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# Mo' Money Mo' Points: World Cup Skiing Success in Relationship to GDP Per Capita, Population, and Snowfall

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# World Cup Skiing Success in Relationship to GDP Per Capita, Population, and Snowfall

By

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# Abstract

This paper analyzes the results from the last 12 seasons of the FIS Alpine World Cup, in order to explore what demographic and economic characteristics have the most predictive power in determining success. The empirical model is formatted based on previous literature focused on predicting countries' success at the Olympics. The results indicate that GDP Per Capita is the most significant variable when predicting success. It is followed by population. Surprisingly the snowfall variable was not significant. The final results suggest that in order for countries to outperform their demographic and economic characteristics they must aggressively fund their alpine teams.

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## 1. Introduction

Ski racing only reaches the center of American consciousness every four years during the Winter Olympics when superstars like Lindsey Vonn and Bode Miller take center stage. However, these superstars normally compete at the World Cup which is an annual occurrence. While the Olympics themselves are a frequently studied there is no specific literature on alpine ski racing success (Bernard and Busse, 2004, Mitchell et al., 2012)

Although the World Cup is undoubtedly an individual sport in which there can only be one winner, whether for the overall title or an individual race it is also a team sport due to the training and funding structures used, where funding is allocated at a team level to athletes that meet the performance guidelines. Consequently, literature developed to predict the outcomes for the Olympic games can be easily revised to accurately predict factors that lead to success on the World Cup circuit both at an individual level and a country level. The theoretical foundations for predicting outcomes in winter sports were established by Pfau (2006) and Doncel and Otamendi (2014). Both of the papers focus exclusively on the Winter Olympics, which most closely mirrors the competition found on the World Cup tour.

Pfau (2006) and Doncel and Otamendi's (2014) approach struggles to predict the outcomes for individual athletes without the addition of individual level variables. It has however, created the ability to see both demographic and economic traits at a country level that lead to success on the World Cup. I hypothesized that GDP Per Capita, snowfall, and population would be the most important factors in predicting the outcome of the World Cup. These variables come from the supporting Winter Olympic literature (Andreff, 2013, Ali and Johnson, 2004, Pfau, 2006), which has found them to be extremely accurate at predicting Olympic medal counts. I have also added the Gini Coefficient, to measure the inequality between countries that are otherwise demographically similar. The first set of regressions uses panel analysis to examine World Cup results based on each athlete's total seasonal points, in addition to the variables above the individual-specific variable of gender. The second set of regressions uses the average total points per nation as the dependent variable and the country level variables are used as independent variables. The last regression is a cross section of the 2017 season, the cross section is used to examine further individual-specific traits. The cross section uses individual points from 2017 as the independent variable, the same independent variables as the first set of regressions with the addition of age and age squared for additional individual-specific explanatory power.

The initial findings are consistent with the literature on the Winter Olympics that finds GDP Per Capita is the most important variable in predicting Olympic success (Andreff, 2013, Ali and Johnson, 2004, Doncel and Otamendi, 2014, Pfau, 2006). GDP Per Capita was consistently the largest coeffeicent, although it was not always positive as predicted. Population was not as statistically significant as predicted. It was only statistically significant during the individual level regressions. In the individual level regression population has small coefficients that shift between positive and negative. These findings are in agreement with Pfau's (2006) findings of populations effect on the Winter Olympics. The most surprising result was the fact snow fall was not significant either statistically or numerically since the coefficient was too small to make a measurable difference; these results contradict the findings from the literature on the Winter Olympics (Andreff, 2013, Doncel and Otamendi, 2014). The Gini Coeffecient which was introduced to diversify the otherwise homogeneous countries did not have significant explanatory power, with signs often appearing as positive meaning more unequal countries were favored contradicting Groot (2012) findings.

By examining factors that contribute to success in World Cup skiing, this study explores a previously unstudied area of sports economic literature. World Cup skiing differs from the Olympics in that it is an annually occurring series of races, instead of individual races that occur once every four years. This work could easily be taken and applied to snow sports such as cross-country skiing or various free skiing disciplines. This paper looks to define what socio economic and political factors as well as certain individual characteristics best determine a country and individuals level of success on the World Cup tour. It also significantly adds to the body of literature focusing on the sport of alpine skiing which has previously only been studied in the context of behavioral economics, using the theory of left digit bias to analyze the results of races (Foellmi, Legge, and Schmid, 2016). Thus, this paper provides an expansion on an understudied area of sports economics and it also paves the way for future research on the World Cup circuit and factors contributing to success.

The rest of the paper is organized as follows: section 2 provides background information necessary to understand the sport of ski racing, section 3 is a survey of related literature, sections 4 and 5 described the data utilized and the analysis methods. Sections 6 and 7 talks about results and discusses their place in the literature respectively, and section 8 offers concluding remarks.

## 2. Background

Ski racing is a niche sport that, although popular in certain parts of the world, such as Europe, remains largely unknown to the rest of the world. While skiing is an individual sport, it is funded and organized by each country's National Governing Body (NGB). The NGBs vary in size and scope depending on each country's level of involvement in skiing. Funding for the NGBs varies in its source, some countries such as Norway, receive almost all of their funding from the government. Other countries such as the United States, receive no funding from the government and all of their funding comes from either donations or sponsorship deals. Skiing is a big business in Europe that garners sponsorship not just from various ski related brands but also from major international brands such as Audi. Skiing also creates primetime sports channels in Europe and has a large following of premier events garnering nearly a hundred thousand spectators (Dauer and Salmina 2014). The NGBs have different organization sectors that manage different parts of the snow sports that they oversee but for the purposes of this paper the focus is just on the alpine ski racing sector.

The World Cup circuit on which this paper focuses is the most elite level of ski racing comparable to the Grand Slam tour of tennis or the Masters tournament of golf. The World Cup is split into men's and women's tours, races that with a few exceptions are held at different stops and courses. The women's tour has 21 stops and 39 races and the men's tour has 19 stops and 37 races.

The World Cup tour is made up of six different events: the city event, slalom, giant slalom, super g, downhill, and combined. The city events, slalom and giant slalom are all disciplines known as the technical (tech) events. The reason for this is that there is less speed involved as the gates that racers are required to go around are set at shorter intervals; there are subsets of skiers that specialize in these tech disciplines. The tech disciplines also feature two runs with the top thirty racers from the first run coming back in reverse order for the second run with the two times being combined to determine the winner. In contrast, super g and downhill are considered speed disciplines as the gates are set much further apart and racers achieve far higher speeds, additionally each race consists of only one run. The combined races are a combination of tech and speed, running one run of the downhill which is the fastest of the speed disciplines, and one run of slalom the most technical type of course. The times from each run are added together to determine the winner.

The World Cup circuit is run by the international governing body for skiing, the International Ski Federation (FIS). FIS creates all of the rules that govern the sport of ski racing and controls the Word Cup. The current World Cup format was implemented in 2005. The way World Cup titles are decided is by adding all of the athlete's World Cup points together adding points together for each discipline, as well for an overall title. At the end of the season individual titles are handed out in each event, in addition to a title for the overall best male and female skiers. Traditionally, the overall title has been won with points ranging between 1600 and 2000. Points are awarded for the World Cup in descending order to the top thirty finishers, first place receives 100 points, second receives 80 points, third 60, and thirtieth receives 1 point.

## 3. Literature Review

### 3.1 Skiing Literature

There is very little literature of any type available regarding skiing as a sport. Winter sports in general are a largely ignored area of study in the field of sports economics. The topic of alpine ski racing has not even been explored in sports economic literature with the exception of a few sentences on alpine ski racing in papers on the Winter Olympics.

An area that has been explored in the literature is ski resorts, and the majority of literature focusing on ski resorts focuses on climate change. Climate change has had a negative effect on the ski industry; the average price of real-estate surrounding ski resorts has decreased. This is due to the fact that in resorts where snowfall is uncertain climate change has further reduced certainty of snowfall, depressing real-estate prices and hurting the ski areas (Butsic et al, 2011). Another result of climate change is the average ski resort size is increasing as warmer winters force smaller resorts to close, due to the cost of snowmaking. The reason that larger resorts are better able to survive is that they are able to invest in more efficient snowmaking infrastructure required to produce snow in warmer temperatures (Beaudin and Huang, 2014). Resorts at lower altitudes are also vulnerable to the increasing temperatures due to the lower elevations which tend to have higher temperatures to begin with (Dinca, Micu, and Surugiu, 2010). A common variable used in ski resort literature is snowfall because it is critical for the success of the ski resorts as well as measuring climate change.

There are also individual papers in behavioral economics that study risk taking behavior in alpine ski racing. It is found that athletes who perceive they are close to the leaders after the first run of the race will adopt a riskier strategy in the second run. In fact, they are better served by maintaining the same strategy from run one which is more likely to allow them to finish the race. This is a result of left digit bias which causes athletes to be more focused on the left number and therefore misinterpret distances, thus causing them to perceive nine hundredths of a second to be significantly smaller than ten hundredths of a second (Foellmi, Legge, and Schmid, 2016). Another article that studies the competitive aspect of skiing looks at career duration in ski jumping. Frick and Scheel (2016) find that three factors affect career duration. First, and the most important factor, is an athlete's success on the World Cup circuit each year. Second, superstars, i.e. former world champions and Olympic medalists, are likely to experience longer careers. Third, athletes from highly competitive nations have shorter careers than equally talented athletes from less successful nations (Frick and Scheel, 2016).

While there is no specific literature on alpine ski racing success, literature regarding economic variables contributing to Olympic success can be applied to alpine skiing. The reason for the overlap is that elite skiing is featured heavily in the Winter Olympic games; therefore, there is a large amount of correlation of the economic variables that contribute to success on both the Olympic stage and the World Cup circuit. Also, skiing is a resource intensive sport where success derives from focusing the same level of resources on skiing as on other resource intensive Olympic Sports, such as hockey. This makes the models developed to predict Olympic success in the literature extremely valuable in the quest to predict success on the World Cup circuit.

**3.2 General Olympic Theory**

Mitchell et al. (2012) study the effects of international championships on the basking in reflected glory (BIRG) effect and nationalistic pride. The BIRG effect is proven robust as it has been established sporting success contributes to general public happiness (Kavetsos and Szymanski, 2010). Borden et al. (1976) establishes, using collegiate football teams, that the BIRG effect is robust and students are more likely to wear their universities apparel after the football team is successful. The BIRG effect is further established by Kommer et al. (1987) who find that, following a World Cup win by the German National Soccer Team, German citizens report higher levels of life satisfaction. The BIRG effect is proven to be robust and elicited by the success of national sporting teams, incentivizing government spending on sports teams. The effect is relevant at a national level when it attaches to specific teams influencing government funding for athletics. Funding increases dramatically for national teams leading up to Olympics held on home soil (Mitchell et al., 2012). The BIRG effect has not been studied over the entire season, but it has been studied at the individual events. It will be interesting to see if the BIRG effect continues to be relevant over the course of an entire season.

Mitchell et al. (2012) find that GDP, population, birthrate, fertility, life expectancy, and dummy variables measuring nations' political leanings could be used to predict medals won in the Summer Olympics. However, of these variables, GDP and population are mostly static when compounded across countries and may not be changed in the four-year span between the games. Mitchell et al. (2012) found that to truly change the outcome and increase national medal counts, government funding was needed. Government funding targeted at elite sports was found to have a highly significant effect on medal outcomes. The article also uses game theory to analyze political gain based on athletic success, motivating governments to fund national sports teams. Mitchell et al.'s (2012) OLS regression comes from the Mitchell and Stewart (2007) paper on predicting sport success using OLS regressions. Mitchell and Stewart (2007) was a seminal paper on predicting international sporting outcomes, such as the Olympics or FIFA World Cup.

Bernard and Busse (2004) is another influential paper on predicting Olympic outcomes using medal totals from 1960 to 1996. They study determinants of a country's Summer Olympic success based on GDP Per Capita and population. In order for a country to generate a high medal count, it needs both a high GDP Per Capita and a large population. This is because a large population is needed to have a large pool of talent and a country needs to be wealthy to dedicate money to sports. They find that a high population alone does not grant Olympic success, rather government support was also found to have a role in success. This was shown by the Soviet Union and other Eastern Bloc countries winning 3% more medals than predicted due to government funding (Bernard and Busse, 2004).

The first assumption that Bernard and Busse (2004) make is that medals won should be proportional to total population of the country. Though population does explain some of the results, it does not serve as a satisfactory measure because of countries such as China, which has a large population but has not won many medals. According to a model based solely on population, China should be winning a high volume of medals due to its large population but it does not. The second model is more accurate when predicting each country's medal count because it takes into account both population and GDP. While the Bernard and Brusse (2004) paper does a good job of predicting medal counts based on GDP and population, they focus almost exclusively on population and GDP, only briefly considering state sponsorship as a variable. State sponsorship and the political environments in individual countries are not considered in the equations, leaving out possibly important factors in explaining Olympic results.

Ali and Johnson (2000) consider how participation and results have changed in the Summer Olympics between 1956 and 1996. During this time period, the Olympic Games transformed from a relatively small international Western-focused event to the true show of international cooperation and sport that they are today. The paper differs from the Bernard and Busse (2004) article because of the built in four year lag variable of past Olympic success. Past Olympic success is an extremely effective predictors of future success; countries that have led the medal count in the past are more likely to lead it again, instead of relying purely on economic predictors. The use of past Olympic success as a predictor of future Olympic success makes sense due to the fact that even if a country starts to heavily invest in sports there will be a lag of a few seasons as athletic talent is developed. The host nations have also proved to be more successful due to the role of the crowd (possibly due to BIRG effect) and that host nations tend to send a larger number of athletes. The success of the host nations can also be explained by the increase of government funding leading up to the games due to politicians attempting to use the BIRG effect and the "feel-good" factor to increase their chances of reelection. The "feel-good" factor is credited to two distinct factors; first being that national sporting success leads to increased life satisfaction among citizens, and second being that hosting international sporting events increases life satisfaction regardless of national success (Kavetsos and Szymanski, 2010). The "feel-good" factor also serves as a motivation for Olympic sponsorship at a national level.

Ali and Johnson (2000) are able to quantify what it takes to increase each individual medal won by a country in terms of population and GDP Per Capita. They find that on average population plays a bigger factor in medal success than GDP Per Capita, although GDP Per Capita still plays an important role in Olympic success. They also find that female participation has significantly risen across time although women mostly come from the wealthier nations. While the host nation also has a significant advantage, it is interesting to note that the host nations tend be large wealthy nations that already experience significant Olympic success. Familiarity is another possible hypothesis for the host countries' success and for the fact neighbors also record an increased medal count. It helps the host country athletes because they do not have to adapt to different surroundings and will presumably have already trained at the venues where Olympic competition is held. This familiarity also extends to the neighboring countries that will not have to adapt to a new climate or time zone. This familiarity becomes even more important in the Winter Games when venues and terrain play a major role in the results. An interesting point to note is that the results most likely also motivate national funding and training opportunities for athletes.

The variables for models discussed in the above papers work as a basis for looking at skiing results. The key parts of the models discussed before are GDP and population, both of which are needed in order to accurately evaluate a country's chances for success on the World Cup tour. Given the above findings, I hypothesize that a high GDP and population should positively affect a country's outcome on the World Cup tour.

**3.3 Winter Olympics**

In Ali and Johnson's follow up 2004 paper, they look at the motivations behind nations participating in the Summer and Winter Olympic Games, and what factors determine the success of these nations. The paper uses the same determinates such as GDP per capita and population but also includes environmental and political climate of each country. In addition to looking at the environmental and political climate of each country, Ali and Johnson (2004) hypothesize that along with population and GDP Per Capita, the country's environmental and political climate will also play a large role in success, especially in the Winter Games as opposed to the Summer Games. They also look at the level of participation by each country, such as the number of athletes sent, and the number of events competed in, not just the total population. These findings contrast from previous literature that solely focuses on the Summer Games.

The analysis found that countries with lower populations actually outperform more highly populated countries in the Winter Olympics. Climate also plays a much larger role in Winter Olympic success because countries with colder climates have an advantage. Ali and Johnson (2004) found that single party governments' and regimes' athletes excel not because these countries send more athletes, but instead because individual athlete wins more medals than statistically predicted. Ali and Johnson (2004) did encounter endogeneity issues in their model with the use of the host nation variable. The host nation variable creates endogeneity issues due to the fact that the host nations from the sample period are wealthy developed nations. It is therefore unclear if the host variable is responsible for their success or it can just be attributed to their high GDP.

Pfau (2006) focuses on only the Winter Games. The results are similar to those of Ali and Johnson (2004) both found that population plays a smaller role in medal count than GDP Per Capita. Pfau uses a logarithmic variable for GDP Per Capita and population because these variables do not follow a linear growth pattern, it also serves to rescale the variables to better fit into panel analysis. The most interesting addition Pfau (200) makes to Bernard and Busse's (2004) model is the addition of geographic variables, such as the climate conditions of each country, to further identify the countries with existing infrastructure and sporting tradition.

The most striking finding is that population is not found to be a significant variable unlike in the Summer Games. A possible explanation for this is twofold: 1) winter sports tend to need colder climates; and 2) the countries that possess these colder climates tend to have smaller populations. Intriguingly, GDP Per Capita is also found to be not significant, however, the reason for this is the number of country specific variables included in the model. Without the country specific variable GDP Per Capita becomes significant. Interestingly, the geographic variables are highly significant. However, Pfau (2006) does not take into account the number of participating athletes from each country when predicting medals only geographic location, population, and GDP Per Capita. This is a significant limitation due to the fact countries send varying amounts of athletes, making the total athletes a substantial concern when calculating predicted medal tallies.

Doncel and Otamendi (2014) also focus exclusively on the Winter Games. Doncel and Otamendi use Panel analysis for their analysis. They input a combination of the established variables of GDP Per Capita and population. Doncel and Otamendi (2014) take it a step further by taking into account the athletic history of the country and past performance in each of the sports in accordance with Ali and Johnson (2004). This is highly relevant, due to the fact that success by longshot nations can possibly be explained by economic factors instead of their past performances. The countries are also segregated into winter and non-winter based on geographic location and climate. In order to create an accurate predictor for the 2010 Winter Games, the authors used data collected from 1992 to 2006.

While results were largely as expected, the United States delivered a surprisingly dominate performance in alpine skiing, creating the largest deviation from predicted medals. One explanation for this result is the finding that the neighbor of the host nation along - with the host - has a sizeable advantage due to geographic proximity (Ali and Johnson, 2004). It is also found that the Winter Olympics have a much less diverse group of countries who win medals with all of the medals being won by only 23 countries. Unsurprisingly, all of the winning countries have large sporting traditions and have a high GDP. Interestingly, more countries specialize by sport in the Winter Olympics and produce dominating performances. While the models are accurate based on the data, they can be affected by a number of outside factors such as weather and extraordinary efforts by an individual athlete. This particular model is more vulnerable to these difficulties due to its by sport nature. The authors also identify that they have not fully looked at countries with a strong tradition of specializing in certain sports, therefore creating a bias in the data due to success not explained by traditional measures.

Andreff (2013) creates a model that takes into account countries specialization in certain sports by providing an even closer look at the infrastructure behind winter sports. Instead of just focusing on a region to explain success in the Winter Olympics, Andreff (2013) also looks at a number of other developmental markers that can lead to Olympic success. One of the key variables in Andreff's model is a variable that tracks winter snow coverage and the length of snow coverage in each of the countries. He groups the countries into polar, high, middle, and low snow coverage (Andreff, 2013). The dummy variable used in the context of the World Cup is valuable as it tracks the density of snow coverage in each of the countries that participate in Winter Games. The dummy variable can also be easily converted over to ski racing, as snowfall is essential for participation in the sport.

Obviously, countries with a high density of ski resorts will be at a distinct advantage over those without. The results are interesting however, and contrast with the previous literature. Snow coverage and length of snow coverage is not a significant variable in countries success at the Winter Olympics. The density and number of ski resorts is extremely significant and increasing ski infrastructure is closely tied to increasing Olympic success; Andreff (2013) therefore concludes that climate tied with infrastructure is the most influential variable to Olympic performance. The variable of snowfall and winter infrastructure is particularly relevant to the World Cup since skiing is a sport that depends heavily on infrastructure and natural snowfall to make the sport accessible. Population can only explain so much. If a large population does not have easy access to the capital required to participate in skiing at a young enough age to gain the skill necessary to compete on an international stage.  It must be stated the countries that are likely to have a high density of ski resorts are countries in high snowfall areas. This creates a dilemma in which you cannot have a high density of ski resorts without high snowfall. Therefore, Andreff (2013) does not give enough credit to how the majority of the wealthy countries in the proper climate will have a high density of ski infrastructure, meaning the previous variables of wealth and climate data should prove sufficient. I hypothesize that snowfall will have a positive effect on a country's success on the World Cup circuit.

**3.4 Inequality in Olympic Success**

Pershin and Tcha (2003) go back to examine the Summer Games. They use a neoclassical model to determine the amount a country should invest in sports teams in order to receive the highest return on investment. The use of the neoclassical model detailing the endowment effect changes the way the Olympics are typically looked at and provides a new model. The model uses neoclassical trade theory to examine the relationship between the relative intensity of commodities, the relative endowment effect, and trade patterns. Countries are found to invest and specialize in specific sports in which they feel they have a competitive advantage. Pershin and Tcha (2003) also provide a fresh perspective from which to look at Olympic success Revealed Comparative Advantage (RCA). According to the endowment effect, countries have limited amounts of capital and labor. The ratio of capital to labor should affect the sport each country should concentrate their resources on. It also takes into account that some countries have greater access to capital and labor. Certain countries' greater access to resources carried over to the regression model, which takes into account the physiological characteristics of each country.

The results of this model are unsurprisingly different from the standard model based off of GDP per capita and population. Pershin and Tcha (2003) create a RCA table across various major Olympic medal sports such as swimming and athletics. Each of the countries that they look at are found to have a significant comparative advantage in certain sports based on physiological characteristics of the country's population. It is also interesting to note that while a higher income does not necessarily mean that an individual country will win more medals, it does mean that they will win them in a more diverse set of events. It is important to keep in mind that while these results are significant they do not take into account a reward system instituted by countries for athletes based on medals won or government funding of sports.

In an attempt to combat the fact that Olympic success is so heavily based on a country's level of wealth, the International Olympic Committee (IOC) places a ceiling on the number of athletes that can represent a country in each event, capping the team size of the most dominant countries (Lui and Suen, 2008). This leads to athletes switching nationalities in order to represent other nations. The IOC tries to limit the international mobility of athletes through a combination of monetary and legal penalties. Many of the wealthiest countries are able to bypass these restrictions for athletes in their quest for Olympic gold. Thus, rich countries have a better chance of attracting star foreign athletes.

Lui and Suen (2008) find that OLS estimations of medal prediction are based downwards due to the fact that many countries have never won a medal. To combat the downwards bias, the authors used the tobit model which is able to censor the data to include the athletes that are on the threshold of a winning medal and not including all of the athletes that are below the medal winning threshold. Lui and Suen (2008) find population and GDP Per Capita are significant as does the rest of the literature. Lui and Suen's (2008) results differ from other papers in the findings that education and life expectancy are found to have no significant effect on the number of medals earned by a country. It is also found that there are strong country specific effects on the medal count. Lui and Suens (2008) results are possibly explained by a strong sporting tradition in those countries as mentioned by Doncel and Otamendi (2014). Lui and Suen (2008) do a poor job of answering their central research questions: what is the international mobility of athletes and to what extent do athletes switch the countries for which they compete? While they do find that high income countries experience greater success, Lui and Suen (2008) do not answer the question of which athletes are responsible for this success.

The fact that the Olympics favors the rich has been well established through extensive findings of GDP being a highly significant variable (Ali and Johnson, 2000, Bernard and Busse, 2004). The numbers backing this fact are startling: the top 9 medal winning countries winning roughly half the gold medals only contain 14% of the total world population (Groot, 2012). Groot's (2012) findings align with the previous literature that has found that Olympic medals are distributed proportionally to the world's income. The medals fit along the Lorenz curve, which is used to visualize inequality on the income curve, with a highly unequal distribution that heavily favors the wealthier countries. The Gini coefficient of Olympic success for the 2004 Summer Games is extremely high 52.7% this means that the wealthier countries had a disproportionate level of success. These results are hardly surprising given previous literature that found population and GDP are the two most important predictors of Olympic success, which none the less makes the level of inequality shocking (Groot, 2012). Although there is less inequality between countries that participate on the World Cup tour than between countries that participate in the Olympics, there is still a disparity between internal inequality in the countries. The method used to measure countries internal income disparity is the Gini coefficient based on income among citizens. All of the countries that participate in the World Cup fit into similar characteristics, being for the most part western highly developed and wealthy countries. The Gini coefficient serves to differentiate the countries by measuring inequality within the countries. I hypothesize that the lower the Gini coefficient the more successful a country will be on the World Cup.

**3.5 The Role of Government Regimes**

Olympic success can be equated as a zero-sum game, meaning that one country's success comes at the cost of another's. This success can be manufactured through a combination of government support and the level of wealth within a country. The variable for governmental support is particularly significant and can be used to explain the success of the socialist and communist countries prior to their demise (Groot, 2012). Olympic success is also a public good because all members of society equally benefit from the success (Lui and Suen, 2008). In particular, communist regions support sports on a world stage, for example, the Eastern Bloc still displays high success rates as a result of high government investment into athletics. It should be noted that the current small communist regimes such as North Korea do not experience this same level of success. It has been hypothesized that the reason for this is that they are not nearly as wealthy or globally prominent as former communist countries such as the Soviet Union and the German Democratic Republic. The current communist countries do not view sports as a global currency and are unable to invest, whereas these former powerhouses viewed international sporting victories as a global currency and a sign of strength (Leeds and Leeds, 2009).

Sports, especially in Soviet Russia, and by extension the entire Eastern Bloc, were extremely important. Sports were used to rally the population around ideas and the current political party. The Soviets also viewed sports as a means of cultivating diplomatic relationships and undermining democracy.  Leaders viewed athletic success as a key piece of foreign policy and used sports to demonstrate the superiority of the communist system. Their unprecedented level of success was a result of the "totalitarianization of national sports systems" (Riordan, 1974). Total control of the state allowed for an enormous amount of resources to be devoted to sporting success, a phenomenon that can only be accomplished in a single party system (Riordan, 1974).

The communist system of state funding to elite sports has in recent years spread beyond the now defunct communist systems and been adapted by democratic western nations. A factor that has been found to be shared by all elite athlete development systems is appropriate sponsorship and funding either from the state or private corporations. The sponsorship supports clear talent identification and development system, well-developed and successful coaching staffs, and specific elite development facilities. As other countries develop their elite sports programs, the elite sports themselves have become increasingly commercialized as both a monetary and political currency, which is an example of politicians capitalizing on the BIRG effect (Houlihan, 2009).

**3.6 Success as a Display of International Status**

Sports have also become increasingly globalized with National Governing Bodies (NGB) overseeing the actual development of the athletes, and international bodies organizing the events and enforcing the rules. Examples of this are the International Olympic Committee (IOC), and the International Ski Federation (FIS), as well as the World Anti-Doping Association (WADA). These international institutes, especially WADA, are examples of the stronger nations exerting their dominance and enforcing the status quo. It has been argued that by fighting to eliminate doping the stronger wealthier countries are further widening the gap by preventing other countries from doping. Doping is the quickest and cheapest method for less successful countries to find success on the international playing field. This has resulted in increasing similarity across the successful wealthy countries in their elite sports development programs and NGBs, regardless of whether the NGBs are government funded or not. Finally, it is important to note that the current system places the power in the hands of the more successful powerful countries who have a greater chance of creating and influencing the international bodies. The wealthy countries have the necessary resources to remain in compliance with international policies in the least disruptive way to their training regimes as possible (Houlihan, 2009).

Sports are increasingly being used to incite national pride and assert national dominance. Interestingly nationalistic pride is found to be minimal during regular international play, whereas Olympic success is much more a point of nationalistic pride on an international playing field; with Olympic medals becoming a form of international currency. It is also interesting to note that while technically Olympic medals are a zero-sum game, they are not viewed as such by countries who view it as a more stable display of power (Elling, Hilvoorde, and Stokvis, 2010)

### 3.7 Contributions to the Literature

The sport of ski racing has not been explored in sports economics and there is currently no literature looking at what factors contribute to a country's success on the World Cup tour. I propose using the literature established to predict the success of nations at the Olympics and transfer it to predicting success on the World Cup circuit. This model will use GDP Per Capita, population, Gini coefficient, previous success, and data on snowfall in each country to predict a country's future success in the World Cup tour. I hypothesize that in order for a country to be successful on the World Cup, they need to have a high GDP Per Capita, a moderate population, a low Gini coefficient, and a significant amount of snowfall.

## 4. Data Description

The majority of Olympic literature with the exception of Bernard and Busse (2004) who use a Poisson model, uses a basic Panel analysis. The existing Olympic literature holds constant to a few standard variables which are population, government structure, and GDP Per Capita (Doncel and Otamendi, 2014, Pfau, 2006). These variables are then inputted in a basic Panel analysis, with the addition of variables that are unique to each paper.

The World Cup provides a denser collection of data since it is an annual occurrence with a multitude of events each season. The collection of data allows for a larger sample size because more athletes participate, unlike the Olympics where countries are restricted in the number of athletes they are allowed to send to each event (Lui and Suen, 2008). While this does increase the number of athletes participating, the diversity of countries shrinks compared to the Olympic games. One reason for the decrease of diversity among countries is the sheer number of athletes competing on the World Cup circuit. I have limited the number of countries that are included. I did this to screen the data and only include countries that are consistently producing strong athletes. This is similar to what Lui and Suen (2008) did using the tobit model, to screen their sample pool. Both methods remove all of the athletes who are just competing in the event and are not at a threshold to succeed in a meaningful way. The criteria is that in order for countries to be included in my dataset they must have produced at least five athletes with at least one top thirty finish. While this does reduce the number of countries from 43 to 22 it provides a more representative sample of countries that have invested in the sport and hold the necessary resources it takes to be successful.

The Olympics only occur once every four years, and countries are able to make significant changes to funding of athletes and infrastructure. This means that countries can dramatically increase the strength of their teams and programs in the four-year period between Games. The Olympic literature also uses lag variable to create an even longer period of time in order to explain the growth periods of teams. The World Cup circuit is an annual event, therefore a lag variable is even more necessary to account for improvements by teams and to give emerging teams time to mature and be able to compete. The lag period is the reason for using data that spans 12 seasons, so changes in team make-ups can be fully captured. It is also a long enough period to accurately rank teams. This means that it is longer than a single athletes typical period of dominance, ensuring that the leading countries have the strongest overall programs instead of just a single exceptional athlete.

My main dataset is downloaded from the International Ski Federation (FIS). The dataset includes the results of every single race on the World Cup circuit from 2000 to 2017. I use observations starting in 2005 since the current system of points was only implemented in 2005. Currently, points are awarded for each individual race, and then athletes accumulate them for individual discipline titles and the overall World Cup title. The variable total points are based on the total points each individual athlete earns over the course of a single season. Some athletes only compete at the world cup level for a single season so they will only appear in the dataset once while other athletes may compete on the World Cup for all 12 of the seasons my dataset covers. FIS identifies each racer by a unique number allowing for the data to be effectively individualized. The individualized ID number allows for racers to be tracked over their entire careers even if their names change. This is especially helpful in long term datasets like this one in which individual racers might change their names, as it provides continuity and accuracy to the dataset. The dataset also includes racer's gender, date of birth, and nationality. The gender variable and date of birth are both valuable as they help to provide a more complete picture during the individual level regressions. Nationality is a necessary variable as it allows for athletes to be segregated by countries and the regression to be created at a country level.

The first additional dataset I am using is a combination of demographic and country specific data at the yearly level. The variables GDP Per Capita, population and Gini coefficient for each country came from this dataset, which is compiled from the World Bank.  GDP Per Capita is an important variable to include due to the fact that a country's wealth is an important indicator of its ability to invest in sports, specifically an expensive sport such as skiing. GDP Per Capita is measured in weighted 2018 US dollars. GDP Per Capita is used instead of GDP because the use of GDP violates the assumption of no heteroscedasticity in panel analysis. This is because when GDP is being compared to population it is just a single large number. GDP is unequal across the range of values that is a country's population, therefore it needs to be broken up into GDP Per Capita so the range of values are equal (Studenmund, 2010). Population is used because there is a certain size of population needed to produce athletes of an elite caliber. A larger population predicts a better chance at success, which is a fact that proven at all levels in literature on the Summer Games, however for the Winter Games a larger population is good to a certain extent, but extremely populous countries have been proven to be at a disadvantage (Pfau, 2006). The Gini coefficient is being included due to the fact that countries with higher levels of equality should be able to produce more athletes as skiing will be more accessible to a larger number of people.

The second dataset is the snow data; this tracks the snowfall in the twenty-two countries from the FIS dataset. The dataset is from the National Oceanic and Atmospheric Administration (NOAA) and is measured in millimeters of snowfall per season. Snowfall is relevant because it is expected that higher levels of snowfall will give countries an advantage in a winter sport like skiing that requires snow. More importantly it will also make the sport more accessible for youths, leading the countries to have a larger pool of talent from which to draw from. It is also interesting to include because some countries over time have started to receive less snow due to global climate change, so it will be interesting to see if climate change causes a reduction in snowfall, and in turn less success on the World Cup circuit for affected countries.

There are three distinct datasets used for regressions. The datasets come from the same sources the dependent variable from the first dataset and first, second, and fifth regressions are the total points from each individual athlete. The fifth regression, is cross-section that takes the year 2017 from the first dataset and adds age and age squared to look at more individual characteristics of the athletes. The dependent variable from the third and fourth regression is the total average points from each country.

For the individual regression 1 and 2 44% of the athletes are female. The average GDP Per Capita is $42,402, this is a relatively high average GDP Per Capita but it make sense because all of the countries in the sample are wealthy developed countries. The average snowfall is 242.3 millimeters this not enough natural snow for ski resorts and ski racing. It is surprising as the literature predicted that these countries should have more natural snowfall. The average population is 56.5, million, this is a relatively small average populations, the average is brought down by the number of small European countries that do not have large population. In comparison to the average population of 56.5 the United States, which has the largest population in the dataset, has a population of 323.1 million. The average Gini Coefficient is 35.69% which is slightly above the world average of 31.8% according to the Organization for Economic Cooperation and Development (Table 1).

**Table 1**

| VARIABLES | (1)<br>N | (2)<br>mean | (3)<br>sd | (4)<br>min | (5)<br>max |
|---|---|---|---|---|---|
| Gender | 3,540 | 0.444 | 0.497 | 0 | 1 |
| GDPPerCapita | 3,241 | 42,402 | 12,966 | 12,898 | 178,723 |
| Snowfall | 3,446 | 242.3 | 248.1 | 0.0613 | 1,296 |
| Population | 3,242 | 5.650e+07 | 8.236e+07 | 34,852 | 3.231e+08 |
| Gini | 3,533 | 35.69 | 6.175 | 23.70 | 91.20 |
| Age | 298 | 26.77 | 4.19 | 18 | 39 |

The mean total points for each season is roughly 200 points. This makes sense due to the distribution of points an individual with roughly twenty top twenty finishes to achieve a point total of 200, the skiers have between 37 and 39 races to do this making it a relatively achievable feat. The minimum number of points earned in a year is one which also makes sense as there will be always be some athletes who only achieve one top thirty result. The mean age of the athletes in the 2017 season is 26 years and 8 months with a standard deviation of just over a year. The youngest athletes were 18 and the oldest athletes were 39 (Table 1). It makes sense that mean age is in the mid twentiess because that is when the human body is at its prime but also old enough that athletes will have had time to accumulate the skills necessary to succeed at the World Cup level.

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**Table 2**

| Season | (1) N | (2) mean | (3) sd | (4) min | (5) max |
|---|---|---|---|---|---|
| 2005 | 268 | 201.58 | 309.76 | 1 | 1848 |
| 2006 | 269 | 210.57 | 319.8 | 1 | 2200 |
| 2007 | 270 | 206.36 | 300.36 | 1 | 1822 |
| 2008 | 267 | 196.83 | 273.31 | 3 | 1409 |
| 2009 | 267 | 204.98 | 292.65 | 1 | 1988 |
| 2010 | 273 | 190.98 | 281.02 | 1 | 1831 |
| 2011 | 274 | 198.00 | 291.48 | 1 | 1922 |
| 2012 | 262 | 215.60 | 299.43 | 1 | 1980 |
| 2013 | 261 | 205.68 | 311.60 | 1 | 2755 |
| 2014 | 271 | 192.57 | 274.33 | 1 | 1583 |
| 2015 | 273 | 198.29 | 293.58 | 1 | 1888 |
| 2016 | 287 | 201.88 | 275.54 | 1 | 1794 |
| 2017 | 298 | 188.28 | 276.54 | 1 | 1866 |

## 5. Methodology

The data is going to be analyzed using a panel analysis, since a panel analysis is being used I will use the Hausman test. Only regression 5 will not use the panel analysis since it's a cross section OLS regression used to further identity the effects of individual characteristics on World Cup success. Both GDP Per Capita and population are being analyzed as a natural log variable. The natural log variable rescales the data so it has more explanatory power as to the distribution of GDP Per Capita and population. Lui and Suen (2008) use the log forms of the variables because it allows for a more accurate comparison of countries, more accurate regressions, and more descriptive graphs. Snow data is present because countries with high snowfall should have an advantage over countries with lower snowfall in a winter sport such as skiing. The Gini coefficient is present due to the fact that all 22 countries represented in the model share many characteristics as they are all wealthy, developed countries with high GDPs and the Gini coefficient serves to differentiate them.

1.

$$\text{T}otalpoints_{it} = \alpha_c + \beta_1 \, ln\_GDPPerCapita_{ct} + \beta_2 \, ln\_Population_{ct} + \beta_3 \, Snowdata_{ct} + \beta_4 \, Gini_{ct} + \beta_5 Seasoncode_t + D_1 Gender_{it} + \theta_i + \epsilon_{ct}$$

The regression uses total points as the dependent variable, the variable total points is the aggregate of each individual skier's total FIS points accumulated over the course of the season. The FIS points are computed at an individual level because some nations have a greater number of skiers than others and some nations have more successful skiers allowing a more accurate weighting of individual talent. The regression is done at a combination of country level and individual level because the independent variables are a mixture of country level variables and individual level variables. It is expected that GDP Per Capita has a positive relationship with total points. Population is interesting because the Summer Olympic literature states that it should have a positive effect on Olympic success (Mitchell et al 2012, Johnson and Ali

2000, Bernard and Busse 2004). Pfau (2006) finds that when looking at the Winter Olympics a larger population is only an advantage to a point. Therefore, given the countries in the dataset, I would expect population to have a slightly negative effect on total points. Snowfall is expected to have a positive effect to a point. Countries just need to have enough snowfall for their citizens to ski. Gini is expected to be a negative value as countries that have lower levels of inequality should better perform. These countries should perform better due to the entire country having the opportunity to ski instead of just the rich elite. The gender variable is an individual level variable and therefore doesn't vary over time, therefore the random effects model is needed to show the coefficients of the variable. The season code looks at trends in the data over the individual seasons and acts as a control for each season. The coefficients of each season do not matter due to the fact the season code variable is in place to serve as a control.

2.

$$\mathrm{T}otalpoints_{it} = \alpha_c + \beta_1\, ln\_GDPPerCapita_{ct} + \beta_2 \mathrm{L1\_ln}\_DPPerCapita_{ct} + \beta_3\, ln\_Population_{ct} + \beta_4\, Snowdata_{ct} + \beta_5\, Gini_{ct} + \beta_6 Seasoncode_t + \beta_6 L1\_Cuppoints_{it} + D_1 Gender_{it} + \theta_i + \epsilon_{ct}$$

The dependent variable is the total points from each athlete, which is the same as in regression 1. The first two variables are the log of GDP Per Capita. Both variables are in logarithmic form due to the fact the log form does a better job of explain GDP growth than metric form. The second variable is a lag of one year on the GDP Per Capita variable. The lag variable serves to explain the development stage of a country's ski program and different changes to the program by explaining current results based on results from the previous year. GDP Per Capita is expected to be significantly positive with a large effect on total point per percent change. The lag variable of GDP Per Capita is also expected to be significantly positive, with a relatively large effect on total points. Population is expected to follow the above regressions being positive to a point before starting to negatively impact total points. Snowfall is expected to have the same effect as the other regressions with it being positive to a point before ceasing to be a factor. The Gini coefficient is expected to have the same effect as regression one being negative and highly significant, due to the fact this is done on the individual level therefore a larger team can increase a country's success. The gender variable is included as a dummy variable to provide increased explanatory power for the individual data. The season code looks at trends in the data over the individual seasons and serves to act as a control for each season's effect. The variable L1 cuppoints is the one-year lag of the dependent variable total points. The lag of total points serves as an explanatory variable for individual results as it states that results are based on previous performance and results. The variable is expected to be significant and have a large positive coefficient. The season code variable looks at trends in the data over the individual seasons and serves to act as a control for each season's effect.

3.

$$Averagepoints_{ct} = \alpha_c + \beta_1\, ln\_GDPPerCapita_{ct} + \beta_2\, ln\_Population_{ct} + \beta_4\, Snowdata_{ct} + \beta_5 Seasoncode_t + \beta_6\, Gini_{ct} + \delta_i + \epsilon_{ct}$$

The dependent variable in this regression is average total points by country. The average total point variable comes from the averaged total FIS points by country. Taking the average total points weighs each country equally regardless of the size of the country's team. The method will emphasize the strength of the overall team instead of just skewing towards teams with a greater number of athletes and therefore a greater number of total points. The GDP Per Capita variable is expected to have the same effect as in the first regression and have a significant positive impact on points earned. Pfau's (2006) findings that population is not always positively linked to winter sports success is expected to play an even more prominent role in this regression where the average of total points is used. Therefore, population is not expected to have a large impact on the average total points. Snowfall is expected to have the same effect on this regression as in regression 1. Increasing amounts of snowfall are expected to positively impact countries total point average to a point before no longer having an effect on points earned. The Gini coefficient is expected to have less of an effect in this regression due to the fact that a large team is less of an advantage than in the first regression. It is still expected to be negative as countries with high levels of inequality are expected to be less successful. The season code variable looks at trends in the data over the individual seasons and acts as a control for each season's effect.

4.

$$Averagepoints_{ct} = \alpha_c + \beta_1\, ln\_GDPPerCapita_{ct} + \beta_2 \mathrm{L1\_ln}\_GDPPerCapita_{ct} + \beta_3\, ln\_Population_{ct} + \beta_4\, Snowdata_{ct} + \beta_5\, Gini_{ct} + \beta_6 Seasoncode_t + \beta_7 L1\_averagepoints_{ct} + \delta_i + \epsilon_{ct}$$

The dependent variable is average points per country. The regression 4 is the same as regression 3 with the addition of the lag variable to GDP Per Capita and lagged average points. GDP Per Capita is expected to be significantly positive and play a large role in determining the number of points won by a country. The one-year lag of GDP Per Capita is expected to be positive and also play a significant role in determining a country's success. A country that has had a historically high GDP Per Capita is expected to be much more successful than a country whose GDP Per Capita has experienced a sudden growth surge. Population is the same as regression 3, significant to a point before becoming harmful. Snowfall will significantly help a country to a certain level before any additional snow ceases to have an impact on results. The Gini coefficient is expected to be negative and mirror the results from regression 3 in which the Gini is not as important in this equation as it is in the individual equations, regressions 1 and 3. The lag variable of average cup points is expected to be positive and have a coefficient of close to one. Meaning that for every one cup point won last season the country should win the roughly the same amount this season. The season code variable looks at trends in the data over the individual seasons and serves to act as a control for each season's effect.

5.

$$\mathrm{T}otalpoints = \beta_1\, ln\_GDPPerCapita + \beta_2\, ln\_Population + \beta_3\, Snowdata + \beta_4\, Gini + \beta_5 Age + \beta_6 Age^2 + D_1 Gender + \epsilon$$

The dependent variable is the total points from each athlete, which is the same as in regression 1 and 2. GDP Per Capita is expected to have a large and positive effect on athlete success since success has been found to be correlated to a country's wealth. Population is expected to be either slightly negative or slightly positive with average sized population offering the most success. A high average snowfall is expected to significantly correlate with success, since snow is needed to train for skiing. The Gini Coefficient is expected to be a negative variable as countries with high levels of inequality should be at a disadvantage. Age and age squared are expected to be significant and positive as older skiers should have more experience and therefore be more successful. The gender variable is included to add more explanatory power to the model as it is an individual level variable.

## 6. Results

For regression 1, I chose to use the random effects model even though the Hausman test has a p value of p=0.000. The reason for this is that the random effects model allows for the inclusion of individual-specific variables such as gender that are needed to capture individual performance in regressions one and two (Studenmund, 2010). GDP Per Capita is highly significant with a p value of p=0.013. GDP Per Capita has the expected result on total points earned; a country earns an additional 99.04 World Cup Points for every percentage point increase in GDP Per Capita, in context a victory on the World Cup earns 100 points. A one percent increase in GDP Per Capita results in one additional victory for the country. This result is in accordance with literature on both the Summer and Winter Olympics that find GDP Per Capita being highly significant to Olympic success (Ali and Johnson, 2000, Doncel and Otamendi, 2014, Mitchell et al, 2012). Population is not statistically significant. While population is negative the coefficient is not huge so for every one percent increase in population 12.57 points are lost, roughly the equivalent to nineteenth place. Snowfall is not a statistically significant variable at any level with a p value of p=0.69. The coefficient of the variable is also so small that it would not have a significant effect on the equation even if it were statistically significant. The Gini coefficient is not statistically significant. The coefficient sign is positive which is not what is expected for every percentage point more unequal the countries are 3.05 more World Cup points are earned or one additional twenty eighth place finish. The gender dummy variable is not statistically significant. The individual seasons are not significant either although they show a trend of decreasing points from the initial season of 2005 (Table 3 Column 1).

Regression 2 uses the Hausman test which has a p-value of 0.000, indicating the usage of fixed effects. I used the random effects model instead of the fixed effects because the random effects model allows for the inclusion of an individual-specific variable. As mentioned above, the dummy variable in this model is gender. The GDP Per Capita variable and the one-year lag of the GDP Per Capita variable are both not statistically significant. What is interesting is that the coefficient the of lag GDP Per Capita is positive 263.2 whereas the GDP Per Capita, which is expected to share a sign has a coefficient of negative 225.3 The positive negative swing is huge because a hundred points equals a World Cup victory. The swing between the lag variable and the current variable is over four World Cup victories. Snowfall, population, and the Gini coefficient are not significant, and all three have small coefficients. The gender dummy variable is significant at a 5% level with a p-value of p=0.022 and a coefficient of 18.62 this is equivalent to a fourteenth-place finish.

**Table 3**

| VARIABLES | (1)<br>Cuppoints | (2)<br>Cuppoints |
|---|---|---|
| L1_Cuppoints | - | 0.797*** |
| | - | (0.0212) |
| Ln_GDPPerCapita | 99.04** | -225.3 |
| | (39.79) | (242.2) |
| L1_Ln_GDPPerCapitaln | - | 263.2 |
| | - | (243.1) |
| Ln_Population | -12.57 | -3.853 |
| | (8.428) | (4.522) |
| Snowfall | 0.0105 | 0.0125 |
| | (0.0265) | (0.0196) |
| Gini | 3.052 | -0.0963 |
| | (2.716) | (1.166) |
| Gender | 19.93 | 18.62** |
| | (16.86) | (8.125) |
| Constant | -806.0* | -256.6 |
| | (450.2) | (270.3) |
| Season Dummy | Yes | Yes |
| Random Effects | Yes | Yes |
| Observations | 3,441 | 2,467 |
| Number of FIScode | 779 | 594 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The other individual variable, the one-year lag of total cup points for each individual athlete, is highly significant at a 1% level with p-value of p=0.000. The coefficient is 0.0.79 so for every one point they earned the year before all other variables remaining the same; they earn 0.8 points in the current year. The lag of the dependent variable needs to be viewed with the caveat that its usage introduces bias into the model, due to the demeaned error still correlating with the regressors. This introduction of bias is especially severe given the "small T large N" context of the model (Ge and Ho, 2018).

The seasons with the exception of 2010 and 2014 are not significant although they have an overall negative trend (Table 3 Column 2).

Regression 3 uses the fixed effect due to its consistency. The fixed effects model greatly reduces the standard error and the variance, allowing for a more consistent model (Studenmund, 2010). GDP Per Capita variable is not significant. The coefficient is positive 55.38, meaning for every one percent increase in GDP Per Capita, the country's average World Cup points earned in a season increases by 55.38 or a fourth-place finish. Population is not statistically significant with a p value of p=0.985. The coefficient is not relevant because it is 0.19 meaning that for every one percent increase in population a country earns only 0.19 more World Cup Points. Snowfall is also not statistically significant and even if it was statistically significant it would not be relevant because a nation only earns 0.024 World Cup points for every additional centimeter of snowfall making its impact irrelevant. The Gini coefficient is not statistically significant with a p value of 0.540. The season codes are not statistically significant although they do show an overall decreasing trend of total points over the course of the dataset (Table 4 Column 1).

Regression 4 is done using the fixed effects model for the same reasons as regression 3 uses the fixed effects model since there are no individual variables. The GDP Per Capita is not statistically significant, but the lag of the GDP Per Capita is significant with p=0.021. It is interesting to note that the GDP Per Capita coefficient is negative 37.28 while the lag coefficient is positive 256. This equates to the GDP Per Capita variable being equivalent to losing a seventh place finish and the lag variable two first place finishes and a fourth-place finish. The population, snowfall, and Gini coefficient variables are also not statistically significant. Average cup points are statistically significant with p=0.004. It has a positive coefficient, but the coefficient is lower than expected with only 0.22 points being earned for every point earned last season. This regression also suffers from the introduction of bias due to the usage of the lagged dependent variable. This is again due to the fact that the demeaned error can still correlate with regressors introducing bias into the model (Ge and Ho, 2018). None of the season code variables are significant, but they do show a negative trend of total points (Table 4 Column 2).

**Table 4**

| VARIABLES | (1)<br>Average points | (2)<br>Average points |
|---|---|---|
| Ln_GDPPerCapita | 55.38 | -37.28 |
| | (52.29) | (61.39) |
| L1_ln_GDPPerCapita | - | 256.6** |
| | - | (109.8) |
| L1_Averagepoints | - | 0.229*** |
| | - | (0.0787) |
| Ln_Population | 0.195 | -1.717 |
| | (10.48) | (10.25) |
| Snowfall | 0.0241 | 0.0369 |
| | (0.0336) | (0.0373) |
| Gini | -3.375 | -3.106 |
| | (5.497) | (6.082) |
| Constant | -299.4 | -1,990* |
| | (690.8) | (1,158) |
| Season Dummy | Yes | Yes |
| Fixed Effects | Yes | Yes |
| Observations | 217 | 198 |
| Number of Nations | 19 | 19 |
| R-squared | 0.041 | 0.144 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Regression 5 is a cross section using basic OLS that looks at the 2017 season. The cross section is used because age is included in the regression, and since age is a sequential variable it cannot be included in a panel analysis (Studenmund, 2010). GDP Per Capita is not significant, the coefficient is 100.8 points or the equivalent of one World Cup victory. Population is not significant and does not have a particularly significant coefficient with -6.22 only being the equivalent to a country losing a twenty fifth place finish, not particularly significant when put in the context of a one percent change in population. Snowfall is completely insignificant both statistically and in the context of its coefficient which is less than a full World Cup point. The Gini Coefficient is also not significant and has a small coefficient that is not particularly signicant. Gender is statistically significant with a p-value of p=0.031. The coefficient of gender is positive 72.28 which is equivalent to a third-place finish in a World Cup race. Both age and age squared are not statistically significant. The coefficient of age is 54.10 which is equivalent to a fourth place finish in a World Cup race and the coefficient of age squared is so small that it is not significant (Table 5).

**Table 5**

| VARIABLES | (1)<br>Cuppoints |
|---|---|
| GDPPerCapitaln | 100.8 |
| | (82.00) |
| Populationln | -6.227 |
| | (19.14) |
| Snowfall | 0.142 |
| | (0.268) |
| Gini | -1.060 |
| | (5.091) |
| Gender | 72.28** |

| | |
|---|---|
| | (33.37) |
| Age | 54.10 |
| | (44.96) |
| Age2 | -0.744 |
| | (0.802) |
| Constant | -1,704 |
| | (1,195) |
| | |
| Observations | 290 |
| R-squared | 0.047 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

## 7. Discussion

The overall results suggest that GDP Per Capita an important predictor of success on the World Cup Circuit. Not only is GDP Per Capita statistically significant in the majority of the regressions, but it also has a large effect on total points earned both at a country level and at an individual level. The results are not able to be directly compared to the results from Olympic literature due to the coefficients, the coefficients related to Olympic medals are much smaller due to the fact only one Olympic medal is awarded for each Olympic victory versus 100 points for each victory on the World Cup. Therefore, it is important to focus on the overall trends and signs instead of the specific coefficients when looking for correlations between literature and my studies' results. It is also important to note that while GDP Per Capita has a large coefficient, the variable is measured through percentage change. The countries being studied have relatively stable GDP Per Capita so changes of this magnitude rarely happen over the course of a single season. These findings are consistent with all of the literature on the Olympic games. Literature on both the Summer and Winter Games found GDP Per Capita to be an extremely important variable for predicting success. A high GDP Per Capita allows for countries to invest and succeed in capital intensive sports such as skiing. (Ali and Johnson, 2000, Doncel and Otamendi, 2014, Mitchell et al, 2012).

Population was predicted to be equally significant to GDP Per Capita, however interestingly it was not statistically significant and had significantly smaller coefficents. The results follow the findings of Pfau (2006), who found that population is not as important to winter sports as it is to summer sports. This is further supported by Tcha and Vitaly (2003) who find that sports requiring large investments of capital are often dominated by smaller, wealthier countries. Pfau (2006) theory is supported by the findings that GDP Per Capita is extremely significant in predicting success in the World Cup.

A finding that went against the majority of Winter Olympics literature and the hypothesized outcome is that snowfall was not a significant variable in any sense. It was not statistically significant in any of the regressions and the coefficient was extremely small to the point of being insignificant. This goes against Doncel and Otamendi (2014) findings who find that geographic location and climate is an extremely important predictor of success. The finding also directly contradicts Andreff's (2013) research on the Winter Olympic games where he finds countries with high levels of snowfall have a significant advantage over those without. One possible reason for this finding could be due to limitations with snowfall data which is gathered from a single weather station in each country possibly not providing an accurate picture of snowfall nationwide.

It is also important to note that the Gini coefficient had less explanatory power than expected. While the coefficients predicted an accurate number of points, the signs were often positive which was not as predicted, since countries with higher levels of equality should be favored (Groot, 2012). The Gini coefficient was introduced to diversify the countries as they were overwhelmingly homogeneous across GDP Per Capita. Therefore, it is an interesting finding that it is not a significant variable in any of the regressions.

Intriguingly the lag variables of GDP Per Capita did not always provide any additional explanatory power to the model. Only one of the lag GDP Per Capita variables was significant. However, both of the lagged of total points earned were significant and they were, extremely accurate at predicting future results. This follows the literature that has found past results are the best predictors of future success (Ali and Johnson, 2000, Lui and Suen, 2008). A possible explanation of GDP Per Capita's lack of significance during the individual level regressions it that the lag variable only looks at one year which is not a long enough time period to see a significant change in the variable due to the low rate of change in the countries being sampled and the high turnover of athletes.

Some limitations of this study are that for the individual level regressions 1 and 2: there are only two individual variables used: gender and previous points, which is only included in regression 3. This limits the explanatory power of the regressions due to the fact there are only two variables for explaining individual variation. This is partly addressed in regression 5, which is a cross section adding the age variable for increased individual explanatory power. However, to truly explain individual success more variables are needed such as height and weight. These variables were not part of a publicly accessible data set making them impossible to include in these regressions.

The importance of the GDP Per Capita variable to ski racing leads to important policy implications. A country is unable to significantly increase their GDP Per Capita, they are however, able to significantly increase the amount of funding directed towards a sport. This ties into the policies used by the Soviets and German Democratic Republic. By heavily funding their international sports teams these countries were able to produce unprecedented levels of success (Riordan, 1974). The policy implications of this study are that in order for a country to experience greater volumes of success than predicted by GDP Per Capita they must be prepared to invest large sums into their sports programs, like the former Eastern Bloc.

## 8. Conclusion

In this paper, I focus on the factors that influence success on the ski World Cup Circuit. I use base variables GDP Per Capita, population, snowfall, and Gini coefficient as means to predict success. I find that GDP Per Capita is the most important variable to predict success. Population and Gini coefficient provide accurate predictions under certain circumstances; however, they play less of a role than GDP Per Capita. My findings suggest that in the case of skiing a country's wealth is the most important determinate of success. Additional work needs to be done with snowfall data to ensure that it is truly not significant to World Cup results.

My paper opens several opportunities for future work, both in the underrepresented area of alpine ski racing and in other ski disciplines. This work could easily be taken and applied to snow sports such as cross-country skiing or various free skiing disciplines. The basis of this work can also be expanded upon to look at various characteristics, such as socioeconomic background and region of the country the athletes are from, and which of these factors is most important in creating a successful ski racer.

This study is unique in that it examines the alpine ski World Cup, which was not an area that sport economists explored. It shows what factors contribute to success on the World Cup. It also paves the way for future research on the World Cup circuit and factors contributing to success.

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