triple points (48), third place gets 12 points, Worldcups prior to 1950 do not count, 2 points for quarter finalists prior to 1986.

With these variations we get a total of 27 formulas. Calculating all of them we find that Brazil and Germany are always either first or second. Italy is always at least third and is tied with Germany for second only in the case of the winner takes all formula.

7 Is there a Time Trend?

Let's have a look at how the rankings have changed over the years. For this we will use our "double rule", calculated from 1930 up to the n^{th} Worldcup. Of course over time the points total increases, so in order to make them compatible we will scale the points so that the best team after each Worldcup has a score of 1.0. We will then draw a graph of Score vs Year.

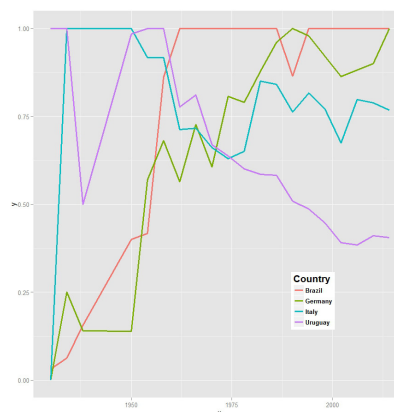


Figure 1: Scores of those countries that were #1 at some point in time

Again though, we need to make a decision: How many countries should we include in our graph? Clearly using all of them is not feasible, and there are a number of reasonable choices: we could include all the countries that have ever won a Worldcup, all the countries that at some point were #1, just Brazil and Germany as the contenders for best team right now, or some other criterion. This choice is somewhat less serious as those discussed before because it won't change the ultimate choice of best team, but different choices can still lead to different impressions. In figure 1 we have this graph, where we include all the countries that at some point were #1: In figure 2 we have the same graph, but now with Brazil and Germany alone and starting in 1954, the first year either of them won a Worldcup.

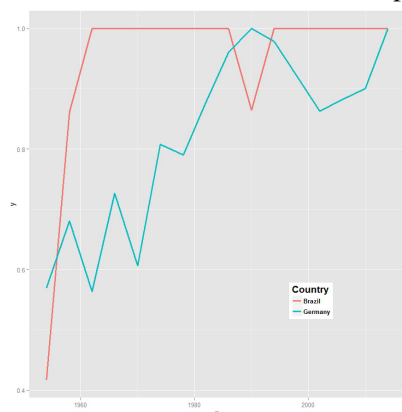


Figure 2: Scores of Brazil and Germany, from 1954 on.

This graph shows quite well (and better than figure 1) that Brazil has been on or near the top for a long time, thanks in large part to winning three Worldcups in 4 tries between 1958 and 1970 (the

Pele years!), but that Germany has been closing on them ever since. With the next Worldcup played in Europe (Russia) the odds are good that Germany will in fact move ahead. If we count only the tournaments held in Europe, Germany has 152 points versus Brazils 71, a distinct advantage.

8 Conclusions

As we have seen, even a simple question such as which country has been the most successful in the Worldcup can not be answered without making some subjective choices, and reasonable people can disagree on the answer. This is very common situation in Statistics. It is not a pleasant one. We have given a couple of common sense guidelines for handling this type of situation: first if possible these decisions should be made by the subject experts. Second we should make changes to a "basic rule" only if it seems absolutely necessary to do so. One final suggestion is an option available to us only recently: we should consider writing an "extended paper" to the official publication. Such a paper could describe in much greater detail than is possible in a peer-reviewed publication all the "little" choices we had to make in an analysis, and why we made them. This extended paper would then be available online, maybe even along side the official one on the publishers website. There have been numerous discussions in recent years concerning the reproducibility of scientific

research, a cornerstone of the scientific method. One reason (among many others) why it is difficult to reproduce other scientists research is that it is difficult to know what they did exactly from the official publication. So such an extended publication with many more details would be helpful with this issue as well.

As to the answer to the question posed in the title, as of 2014 it seems most prudent to declare a tie between Brazil and Germany!