THE IMPORTANCE OF TAKING PART: THE IMPACT OF BARRIERS TO ENTRY ON FEMALE PARTICIPATION AT THE SUMMER OLYMPIC GAMES

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International Political Economy

Abstract

Research on participation and medal winning at the Olympics has historically focused on economic indicators such as GDP or population size. The use socioeconomic indicators such gender equality to study female success at the Olympics is a recent development in the field of Olympic research. This paper expands on this research and looks at the effects of barriers to entry such as equipment costs and facility costs on the success of women of various nations at the Olympics. The paper tests the hypothesis that sports with the highest barriers to entry will have lower participation and medal winning rates at the Olympics for women. The findings show that as barriers to entry increase the proportion of female athletes in a given sport, for a given country, in a given year, decreases. This can also be seen to a lesser extent in the proportion of medals won by female athletes. This indicates that female athletes are not getting the same training and competition opportunities as their male counterparts. The hope with this research is that it will provide a framework and direction for the IOC and other stakeholders in the years following the conclusion of the IOC's flagship program – *Agenda 2020*. It also seeks to offer a more complete understanding of the inequalities that women face in sport with the hopes of increasing female participation in sports.

KEYWORDS: (inequality, Olympics, Olympic Games, participation, barriers to entry)
JEL CODES: (Z200, Z220, Z280)

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Introduction

The Olympic Games are among one of the great global unifiers, and the Olympic brand often conveys more than just a sporting event. The Olympic movement strives to celebrate a spirit of international cooperation and athletic excellence and puts national social movements in the international spotlight, whether it be the civil rights movement in the US at the 1968 Olympics or the Refugee Olympic Team at the 2016 Olympics. However, the growing sustainability issues surrounding the Olympic Games overshadow the Olympic ideals conveyed in the quote by the founder of the modern-day Olympics, Pierre de Coubertin, "the most important thing in the Olympic Games is not winning but taking part."

While the question of sustainability at the Olympics is important, often overlooked is the question of equality at the Olympics; specifically, equality in participation between men and women. When the International Olympic Committee (IOC) unveiled their *Agenda 2020* in 2014, it highlighted their commitment to reimagining the "Olympic movement" to increase female representation at the games. Recommendation 11, "Foster Gender Equality," promoted two goals: "to achieve 50 percent female participation in the Olympic Games and to stimulate women's participation and involvement in sport" and to "encourage the inclusion of mixed-gender team events" (IOC, 2017a). The increased participation of women at the Games reflects the IOC's commitment to increasing gender equality at the Olympics. At the 2012 Summer Games in London, women for the first time in history competed in all the same sports as men, and four years later, at the Rio 2016 Games, women's participation saw an all-time high with women making up 45.2% of all athletes. Furthermore, the Olympic

Games in Tokyo in 2020 are set to break yet another record with women projected to make up 49% of athletes (IOC, 2017b) .

The factors that go into promoting gender equality at the Olympics are subject to a lot of research. Various economic studies correlate the rise in gender equality in various nations to the rise of equality in their Olympic delegations (Johnson, & Ali, 2004; Johnson, & Ali, 2000; Klein, 2004; Lowen, Deaner, & Schmitt, 2016; Noland & Stahler, 2016; Noland & Stahler, 2017; Potts & Edwards, 2013; Ruseski & Maresova, 2014). Empowerment is an important aspect in increasing gender equality, not only at the Olympics but also on the national level. Furthermore, studies show that empowerment is closely related to economic development (Duflo, 2012). Sport and economic development can often be seen to develop hand in hand. Nations with freer economies and political institutions often produce higher numbers of world class competitors. More populous nations have a bigger talent pool that leads to more talent development, as long as these young athletes have leisure time to devote to sports and athletic endeavors. Sport, in turn, is correlated with a healthier population, and a healthier population tends to practice more sports (Klein, 2004). Thus, sport and society are closely related and changes to one can lead to changes in the other.

This paper seeks to fill a gap in research by providing further analysis on the effects of national gender equality on Olympic success. The definition of success used in this paper is the one used by Lowen et al. (2016), who define success as "the number of participants and the number of medals won in the Summer Olympics." While many scholars (Johnson, & Ali, 2004; Johnson, & Ali, 2000; Klein, 2004; Lowen, Deaner, & Schmitt, 2016; Noland & Stahler, 2016; Noland & Stahler, 2017; Potts & Edwards, 2013;

Ruseski & Maresova, 2014) highlight the importance of the empowerment of women in reaching gender equality at the Olympics, this measure of equality still does not account for some of the underlying variables at play. High barriers to entry in some sports due to high equipment costs can have huge impacts on women's access to training facilities and proper equipment, which in turn obstructs talent development. These studies (Andreff, Andreff, & Poupaux, 2008; Johnson & Ali, 2004) often compare sports like soccer or running with relatively low barriers to entry to sports like cycling or sailing where equipment is a vital part of performance and is often unattainable for athletes who suffer from socio-economic inequality. This paper focuses on the 1992-2016 Summer Olympics because of the greater diversity in participant nations and greater media exposure not only of athletes as a whole, but of women in particular. This analysis offers the IOC, National Olympic Committees (NOC), International Federations (IF), and national governments guidance in pursuing next steps in furthering equality within the Olympics and sports as a whole in the years following Agenda 2020.

Literature Review

The increase in scope and reach of the Olympic Games since the late 1990s led to a wealth of socioeconomic research on various aspects of the Olympics. Early studies often focused on economic indicators such as GDP or population size to analyze how these correlate to medal counts. Research then shifted to focus more on how these indicators affect performance across nations. The newest trend in Olympic socioeconomic research is looking at gender inequality and how this correlate's to not only medal count but also participation across sports. This new trend is a response to the growing understanding that GDP and population do not correctly reflect national characteristics, especially social characteristics. Understanding of the existing research is essential in creating a model to study the effects of gender equality on women's sport equipment access.

Determinants of Olympic Success

The foundations for the modern analysis of Olympic success rates is often traced to Johnson & Ali's (2000) "Coming to Play or Coming to Win". This research focused on determining the economic and political determinants of national participation, and of female participation at the Olympics. The researchers chose to focus primarily on medal counts looking at both national and individual success at the Olympics. They found that population size, a nation's GDP, and the host nation status (if the nation was hosting the Olympics) were significant in determining the success rates of athletes and nations at the Summer and Winter Olympics.

Johnson & Ali (2004) echo this research in a later paper that uses a very similar methodology to predict the differences between the Summer and Winter Olympics.

Again, they found that socioeconomic variables explain Olympic participation and success extremely well. They found that host city status is less important in the Winter Games than it is in the Summer Games. Additionally, they show that income plays a bigger role relative to population at the Winter Olympics in determining participation at the Olympics. Much of the later research focuses on the Summer Olympics because of the international scope of the Summer Games. The Winter Games have natural barriers to entry which limit the number of countries that partake in them. Both papers were the basis for much of the subsequent research done on participation at the Olympics. These studies highlight the important determinants of Olympic participation and success.

Role of Gender Equality

Many researchers study the impacts of gender equality on either participation, medal count, or both (Johnson & Ali, 2004; Klein, 2004; Lowen et al., 2016; Noland & Stahler, 2016; Noland & Stahler, 2017; Potts & Edwards, 2013; Ruseski & Maresova, 2014). Klein (2002) is one of the first economist to demonstrate that greater gender equality leads to increased performance of women on the international stage. Klein examines the labor force integration rates and how that affects the number, and type of medals won by a country's women. He considers two events in particular, the 2000 Olympics in Sydney and the 1999 Women's soccer World Cup. Both demonstrate the hypothesized positive correlation and he posits that this is because these "[countries] enable athletically talented women to reach their full potential" (Klein, 2002). Johnson & Ali (2002) support these finding. They find that higher national income leads to increased success and participation of female athletes showing that "an additional $1,000 GDP per capita would raise the average nation's female participation by two athletes".

Noland & Stahler (2016) investigate women's participation and medaling in Olympic Games between 1960 and 2012. The research looks at a wide variety of equality indicators such as education rates, Muslim versus non-Muslim nations, and whether the nation was part of the communist bloc. Interestingly, they find that there is a positive correlation between women's equality and medal count but that there is no significant correlation between women's equality and female inclusion in the Olympics. This contradiction might indicate that there is an unexplained variable in the dataset that is affecting sport participation. They support these findings in a later paper (Noland & Stahler, 2017) and put more emphasis on the importance of education in women's Olympic success.

Lowen, Deaner & Schmitt (2016) are the first to take a comprehensive look at the connection between women's empowerment and equality, and Olympic participation. They utilize the World Economic Forum's Gender Inequality Index as a measure of gender equality as it combines three important indicators of women's equality: reproductive health, empowerment, and economic status. They find that higher equality is associated with higher participation and medal counts in the Summer Olympic Games from 1996 through 2012.

Role of GDP and Population size

Most research focusing on participation and success at the Olympics focus on two indicators in particular: GDP and population size. These indicators are easily measurable which often means data is readily available. GDP and population size also have the added benefit of offering a good general overview of the socioeconomic standing of a nation. In the context of the Olympic Games, Johnson & Ali (2004) argue

"High productive capacity or income per person (measured by GDP per capita) displays an ability to pay the costs necessary to send athletes to the Games and may also be associated with a higher quality of training and better equipment."

Bernard & Busse (2004) build upon Johnson & Ali's research focusing specifically on the impact of GDP and population size on national Olympic performance. The research concludes that "economic resources play a very significant role in determining success". Like many papers analyzing the determinants of Olympic success, Bernard and Busse (2004) use their findings to predict the medal count of an approaching Olympic Games. They find that the Soviet Union and Eastern Bloc often overperform at the Olympic Games, meaning they get more medals than their GDP and population would predict. This would later be explained by Noland & Stahler (2016) who correlate this inflated success, to the systematic doping in East Germany and the former Soviet Union.

Andreff et al. (2008) also use GDP and population to predict medal counts but they introduce an extra variable for culture in their study allowing them to look at the impact of culture on a region's participation. Their findings on GDP and population are similar to the findings in previous research (Bernard & Busse, 2004; Johnson & Ali, 2004). However, their variable for culture on the other hand remained pretty vague and is slightly problematic as they separated the "cultures" by continent and sub-regions. Even if their findings indicate that there is an underlying variable at play in this field, more research is needed on the effects of national sporting culture on Olympic participation. Andreff et al. (2008) find that nations in the northern hemisphere in general have higher participation and medal counts.

Political vs Economic Freedom

An important finding in the Bernard & Busse (2004), is the discovery of the inflated medal count of communist countries and Eastern Bloc countries. They find that on average these nations perform three percentage points better than would be expected given the GDP and population data. They did not offer a reason for this finding which begged the question of whether economic or political freedom was at play here. Even though it is now known that this inflated success was due to wide spread doping, it still raises an interesting question on the effects of various economic and political factors on sport performance. While the role of economic freedom has a clearer positive effect on participation of both genders at the Olympics, the significance of political freedom is less clear.

The effects of economic freedom on participation are studied by Ruseski & Maresova (2014). The research focuses less on the effects of economic freedom on Olympic participation and more on athletic participation as a whole, however they still find a positive relationship between hosting the Olympics and participation in sports. The key finding of the paper is that "economic freedom shows positive association with participation in sport and physical activity". This is because policies that promote gender and economic equality lead to individuals deciding to partake in sports and physical activity which supports the overall hypothesis that socioeconomic equality leads to greater participation at the Olympics.

Andreff et al. (2008) use political regime as an explanative variable in their research. They look at two distinct regimes, communist versus capitalist and rank these countries on a spectrum: communist, transition states, ex-communist, or capitalist. They

find that transition states (countries such as China), that are transitioning out of Communism, have the greatest participation rates and Olympic success. These findings suggest that as political and economic freedom increases, so does participation and Olympic success.

Conversely, Potts & Edwards (2013) argue that political equality is associated with lower success but that this only becomes apparent at the "58th percentile in political equality, a category associated with high degrees of overall gender equality". They argue that this might indicate decreasing returns of gender equality on Olympic success. However, the data used in the research is based on a one-year sample (the 2012 London Games) which raises questions about the validity of these findings even with the proper methodology.

Role of hosting the Olympics

Research shows that hosting the Olympics positively impacts subsequent Olympic participation and success. (Andreff et al., 2008; Bernard & Busse, 2004; Johnson & Ali, 2004; Ruseski & Maresova, 2014). Bernard & Busse (2004) find that hosting the Olympics increases medal count of nations by 1.8% over their projected total. Johnson & Ali (2004) find that the host nation will send 210 more athletes during a host year (under half of them are women). Hoffmann et al. (2002) add to this field of research by arguing that hosting the Olympics creates a sporting culture in a nation for certain sports in particular which will lead to increased success and participation in future years. This is in large part due to the fact that hosting the Olympics can often encourage increased investment in national athletics by the national government.

Cost of Sports

The cost of sports, and the barriers to entry in sports are hard to estimate. Some research has been done on the cost of sports but there are numerous factors that complicate the findings of these studies such as the location of the study, the age group studied, or the type of methodology employed. Current research focuses mainly on the cost of youth sports (Gregory, 2017; Île-de-France, 2014) because of the rising cost seen in this sector. Research done by the French Government (Île-de-France, 2014) shows that the cost of practicing sports hinders sport participation but that this is more prevalent in some sports that others. They show that the barriers to entry are higher in sports such as equestrian than sports such as soccer. However, they also find that the cost of sports is not the biggest hindrance to sports participation but rather the appeal of the sport to those people is what keeps people away from certain sports. Finally, this paper also demonstrates that the task of evaluating the cost of sports is not easy and so this paper looked less at the economic figures but instead relied on survey data from France. They argue that there are too many factors that determine the cost of the sport (equipment, region, facility…) to be able to come up with a single metric for the cost of sports.

Gregory (2017) relies on research from various sources to show that the cost of youth sports in the US is rising rapidly. According to this research, the kids' sports industry in the US has become a $15 billion industry and is set to grow further. They use research done by Utah State University to show that this "astronomical cost" hinders participation in some sports more than others. For example, soccer and basketball aren't as expensive as sports such as baseball or hockey because of lower equipment costs. However, no research has been done on the cost of practicing sports internationally at the elite level. This is due to

the lack of availability of data, and even when data is available the variability in methodology for collecting this data makes it hard to compare different regions.

Summary

Gender equality, GDP, population size, and economic freedom are all shown to have a significant positive impact on the Olympic medal count and participation of women in the Olympics. What is less clear and much harder to study is the role of barriers to entry in various sports (capital intensive versus labor intensive; or equipment versus skill sports) on the medal count and gender participation. This gap in knowledge is partly due to a lack of consistent data across all sports and regions on the issue which complicates the quantification of the barriers to entry facing the athletes competing in various sports. However, it is important to fill this gap in knowledge as this might indicate a lack of equal funding for training between men and women in various sports and nations.

Theory

Research shows that there is a negative correlation between gender inequality and women's participation at the Olympics which comes as no surprise since sport requires a certain level of socio-economic freedom to partake in. (Johnson & Ali, 2004; Klein, 2004; Lowen et al., 2016; Noland & Stahler, 2016; Noland & Stahler, 2017; Potts & Edwards, 2013; Ruseski & Maresova, 2014). However, the research on training and competition inequality between men and women at the Olympics is much more limited. A few researchers shed some light on this field (Johnson & Ali, 2004). Their investigation looks at both the Summer and Winter Olympics and separates the events into labor-intensive sports, capital-intensive sports and team sports. However, their analysis does not look at the effects of gender inequality on participation in these sports, and there are some important limitations to their division of the Olympic events. Additionally, studies on the cost of practicing sports is done primarily to investigate the cost of children's sports in developed nations. There is still very little research done on the cost of competing at the elite international level.

This analysis combines the research done on gender inequality with a new categorization of sports based on their accessibility to test the hypothesis that gender inequality has a negative correlation on the participation of women in more "expensive" sports. The Summer Olympics offers the perfect testing ground for this hypothesis because of the international scope of the competition. Certain key tenants of the Summer Olympic Games create natural controls that benefit economic research: the large proportion of countries and territories represented; the wide variety of events for athletes

to participate in; the increasing number of events for women; and the near equal media coverage of both men's and women's events (Lowen et al., 2016).

Thus, using data from the Summer Olympic Games, the analysis employs a Tobit regression model and builds upon current literature on gender equality rates and their impact on participation at the Olympics to test the hypothesis that greater barriers to entry will hinder success of women at the Olympics. This section outlines the theory underlying the model and the modifications made to the base model adopted from previous literature. The section concludes with the specification of the empirical model and provides a description of all variables used.

Base Mode

The base model employed in this paper builds on the research conducted by Johnson & Ali (2002) and Lowen et al. (2016). Incorporating both of their models into the base model is important as they explore very similar topics with slightly different foci and variables. Johnson & Ali (2002) focus on building a model that can be used to interpret the various factors that affect the success of women in the Olympics. They define success as high participation rates as well as high medal counts. They find that variables such as a nation's per capita income (GDP per capita), population size, and host city status are all important variables in determining Olympic success. Lowen, et al. (2016) base their model on the model created in Johnson & Ali's (2002) paper but focus the regression to investigate the effects of gender equality on participation by using the Gender Inequality Index (GII) as a variable for equality/inequality. They still use variables such as GDP or population, that are important explanatory variables in Johnson & Ali's (2002) paper, but instead use them as control variables in their model.

Lowen, Deaner & Schmitt's (2016) model is thus used as a base for the empirical model used in this research. The model for participation is defined as follows:

$$part_{it} = \alpha + \beta_1 GII_{it} + \beta_2 Host_{it} + \beta_3 Polity2_{it} + \beta_4 MuslimPct_{it} + \beta_5 GDP_{it} + \beta_6 POP_{it} + \beta_7 GDP^2{}_{it} + \beta_8 POP^2{}_{it} + \beta_9 Ln(GDP)_{it} + \beta_{10} Ln(POP)_{it} + \beta_{11} t + u_i + \varepsilon \quad (2.1)$$

$$medal_{it} = \alpha + \beta_1 GII_{it} + \beta_2 Host_{it} + \beta_3 Polity2_{it} + \beta_4 MuslimPct_{it} + \beta_5 GDP_{it} + \beta_6 POP_{it} + \beta_7 GDP^2{}_{it} + \beta_8 POP^2{}_{it} + \beta_9 Ln(GDP)_{it} + \beta_{10} Ln(POP)_{it} + \beta_{11} t + u_i + \varepsilon \quad (2.2)$$

Where:

$part_{it}$ is a measure of female participation from nation i in year t.

$medal_{it}$ is a measure of female participation from nation i in year t.

GII_{it} is the World Economic Forums measure of national gender inequality for nation i in year t.

$Polity2_{it}$ is a variable developed by Marshall, Jaggers & Gurr which scores nations from 10 (indicating a full democracy) to -10 (indicating a full autocracy) from nation i in year t.

$MuslimPct_{it}$ is the percentage of the nation i that is Muslim in year t.

GDP_{it} is GDP per capita of nation i in constant international prices (in thousands) in year t.

POP_{it} is the population of nation i (in millions) in year t

t is a time trend (1=1996 Games, 2=2000 Games, 3=2004 Games, 4=2008 Games, 5=2012 Games.)

u_i is a nation-specific error term

ε is the unexplained error.

Modifications

The empirical model employed in the paper applies several modifications to the base model provided by Lowen et al. (2016). This model bases its variables on the model developed by Johnson & Ali (2002) and furthers their research on the determinants of participation at the Olympics. This analysis keeps many of these modifications; however, some variables are omitted while other variables are added to change the focus towards researching the impacts of access to proper training resources. The changes the base model provided by Lowen et al.'s (2016) model are outlined below.

Lowen, et al.'s (2016) Modifications to the Johnson and Ali (2002) Model. The Johnson & Ali (2002) model focuses on finding a clear model that can be used to predict the medal count for any given nation at any given Olympic Games. This model was successful (96% accuracy) in predicting the Olympic medal count and also started the literature on sport participation analysis at the Olympic level. However, it does not "consider the determinants of winning medals by sex nor does it consider empowerment-related variables that might underlie the differences in participation nor medal by sex" (Lowen et al., 2016). To investigate the effects of empowerment and equality Lowen, et al. (2016) add the Gender Inequality Index (GII) to Johnson & Ali's (2002) model. The GII is an index measuring gender disparity across various nations and was introduced in the UN's 2010 Human Development Report. Lowen et al. (2016) acknowledge that there are several limitations to using a complex index such as the GII. They cite Permanyer's

(2013) discussion of the limitations of using the GII. They note that, like many aggregates, it incompletely combines absolute and relative gender equality performance measures which can cause poor measurements of "women's outcomes in low-income countries" and the use of relative education and economic outcomes measures may hide declines in women's outcomes when both men and women experience worse outcomes simultaneously (Lowen et al., 2016). However, it remains useful in both their paper and this paper as it is a "widely accepted, globally implemented, and resource based" (Lowen et al., 2016) measure of equality and empowerment.

Lowen et al. (2016) also change the variable that measures political regime to include a quantitative approach to measuring political systems. Johnson & Ali (2002) use a qualitative measure for political system and group them based on their status as a monarchy, military system, other political system, or democratic systems (either parliamentary democracies or republics). However, this approach has several limitations. It limits the researchers to groups of nations under vague labels which makes ranking of the various nations based on their political system near impossible. This broad approach does not account for small year-to-year changes in the political systems of these nations, which leads to some inaccuracies in categorizing the political system of a nation. The *Polity2* scores developed by Marshall, Jaggers & Gurr (2011) remedy these issues by combining numerous national statistics and forming a numeric variable that reflects these statics. Lowen et al. (2016) thus classify scores from -10 to -6 as autocracies, -5 to +5 as anocracies, and scores above 5 as democracies. While this approach offers fewer categories which in turn means that the categories are broader, this approach allows for

small year-to-year changes in the national political systems to be accounted for and offers a continuous scale on which nations are placed based on their political system.

Finally, Lowen et al (2016) omit some variables in Johnson & Ali's (2002) model. The variable that depicted the host country's neighboring countries is omitted because it lacked significance in Johnson & Ali's (2002) study. They also chose to omit the variables for areas that experience either sever or light frost as these variables are less important in a study involving the Summer Games. This study also omits these variables for the same reasons.

Modifications to the Lowen et al. (2016) Base Model. The modifications done to the base model constitutes the changes to the dependent variables. The main modification made to the base model is the omission of two of Lowen et al.'s (2016) key variables. The first variable omitted is the percentage of a nation's population that is Muslim. This variable is ignored because the nature of the variable is morally problematic and is not as useful in describing barriers to entry as other variables might be. Second, the *Polity2* variable is removed. While this is a good indicator of the political system, it has numerous limitations. First, data availability is limited which impacts both frequency of the data available and second it also omits several smaller nations included in this dataset. This would skew the data towards larger nations that have more resources to send more "equal" Olympic delegations which would skew the findings of this paper. Political system indicators in both Johnson & Ali (2002) and Lowen et al. (2016) lacked significance in explaining participation and medals won and thus no political system indicator was added to this model.

The main addition in the empirical model is the addition of a classification of Olympic events based on their common characteristics which will help define Olympic success. First, a couple of assumptions need to be established. The analysis focuses on the 1992 – 2016 Summer Olympic games. This is due to the aforementioned barriers to entry that limit the number of nations and athletes in attendance at the Winter Olympic Games. The empirical model also uses Lowen et al.'s (2016) definition of success which looks at both female participation and female medal count per nation. In this study, the success variables are subdivided by category of events with similar characteristics.

Devising a model that accurately ranks the Olympic events based on their accessibility is a complicated task. Johnson & Ali (2002) attempt to do this by separating sports by labor-intensive, capital-intensive or team sports. However, there are a couple of limitations with this approach to the division of Olympic events. The lack of specificity in the categories limits the explanatory power of these variables and does not offer a complete picture of the Olympic events. For example, Johnson & Ali (2002) categorize summer capital intensive sports as those "involving horses, the equestrian and modern pentathlon events, and sailing," while the capital-intensive sports at the Winter Games "consists of luge, bobsleigh and ski jumping, all of which require expensive dedicated infrastructure for practice." This does not account for the fact that bobsleigh tracks are scarce and if these training facilities do exist, they are expensive, both to rent the track and to rent the equipment. However, sports such as cycling, while they are capital intensive, have free training facilities as athletes can simply ride on the surrounding roads. Additionally, Johnson & Ali (2002) group sports such as soccer and water polo under the same umbrella of team sports. While they are indeed both team sports, soccer is

a sport with low barriers to entry while water polo requires access to either a body of water or a pool.

The implications of these mischaracterizations are that these variables offer little explanatory value to the underlying accessibility issues facing certain sports. While this characterization might work fairly well for the "capital-intensive" variable, not all labor-intensive sports are inaccessible, and not all team sports are accessible. But as explained above, the "capital-intensive" category is still too broad and does not offer the complete picture of the Olympic event.

There is research on the cost of sports at the national level. The cost of sports varies across borders which makes international surveys difficult. For example, the cost of skiing in Algeria is going to be higher than the cost in Switzerland. Similarly, the cost of building facilities in various countries and regions differs which makes research on facility cost difficult to estimate even on a national level. Thus, the prospects of quantifying and stratifying these variables is challenging and instead a qualitative approach needs to be employed.

This paper uses several variables that seek to break down sporting events into distinct categories. Several variables are used to indicate whether the event meets a criterion to place it within a certain category. Working under the assumption that access to sporting equipment and sporting facilities are two of the main barriers to entry to sport, the Olympic events can first be broken down as follows: equipment needed (cycling, equestrian, or boat sports), equipment not needed (soccer or running), facility needed (swimming or gymnastics), facility not needed (marathon running or road cycling). Sports can further be separated into four distinct categories (summarized in Table 2.1

below) that are used in this analysis: equipment necessary and facility necessary, equipment necessary but facility not necessary, equipment not necessary but facility necessary, and finally equipment not necessary and facility not necessary. For example, track cycling can be considered an equipment heavy sports, and a sport that requires a specialized facility; thus, it would go under both the "equipment necessary and facility necessary" category. The focus of this paper is to look at the difference between low barriers to entry and high barriers to entry because the grey area in between (sports with either equipment or facility necessary) is much more difficult to separate and stratify. Thus, a barrier to entry variable was created that divided sports by low barriers to entry (no equipment or facility necessary), some barriers to entry (either equipment or facility necessary), and high barriers to entry (both facility and equipment necessary). A full summary of the event categorization can be found in Appendix A, Table 2.2. This approach does have several drawbacks. While it allows for very basic stratification of sports based on barriers to entry, it does not allow for a full ranking of sports based on cost. Additionally, it is still an arbitrary measure of barriers to entry. However, this new approach does a better job measuring barriers to entry in sports and the hope is that this model can be expanded in future studies to include more variables that might make ranking easier.

Table 2.1 – Summary of categories used to separate sport by accessibility

	Facility Needed	**Facility Not needed**
Equipment Needed	High barriers to entry	Some barriers to entry, usually lower than when facility is needed

Equipment Not Needed	Some Barriers to entry, Usually higher than when equipment is needed	Low barriers to entry

Source: author

While this is in no way an exhaustive list of categories that sports can be grouped under, this offers a simple model to determine whether equipment access and/or facility access hinder female success in the Olympics.

Empirical Model

This analysis uses the following empirical model:

$$ParSport_{it} = \alpha + \beta_1 Barr + \beta_2 GII_{it} + \beta_3 LaborPart_{it} + \beta_4 EduGPI_{it} + \beta_5 GDP_{it} + \beta_6 POP_{it} + \beta_7 GDP^2{}_{it} + \beta_8 POP^2{}_{it} + \beta_9 Ln(GDP)_{it} + \beta_{10} Ln(POP)_{it} + \beta_{11} Host_{it} + \beta_{12} t + u_i + \varepsilon \quad (2.3)$$

$$MedSport_{it} = \alpha + \beta_1 Barr + \beta_2 GII_{it} + \beta_3 LaborPart_{it} + \beta_4 EduGPI_{it} + \beta_5 GDP_{it} + \beta_6 POP_{it} + \beta_7 GDP^2{}_{it} + \beta_8 POP^2{}_{it} + \beta_9 Ln(GDP)_{it} + \beta_{10} Ln(POP)_{it} + \beta_{11} Host_{it} + \beta_{12} t + u_i + \varepsilon \quad (2.4)$$

Where:

$ParSport_{it}$ is a measure of female participation (as a percentage of total athletes) from nation i in a given sport in year t.

$MedSport_{it}$ is a measure of female medal count (as a percentage of male) from nation i in a given sporting category outlined in year t.

Barr is a measure of barriers to entry created from the event categorization above Where 0=low barriers (no facility or equipment), 1=some barriers (either facility or equipment), 2=high barriers (both facility and equipment).

GII_{it} is the World Economic Forums measure of national gender inequality for nation i in year t.

$LaborPart_{it}$ is the female labor force as a percentage of total labor force for a nation i in year t. This includes people ages 15 and older who supply labor for the production of goods and services.

$EduGPI_{it}$ is the ratio of girl's to boy's enrollment in primary and secondary schools (either public or private) for a nation i in year t. A GPI equal to 1 indicates parity between females and males while a value less than 1 indicates disparity in favor of males and a value greater than 1 indicates disparity in favor of females.

GDP_{it} is GDP per capita of nation i in constant international prices (current US$) in year t.

POP_{it} is the population of nation i in year t.

$Host_{it}$ is a dummy variable indicating if the participant was part of the host nation i in year t.

t is a time trend (1=1992 Games, 2=1996 Games, 3=2000 Games, 4=2004 Games, 5=2008 Games, 6=2012 Games, 7=2016 Games).

u_i is a nation-specific error term

ε is the unexplained error.

Summary

By specifying the base model, the modifications applied to it, and the final empirical model, this section captures various theoretical observations of this analysis. The next section on Data describes the dataset employed and estimates the models, the

dependent variables and the independent variables. It also provides the sources for the data used in this paper.

Data

This section describes the variables used in this study, their definitions, and their sources. This study uses data obtained from the International Olympic Committee's Olympic Study Center (OSC), the World Bank Open Data website as well as the United Nations Data website to create the dataset used to study the effects of barriers to entry on female participation at the Olympic Games.

Dataset

Previously identified predictors of Olympic success informed the variables choices made in this study with a particular emphasis on variables employed by Johnson & Ali (2002) and Lowen et al. (2016). The analysis uses data obtained from the OSC which includes all Olympic participants (Summer and Winter) since 1984. The data includes information on the athletes' name, National Olympic Committee (NOC) affiliation, age, gender, the event they participated in, and medal status. The data set was first narrowed to include only summer Olympics since 1992 (1992-Barcelona, 1996-Atlanta, 2000-Sydney, 2004-Athens, 2008-Beijing, 2012-London, and 2016-Rio de Janeiro). The study omits twenty-one nations[1] that are not included in UN or World Bank studies reducing the number of athletes to 91,115. Despite the omission of over 20,000 athletes that this created, the sample size remains large enough for the analysis to be considered representative. The athletes are then grouped together by country, NOC affiliation, gender, and event to allow for the male to female athlete proportions to be

[1] Nations removed were: Netherlands Antilles, Aruba, American Samoa, Bermuda, Cayman Islands, Cook Islands, West Germany, East Germany, Guam, British Virgin Islands, Kosovo, Monaco, Nauru, North Korea, Puerto Rico, Serbia & Montenegro, San Marino, Somalia, Czechoslovakia, Chinese Taipei, and Tuvalu.

calculated. This brought the dataset down to 12,583 observations which includes over 90,000 athletes from 190 nations.

Two objective standards are used to create the event categorization by facility and equipment. These standards were then used to create three categories for barriers to entry: low barriers, some barriers, and high barriers. First, the "low barriers" variable includes all events that require neither equipment nor facility and received a value of 0. Second, the "some barriers" includes all events that require either equipment or facility (but not both) and received a value of 1. Finally, the "high barriers" variables includes all variables that require both equipment and facility to practice and received a value of 2. These are categorical variables and the number they obtained was not used as a numerical variable in the regression to avoid a multiplier effect. A full list with the event categorization can be found in Appendix A. These are added to the dataset for each athlete.

Dependent Variable

There are two dependent variables employed in this study. The first dependent variable is the proportion of female athletes relative to the total number of athletes in that event from nation i in year t. This is a similar approach to the one employed by Lowen et al. (2016) with the exception that it also looks at specific nations. The second dependent variable is the proportion of medals won by female athletes relative to the total number of athletes in that event from nation i in year t. This study thus expands the current literature by using a more complete model that includes barriers to entry of a sport to predict the dependent variables:

- **$ParSport_{it}$:** is a measure of female participation (as a proportion of total athletes from nation i in a given event in year t).
- **$MedSport_{it}$:** measures female medal count (as a proportion of total athletes from nation i in a given event in year t.

The analysis uses data for 190 nations over all seven summer Olympiads between 1992 and 2016. Participation and medal winning data as well as the sport event categorization (or barrier to entry variables) all use data from the OSC.

Independent Variable

Gender Inequality Data. Lowen et al. (2016) inspire the addition of the gender inequality variables. While the base model only looks at the Gender Inequality Index (GII), this model uses a more complete representation of gender inequality in a given nation. To do so two additional measures of gender equality are used: labor force participation, and the Gender Parity Index in education. The variables are defined as follows:

- **GII_{it}:** index based on reproductive health (maternal mortality and adolescent fertility), empowerment (parliamentary representation and secondary education attainement) and the labor force participation rate in any given year. Scores range from 0 (gender equality) to 100 (gender inequality) in nation i, in year t.
- **$LaborPart_{it}$:** female labor force participation rate as a percentage of total show the extent to which women are active in the labor force in nation i, in year t. This includes people ages 15 and older who supply labor for the production of goods and services in a given year.

- **EduGPI$_{it}$:** ratio of girl's to boy's enrollment in primary and secondary schools (either public or private) in nation i, in year t. A GPI equal to 1 indicates parity between females and males. In general, a value less than 1 indicates disparity in favor of males and a value greater than 1 indicates disparity in favor of females.

The analysis aims to study slightly different aspects of gender inequality through the use of three different measures of gender equality/inequality. They also differ in data availability and accuracy which offers slightly different scopes of analysis and ensures the correlation between variables is not skewing the results (correlation matrix found in table 3.3). These variables are summarized in table 3.1 below.

TABLE 3.1

GENDER INEQUALITY INDICATORS SUMMARY STATISTICS

Variable	Obs	Mean	Std. Dev.	Min	Max
GII	11,246	.2880762	.1788642	.04	.833
LaborPart	12,384	41.55827	7.8877	8.09843	55.9051
EduGPI	8,954	.9907007	.0635765	.4059	1.26462

Source: author's calculations

Permanyer (2013) provides a careful discussion of the tradeoffs made when using the GII. They note that the index uses many indicators that have differing levels of reliability and availability which means that fewer data points being available. This is also a limitation of using EduGPI especially when looking at small nations where data are

not available as frequently. However, these two indices offer a good picture of societal attitudes towards women in a given nation. EduGPI offers a good overview of the barriers that girls face to education and the GII offers an overall picture of gender inequality in that nation. On the other hand, LaborPart data is more readily available and offers a good indication of socioeconomic barriers for adult women. However, it does not offer a clear indication of the types of jobs that are available to women and thus has certain limitation. GII data are from the United Nations Development Program while LaborPart and EduGPI data are from the World Bank.

Sport Event Categorization. The analysis creates a new "barrier to entry" variable by splitting events up into three distinct event categories based on their relative capital cost: low barriers to entry, some barriers to entry, and high barriers to entry. This variable seeks to demonstrate that as barriers to entry increase, the proportion of female athletes competing in that sport from that nation decreases. The barr variable categorization is found in Appendix A.

Barr: measure of barriers to entry created from the event categorization above

Where 0=low barriers (no facility or equipment), 1=some barriers (either facility or equipment), 2=high barriers (both facility and equipment).

National Context Components. These variables draw upon current literature outlined in the literature review above. GDP, host status and population data are the most basic indicators of Olympic success and serve as control variables. The variables are defined as follows:

- **GDP_{it}:** Gross Domestic Product per capita of a given nation i, in a given year t (current US$).

- **POP_{it}:** total population of a nation i, in a given year t.
- **$Host_{it}$:** dummy variable indicating if an athlete from a nation i, in a given year t is from the host country of that year's Olympic Games (1 if host; 0 if not).

Both GDP and population data are from the World Bank while the host dummy is from the OSC data. A summary of these variables is found in table 3.2 below.

TABLE 3.2

NATIONAL CONTEXT SUMMARY STATISTICS

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP	12,408	16602.84	18416.38	123.8762	164993.2
POP	12,569	7.13e+07	2.05e+08	19200	1.40e+09
Host	12,583	.0220933	.1469929	0	1

Source: author's calculations

Advantages and Limitations

As outlined above, this study has several advantages in testing how gender inequality affects Olympic success. First, it builds on current literature (Lowen et al., 2016) on gender inequality's effect on the proportion of male and female athletes participating at the Games by including several different measures of gender equality/inequality beyond GII (LaborPart, & FemGPI). While no index is perfect, a cross examination of different indices can offer a clearer picture of gender inequality's effect on Olympic success.

Second, including variables on barriers to entry to sport (such as facility and equipment necessity to practicing a sport) expands the limited literature (Johnson & Ali, 2002) on the correlation between gender equality and access to sport. However, the event categorization employed in this paper does include some drawbacks. Lack of individual sport participation cost data forces the creation of subjective categorizations of sports such as the one used in this study. While it does allow for more distinctions to be made between sports than the "labor vs. capital intensive" categorization employed by Johnson & Ali (2002), the categorize are still too broad to paint a clear picture of the barriers to entry in each sport. For example, sports such as tennis or track cycling are grouped together and while both sports do require specialized equipment and venue, the cost and accessibility differ greatly. Where tennis is a global sport with courts found in nearly every country, velodromes are much more scarcely found. Additionally, the cost of an Olympic track bike can reach sums close to US$15,000 whereas tennis rackets employed by professionals are closer to US$400. Additionally, it also does not account for individual nation's cultural barriers to entry. However, the hope is that the categorization used in this study can be expanded to create a more complete picture of the real cost of practicing a given sport and can expand literature on barriers to entry and their effects on sport participation.

Another disadvantage of this dataset is the lack of complete or accurate gender equality/inequality data for smaller or less wealthy nations. This adds a bias towards larger nations that already tend to have greater gender equality or at least tend to have more equitable gender representation within their Olympic delegation.

Another bias favors larger nations since the Olympic Games favor sports practiced in the larger nations. For example, a sport such as cricket that has a far greater international reach than a sport such as fencing is not included in the Olympic event lineup. However, as stated in section 2, these drawbacks are fairly small in comparison to the advantages the Olympic Games provide when studying sports. Their global reach, TV coverage, gender parity, and event diversity are unmatched in the sports field and makes it a good testing ground for the purposes of this study.

One important limitation is the difference in the number of male and female athletes at the Olympics. While the Olympic games are getting close to reaching gender parity in participation, no Olympic Game features an equal number of male and female athletes. The data set includes 54,195 male athletes but only 36,872 female athletes. This is in large part due to the fact that historically, there were more Olympic events for men than for women. While, recent Olympic editions have featured a historically high number of male and female events – London 2012 was the first summer Olympic games with the same number of events for male and female athletes – the dataset unfortunately does not reflect this.

A Variable Correlation Matrix is provided in Table 3.3 below. The matrix shows that there is very little correlation between the variables. However, as expected, GDP and GII show some correlation due to the close interaction between GDP and income levels which is used as a factor in the GII. While the correlation between GII and GDP is a cause for concern, this was controlled for through the addition of two gender equality variables (LaborPart, and EduGPI) neither of which shows any significant correlation with GDP.

TABLE 3.3

VARIABLE CORRELATION MATRIX

	Barr	**GII**	**LaborPart**	**EduGPI**	**GDP**	**Pop**	**Host**
Barr	1.0000						
GII	-0.0964	1.0000					
LaborPart	0.0096	-0.4727	1.0000				
EduGPI	0.0614	-0.3502	0.1713	1.0000			
GDP	0.0614	-0.6580*	0.2541	0.1666	1.0000		
Pop	0.0232	0.0332	-0.0695	-0.0360	-0.0992	1.0000	
Host	0.0214	-0.0762	0.0108	0.0257	0.0267	0.2266	1.0000

* signifies an important level of correlation

Source: author's calculations

Summary

The dataset created using data obtained from the International Olympic Committee's Olympic Study Center (OSC), the World Bank Open Data website as well

as the United Nations Data website, offers a large sample size well suited for testing the effects of barriers to entry on participation at the Olympics. Additionally, the dataset is robust against most econometric tests and only demonstrates some minor multicollinearity. The next section on Results describes the results of the various regressions run in this analysis.

Results

This section presents the findings from the Tobit regression using marginal effects of female success at the Olympics. This section also outlines some of the modifications made to the model and discusses the process implemented to achieve the final model and results. Overall, the model confirms the hypotheses outlined below but does still show some weaknesses that should be addressed in future studies.

Barrier to Entry Hypothesis. The study seeks to develop an understanding of the effects of barriers to entry in both society and sport on female participation at the Olympics. This is studied by testing several hypotheses. First, this study expects that the impact of gender equality/inequality measures for a given country to be significant and inequality to be negatively correlated to female participation at the Olympics. This would not only reaffirm previous studies but would also indicate that a condition necessary to sport participation is socioeconomic freedom and empowerment. This can be expected if the second hypothesis that is tested is true.

Female Participation Hypothesis. The second hypothesis is that the effects of barriers to entry on female participation will be statistically significant and negative. This indicates that while female participation at the Olympics is increasing, there are still significant inequalities in access to sport between male and female athletes. This should be more prevalent in nations with higher inequality rates and for sports with higher barriers to entry (such as equestrian). This can be expected because socioeconomic inequality limits access to sports with relatively higher barriers to entry.

Medals Hypothesis. Finally, the same relationship should be seen (to a lesser extent) in the proportions of medals won by gender. The study expects the coefficient on

the female proportion of medals won by a given nation in a given year and gender inequality to be negative and significant. Additionally, it anticipates that the coefficient between female proportion of medals won by a given nation in a given year and barriers to entry to be negative and significant. This implies that gender inequality and barriers to entry are both limiting the quality, and amount of training that women are able to receive.

This research expands on current research and adds variables that allow for a more comprehensive analysis of the role gender inequality and barriers to entry play in female participation at the Olympics. This fills a gap in literature where there is very little research on sport level barriers to entry at the Olympics. The model more accurately captures the interaction between gender inequality, sport, and participation at the Olympics.

Regression analysis

Econometric testing of the initial regression indicated the need for corrective measures. As shown in Table 3.3, mild multicollinearity is present in the data between GDP and GII. While the collinearity is an issue, this should be accounted for through the use of a quadratic and a log form of GDP. Additionally, the use of two other measures of gender equality (LaborPart and EduGPI) tests the accuracy of the GII variable findings. Since the dataset includes a large sample size and the analysis uses a Tobit regression, heteroskedasticity and nonnormality are not expected to be issues and so were not tested for.

However, the analysis suffers from very low R-squared values. While this would usually be a cause for concern, this is not expected be an issue in this study because the independent variables have several degrees of separation between them and the

dependent variable. Since significance is still found with coefficients that reflects previous literature, nothing was done to correct for this in the analysis.

TABLE 4.1

RESULTS FOR PROPORTION OF FEMALE ATHLETES (BY COUNTRY, YEAR, AND SPORT)

VARIABLE	GII			Labor Participation			Education GPI		
Low Barriers		(base)[2]			(base)			(base)	
Some Barriers	-.0716*	-.0750**	-.0718**	-.0427*	-.0462*	-.0451*	-.0618*	-.0672**	-.0688**
	(.0290)	(.0290)	(.0290)	(.0282)	(.0282)	(.0282)	(.0320)	(.0321)	(.0321)
High Barriers	-.112***	-.120***	-.124***	-.0694***	-.0781***	-.0884***	-.0852**	-.0948***	-.104***
	(.0303)	(.0303)	(.0303)	(.0295)	(.0295)	(.0295)	(.0334)	(.0335)	(.0335)
GII	-.386***	-.441***	-.415***						
	(.0515)	(.0624)	(.0633)						
Labor Participation				.0128***	.0129***	.0136***			
				(.000889)	(.000895)	(.000881)			
Education GPI							.258**	.229*	.0799*
							(.119)	(.121)	(.127)
GDP	2.25e-06***	2.32e-06*		3.49e-06***	6.04e-06***		3.51e-06***	5.78e-06***	
	(4.89e-07)	(1.30e-06)		(3.61e-07)	(8.92e-07)		(3.89e-07)	(8.79e-07)	
Population	3.06e-10***	1.13e-09***		3.34e-10***	9.81e-10***		2.83e-10***	9.36e-10***	
	(3.22e-11)	(1.39e-10)		(3.07e-11)	(1.28e-10)		(3.49e-11)	(1.49e-10)	
GDP^2		-1.09e-11			-4.64e-11***			-3.63e-11***	
		(1.60e-11)			(1.35e-11)			(1.16e-11)	
$Population^2$		-6.59e-19***			-5.15e-19***			-5.14e-19***	
		(1.08e-19)			(1.00e-19)			(1.15e-19)	
Ln(GDP)			.0210***			.0432***			.0467***
			(.00782)			(.00441)			(.00560)
Ln(Population)			.0546***			.0561***			.0479***
			(.00419)			(.00394)			(.00450)
Host	.0552	.0250	.0268	.0618	.0302	.0231	.0349	.0115	.0196
	(.0413)	(.0416)	(.0412)	(.0417)	(.0419)	(.0416)	(.0487)	(.0488)	(.0482)
Constant	.387***	.385***	-.644***	-.314***	-.351	-1.58***	-.00486	-.00714	-.957***
	(.0355)	(.0403)	(.114)	(.0459)	(.0463)	(.0890)	(.121)	(.123)	(.148)
Observations	11,100	11,100	11,100	12,223	12,223	12,223	8,858	8,858	8,858
R-Squared	0.0151	0.0170	0.0186	0.0203	0.0221	0.0247	0.0091	0.0112	0.0123

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

[2] "Low barriers" variable is used as the "base" value by which the variables "some barriers" and "high barriers" are calculated.

Source: author’s calculations

Regression for GII and Proportion of Female Athletes

The GII regression proves to be very effective in explaining the difference in proportion of female athletes sent by each country in various sports. The variables hypothesized to be statistically significant are significant at the 95% or 99% confidence level with only a few variables not falling within those ranges. The results found in Table 4.1 also match the hypothesized coefficients from the review of relevant literature.

Results Matching Hypothesis. Variables that both match the expected coefficient sign and that are statistically significant with at least 95% confidence are: the barriers to entry variables ("high barriers" & "some barriers"), the Gender Inequality Index, GDP, and population. As expected, GDP and population are both statistically significant and have a positive coefficient meaning that wealthier nations and nations larger populations send a greater proportion of female athletes. The analysis shows that a $10,000 increase in GDP per capita will lead to a 2% increase in the share of female participation at the Olympics. This reaffirms results found in the numerous studies outlined in the literature review including results found in Lowen et al. (2016). This alone is an indication that female athletes are often not a priority among NOC's for smaller nations. While the analysis does not offer a clear indication of the source of this inequality, it could be due to underlying sexism that pushes smaller NOC's to prioritize sending male athletes over female athletes to the Olympics. It can also be due to underlying inequalities in sport participation and/or access between men and women in smaller nations. Further research needs to be done to find the source of the disparity between male and female sports participation in smaller nations.

As in the Lowen et al. (2016) study, the results indicate that GII is also significant and negatively correlated with female participation at the Olympics. Specifically, the results show that a 10-point increase in GII will lead to approximately 3-4% increase in the share of female participation. This is higher than the values found in Lowen et al. (2016) and could be due to the larger sample size which also includes a higher proportion of "small" countries where the effects of GII might be more pronounced. But even if the coefficients found here are higher than the ones found in Lowen et al. (2016), they still indicate that gender inequality is an important factor in the participation of female athletes.

A particularly important finding in this model comes in the results for the effects of barriers to entry on female participation at the Olympics. The results confirm the second hypothesis made above. Sports with higher barriers to entry tend to have fewer female participants relative to male participants at the Olympics. Specifically, the data indicates that the presence of some barriers to entry (either equipment or facility but not both) leads to a drop 7% drop relative to the absence of barriers to entry. This is nearly doubled to 12% for the high barriers to entry category which indicates that as barriers to entry increase fewer female athletes participate relative to men at the Olympics. This is an important finding as it not only demonstrates that the event categorization that was used in this paper can prove useful for further analysis, but it also demonstrates formally that not all sports are equally accessible to women around the world.

A separate regression was run using "some barriers" as the base level. This regression found in Appendix B was found to be statistically significant at the 1% level in all three regressions with a positive coefficient (with the same magnitude as the "some

barriers" variable found in the first regression). This shows that low barriers to entry increases the proportion of women that participate at the Olympics relative to sports with higher barriers to entry in any given year further proving the hypothesis that lower barriers to entry lead to higher participation in those sports.

Results Not Matching the Hypothesis or With Uncertain Hypotheses. One significant difference is the absence of significance of the "host" variable. Both Johnson & Ali (2002) and Lowen et al.'s (2016) models find that host country status increases the proportion of female athletes competing at the Olympics for that nation. There are numerous possible explanations for this difference. An important difference between Johnson & Ali's model and this model is the inclusion of Winter Olympics in their study. Johnson & Ali look at Olympic games between 1952 and 2000 and include winter Olympics. This skews data in favor of northern nations that already in any given year send higher proportions of athletes to the Winter Games. Second there is a significant difference in scale between Lowen et al's (2016) study and this one. Lowen et al. (2016) only include 10,000 athletes in their regression while this study includes over 90,000 athletes. The difference in sample size between the two studies over the same period (1992-present) leads to the variables being skewed in favor of larger nations who are also more likely to host the Olympics.

Another difference between Johnson and Ali's (2002) study and this one is the lack of significance of the squared GDP variable. However, this was also found to be the case by Lowen et al. (2016). Again, the lack of significance found in this study and Lowen et al.'s might indicate that the addition of Winter Olympics to the sample – such as in the Johnson & Ali (2002) study – disproportionately favors larger nations (or the

"global north") and skews the data in favor of nations with higher GDPs making the quadratic form increase in significance. Another possible explanation is the presence of correlation between GDP and GII. This could be a possible explanation as the other two regressions (labor participation and Education GPI) both show significance for the squared GDP and neither variable suffers from correlation issues with GDP.

Regression for Labor Participation and Education GPI and Proportion of Female Athletes

The next regressions support the findings found in the GII regression for the most part. Variables that maintain approximate coefficient size and significance are:

- **Some Barriers –** equipment or facility necessary to practice sport
- **High Barriers -** equipment and facility necessary to practice sport
- **GII_{it} -** is the World Economic Forums measure of national gender inequality in for nation i, year t.
- **$LaborPart_{it}$** - female labor force as a percentage of the total show the extent to which women are active in the labor force for a nation i, in year t.
- **$EduGPI_{it}$-** ratio of girl's to boy's enrollment in primary and secondary schools (either public or private) for a nation i, in year t.
- **GDP_{it} -** Gross Domestic Product per capita of a given nation i, in a given year t in billions of current US$.
- **Pop_{it} -** total population of a nation i, in a given year t.
- **Pop_{it}^2 -** squared total population of a nation i, in a given year t.
- **$Ln(GDP)_{it}$ –** logarithmic form of Gross Domestic Product per capita of a given nation i, in a given year t in billions of current US$.

- **Ln(pop)$_{it}$ –** logarithmic form of total population of a nation i, in a given year t.

Results Differing from GII regression. There are no major differences between the various indicators of gender equality/inequality despite the differing sample sizes. The coefficients for "labor participation" and "Education GPI" are both positive whereas the GII coefficient was negative. This is to be expected since GII is a measure of inequality (where the higher the number, the more unequal the nation is). On the other hand, "Education GPI" and "labor participation" are both measure of equality (where the higher the number, the more equal the nation is). This also demonstrates that measures such as Education GPI, while they have smaller sample sizes, they still remain representative of the dataset as a whole.

Model qualities

All three models tell very similar stories. They all show that barriers to entry are significant in explaining a decrease in the proportion of female athletes from a given nation in a given event. The robustness of this finding was tested by running a regression of years 1996 and 2000 and comparing the results to a regression with data from years 2012 and 2016 (results found in Appendix C). This was done to check that the number of events that are offered to female athletes did not skew the data. This was done because the London Olympic Games in 2012 were the first Olympic Games to reach parity in the number of events offered to male and female athletes. The results demonstrate that while both the number of female athletes and number of events available to female athletes have increased over time, barriers to entry have remained significant in explaining the lower proportion of female athletes at the Olympics. The regressions show that GII, "some barriers", and "high barriers" were and still are statistically significant with

coefficients that match the hypotheses. The coefficients for high barriers to entry and GDP have both gone down which indicates that while inequality is still an issue, it is less pronounced than it was 20 years ago. Thus, the propositions to increase female participation at the Olympics set forth in Agenda 2020 are increasing the proportion of female athletes sent by the various NOCs and show that further long-term commitments to increase female participations should be encouraged – especially in sports with high barriers to entry.

Regression for Equipment and Facility and Proportion of Female Athletes

Another regression tests whether both equipment and facility play an equal role on the proportion of female athletes competing for a nation, in a given event and in a given year. The regression is for events that require equipment or facility (but not both) and excludes all "low barrier" sports and "high barrier" sports. The results for this regression are in Appendix D.

There are numerous interesting observations from this analysis. The equipment, GDP, population, and host status variables all confirm the hypothesis. However, facility lacks significance which is surprising since logic would dictate that facilities are the more capital-intensive investment of the two and thus would impact participation more. There are several reasons this might be the case. First, many sports that require a facility are team sports and nations tend to send more equal number of athletes in those sports since a minimum number of players are required to participate in those events.

Second, events such as "track and field" or "judo" are within the facility category. While good facilities definitely aid training by raising the quality of the preparation athletes can receive, it is not necessarily a requirement to practice the sport. On the other

hand, events such as “mountain biking” or “road biking” in the equipment category require a bike and the absence of the bike would make that event impossible to practice. This highlights a limitation in the event categorization. The lack of cost data artificially equalizes the relative costs and skews the data in favor of equipment heavy sports by not capturing the true cost of building facilities. A final reason the facility variable might lack significance is that facilities are usually funded by the state with relatively small direct expenses coming from the citizens of that nation. On the other hand, sporting equipment tends to be a personal purchase which favors the demographic with greater purchasing power – this tends to be men in wealthier nations.

This does not limit the importance of the findings. The analysis shows that there is a statistically significant decrease in the proportion of female athletes competing in sports that requires equipment and even though the facility variable lacks significance, it still indicates that there is a slight negative correlation between the necessity of a facility and the proportion of female athletes practicing that sport.

TABLE 4.4

RESULTS FOR PROPORTION OF MEDALS WON BY FEMALE ATHLETES (BY COUNTRY, YEAR, AND SPORT) USING "LOW BARRIERS" AS BASE LEVEL

VARIABLE	GII		
Low Barriers		(base)[3]	
Some Barriers	.0525	.0517	.0764
	(.179)	(.179)	(.179)
High Barriers	-.0909	-.101	-.0969
	(.184)	(.183)	(.184)
GII	-.497*	-.799**	-1.27***
	(.277)	(.356)	(.317)
GDP	7.29e-06	6.44e-06	
	(2.13e-06)	(6.22e-06)	
Population	9.64e-10***	2.44e-09***	
	(1.12e-10)	(5.70e-10)	
GDP^2		-2.55e-11	
		(7.86e-11)	
$Population^2$		-1.13e-18 ***	
		(4.35e-19)	
Ln(GDP)			-.00172
			(.0347)
Ln(Population)			.181***
			(.0209)
Host	.047025	-.000701	.0454
	(.137)	(.138)	(.137)
Constant	-.0743	-.0384	-2.78***
	(.208)	(.230)	(.563)
Observations	2,638	2,638	2,638
R-Squared	0.0216	0.0216	0.0198

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: author's calculations

[3] "Low barriers" variable is used as the "base" value by which the variables "some barriers" and "high barriers" are calculated.

Regression for GII and Proportion of Medals Won by Female Athletes

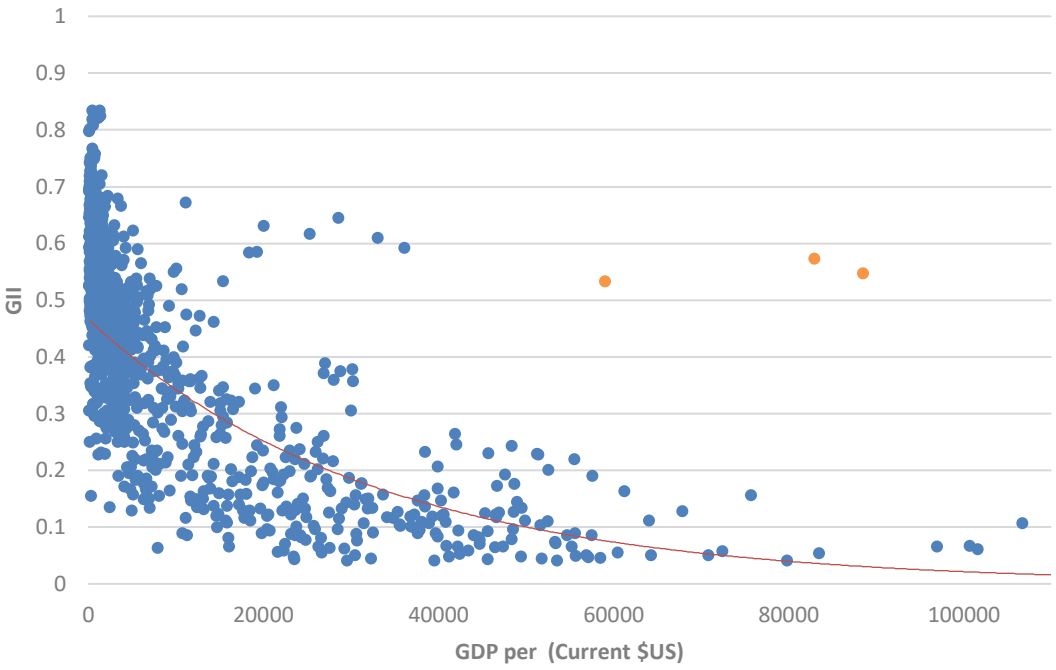
Unlike the results for proportion of female participants (by sport, and year), the second model does not show the same explanatory power when looking at proportion of medals won by female athletes. Only data using GII was used because regressions run with Labor Participation rates and Education GPI supported the findings in the GII regression without noticeable differences. The results found in Table 4.4 in large part do not match the hypothesized coefficients above.

Results Matching Hypothesis. Variables matching the hypothesis are GII, and population. This matches the findings made in Johnson & Ali (2002) and Lowen et al. (2016). GII and population can be expected to yield higher proportions of medals won by women since they both correlate to higher participation numbers and higher participation correlates to more medals won by that nation (Johnson & Ali, 2002). For example, the findings show that a 10-point increase in GII leads to a 5-10% increase in medals won by female athletes (by country, and year) which supports findings made in previous literature.

Results Not Matching the Hypothesis or With Uncertain Hypotheses. One big surprise is the lack of significance of GDP (in both the logarithmic form and the non-exponential form). Both Johnson & Ali (2016) and Lowen et al. (2016) find that GDP is statistically significant throughout all modifications of GDP. However, GDP is significant in this study when it is squared. This indicates that the proportion of medals won by female athletes correlates with an exponential increase in GDP per capita. Thus, as nations get larger their female athletes win many more medals relative to nations with smaller GDP's per capita.

Other important variables that did not support the hypothesis were the barriers to entry variables. The regressions show that there is no significance at any level for the "some barriers" variable and the "high barriers" variable. This can be explained by the fact that female athletes from large nations with higher GDPs per capita win a disproportionate number of medals. Female athletes that train and live in those larger nations enjoy higher incomes and in general also enjoy more equality and are thus not affected to the same extent by the same barriers to entry. A graph of the relationship between GDP per capita and GII is found below in figure 4.1. The graph demonstrates that as GDP per capita increases, GII decreases. Thus, nations with a higher GDP per capita also tend to be more equal. Three significant outliers exist (highlighted in orange) all coming from the same nation – Qatar which suffers from one of the largest gender equality gaps in the world while still benefiting from high per capita income (Scott, 2017).

Figure 4.1. Scatter plot of GDP against GII.



Source: author

These results indicate that while barriers to entry might affect the proportion of medals won by female athletes, the income level of that nation is the more powerful explanatory variable. The data demonstrate that the lack of large talent pools and lack of funding for adequate training facilities in smaller and "less wealthy" nations are the main sources of medal winning inequality.

Summary

Overall, the analysis confirms the hypotheses laid out at the beginning of the section. The coefficients for the barriers to entry variables, when significant, reflect the anticipated relationships, and thus confirm that barriers to entry in sports negatively affect female participation in those sports. Additionally, the coefficients are similar in

magnitude when comparing various measures of inequality, indicating that the coefficients accurately reflect their impact given the dataset

Conclusion

While female athletes are benefiting from increased representation at the Olympics and now participate in the same events as their male counterparts, they still suffer from domestic inequalities in their respective countries. Barriers to entry play a significant role in shaping the demographics of sports and these effects persist throughout the duration of this study. This is an area that is largely overlooked in academic research but is vital in understanding the true nature of inequalities within sports.

Current literature focuses on the macro level indicators – GDP and population size – that affect participation and medal winning at the Olympics but largely overlook the social factors. This paper fills this gap in literature by offering a new and simple way to measure barriers to entry in each sport based on two factors – the necessity of specialized facilities or equipment to practice a given sport. Overall, this categorization is effective in demonstrating that barriers to entry are negatively correlated to female participation.

Controlling for variables found to be significant in previous research such as GDP per capita, population size, and host nation status, a dataset was constructed by adding barrier to entry and gender inequality variables. This dataset included data received from the Olympic Studies Center (OSC) on each Olympic participant with information on the NOC they participated for, the event they competed in, and their medal status. GDP and population data were added from the World Bank's online database and gender inequality data was retrieved from the United Nation Development Program's online database.

Finally, the dataset uses a categorization of Olympic events based on equipment and/or facility requirements created for this study.

The analysis used a model based primarily on a model first used in Johnson & Ali (2002) and updated in Lowen et al. (2016). The study improves upon the models from these two studies by expanding the dataset to include more Olympic events and participants. In addition to a larger and therefore more representative dataset, this study uses a wider variety of gender inequality indicators to ensure that correlation between GII and GDP is accounted for. Finally, the study uses a more comprehensive method of ranking events based on barriers to entry, thus improving on current literature and increasing the explanatory power of the barriers to entry variable. The dataset and model built for this study then test a central hypothesis: do barriers to entry inherent to a certain sport reduce female participation in that event. The model used in this analysis proves the hypothesis correct while generally confirming the predictors used in previous studies – GDP, population, host status, and GII.

The findings in this analysis have numerous implications. The analysis shows that not all sports are equally accessible to female athletes in different nations. Barriers to entry limit female participation in events containing high barriers to entry (such as equestrian or modern pentathlon) which require high capital investment to practice and compete in. While female athlete participation is lower – across Olympic events and nations – relative to male athletes, the proportion of female athletes competing in events that require either specialized equipment or a specialized facility goes down considerably. This effect is even more pronounced in events requiring both equipment and facility. However, while the model is effective at predicting the proportion of female participants

in a given sport, it is not useful in predicting medal winning at the Olympics. This is not surprising considering the size of the dataset and the small number of medals handed out relative to the number of participants. This study supports previous findings that show that other factors such as GDP and population are better predictors of medal winning at the Olympics.

The applications of these findings are numerous and stretch beyond the Olympic Games. The Olympic Games are a useful economic testing ground because of their gender, national, and event representation however the results in this paper can be used to highlight the socioeconomic, national, and sport specific factors that need to be addressed to improve access to sport for women. The findings in this paper show that both gender inequality and barriers to entry hinder female participation in sports. And while this is demonstrated on the Olympic stage, it is a reflection of societal norms and sport funding inequalities worldwide.

National Olympic Committees, the International Olympic Committee, International Federations (IF) and national governments all have a stake in changing the demographic makeup of these sports. First, NOCs need to ensure that female athletes have an equal opportunity to compete at the Olympics. The IOC is by far the largest sporting institution in the world and has already demonstrated through Agenda 2020 that it is able to bring about real change by increasing the number of events available to female athletes which in turn increases the number of female athletes in attendance at the Olympic Games. As they near the expiration of Agenda 2020, the IOC should continue its commitment to increasing female participation at the Olympics by working with the various sports federations and organizing committees in the formulation of the next set of

Olympic movement goals. International Federations need to recognize and acknowledge that barriers to entry exist in all sports and that certain sports aren't as accessible to certain demographics around the world. This should be followed by increased funding for underrepresented groups or rules that aim to decrease barriers to entry. For example, USA Swimming, a National Federation, passed a ban on tech racing suits (usually sold for around US$200-300 each) for all swimmers 12 and under (Keith, 2018). This limits the amount of money necessary to be competitive at the age group level thus leveling the playing field. These types of rules should be encouraged at the international level by IFs and can bring about significant change.

Finally, sports play an important role in national development. In a speech given at a UN summit in 2016, UN Assistant Secretary-General and UN Women Deputy Executive Director Lakshmi Puri said: "sport has enormous power to generate real social, economic and environmental change and contribute to sustainable development, social cohesion and even to challenge mind sets and prejudice […] sport has huge potential to empower women and girls" (Puri, 2016). This shows that national governments have a real stake in increasing female participation in sport. While the direction of causation was not tested in this paper, further research should be done on the effects sport have on a national level in changing attitudes towards women. Regardless, gender equality can be a great tool in promoting sustainable development goals especially if sport is found to be a useful tool in promoting the empowerment of women.

While the findings in this paper are exciting and their ramifications important, some limitations still exist. First, the low R-squared, while it shouldn't cause too much concern is still unusually low and could be due to some omitted variable bias in the

dataset. However, this was not a cause of major concern in this study since R-squared values in previous literature are either not reported or are also found to be low indicating that this might be related to the nature of the dataset.

Second, while the event categorization in this paper offers a good first step in creating a "barrier to entry" variable it should be built upon as it still remains vague. It does not allow for the ranking of events based upon their relative barriers to entry lumping events such as sailing and football (soccer) in the same category. It additionally doesn't capture the full cost of practicing sports that requires a facility as it skews the data in favor of sports requiring equipment instead. More research should be done to standardize the international cost of each sport to fully capture the barriers to entry. Finally, it does not capture cultural factors that affect female participation such as laws or norms that limit the practice of sport by women. However, as the results of this analysis show, this categorization offers a good stepping stone in building further models that measure a sports barrier to entry.

Political and economic indicators such as GDP per capita, population size, and host status do a good job in predicting success at the Olympics, however, they do not give a complete picture of the true inequalities that female athletes face in sport. The paper expands on the limited research in this field and shows that the inequalities are complex and run much deeper than the Olympic Games. This paper shows that sports with greater barriers to entry tend to have fewer female athletes from any given nation, in any given year. This effect is stronger in nations with higher gender inequality suggesting that national policies and local cultural norms also play an important role in hindering female participation in sport. Gaining a clearer understanding on the real nature of these

inequalities is vital in leveling the playing field for men and women alike.

APPENDIX A

TABLE 2.2

OLYMPIC EVENT CATEGORIZATION

Event	**Equipment**	**Facility**	**barr**
Modern Pentathlon	1	1	2
Sailing	1	0	1
Judo	0	1	1
Pool Swimming	0	1	1
Boxing	0	1	1
Weightlifting	1	1	2
Tennis	1	1	2
Canoe Slalom	1	1	2
Equestrian	1	1	2
Table Tennis	0	1	1
Cycling Road	1	0	1
Track & Field Athletics	0	1	1
Road Athletics	0	0	0
Rowing	1	0	1
Shooting	1	1	2
Handball	0	1	1
Badminton	0	1	1
Canoe Sprint	1	0	1
Archery	1	1	2
Cycling Track	1	1	2
Football	0	1	1
Water Polo	0	1	1
Wrestling	0	1	1
Rink-Hockey	1	1	2
Diving	0	1	1
Gymnastics Artistic	1	1	2
Gymnastics Rhythmic	0	1	1
Basketball	0	1	1
Basque Pelota	1	1	2
Fencing	1	1	2
Volleyball	0	1	1
Hockey	1	1	2
Taekwondo	0	1	1
Baseball	1	1	2
Synchronized Swimming	0	1	1
Beach Volleyball	0	1	1
Cycling Mountain Bike	1	0	1
Softball	0	1	1
Triathlon	1	0	1
Cycling BMX	1	1	2
Marathon Swimming	0	0	0
Golf	1	1	2
Rugby	0	1	1

Source: author.

APPENDIX B

TABLE 4.2

RESULTS FOR PROPORTION OF FEMALE ATHLETES (BY COUNTRY, YEAR, AND SPORT) USING "SOME BARRIERS" AS BASE LEVEL

VARIABLE	GII		
Low Barriers	.0716*	.0750**	.0718**
	(.0290)	(.0290)	(.0290)
Some Barriers		(base)[4]	
High Barriers	-.112***	-.120***	-.124***
	(.0303)	(.0303)	(.0303)
GII	-.386***	-.441***	-.415***
	(.0515)	(.0624)	(.0633)
GDP	2.25e-06***	2.32e-06*	
	(4.89e-07)	(1.30e-06)	
Population	3.06e-10***	1.13e-09***	
	(3.22e-11)	(1.39e-10)	
GDP^2		-1.09e-11	
		(1.60e-11)	
$Population^2$		-6.59e-19***	
		(1.08e-19)	
Ln(GDP)			.0210***
			(.00782)
Ln(Population)			.0546***
			(.00419)
Host	.0552	.0250	.0268
	(.0413)	(.0416)	(.0412)
Constant	.387***	.385***	-.644***
	(.0355)	(.0403)	(.114)
Observations	11,100	11,100	11,100
R-Squared	0.0151	0.0170	0.0186

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: author's calculations.

[4] "Some Barriers" variable is used as the "base" value by which the variables "Low barriers" and "high barriers" are calculated.

APPENDIX C

TABLE 4.3

RESULTS FOR PROPORTION OF FEMALE ATHLETES (BY COUNTRY, YEAR, AND SPORT) COMPARING YEARS 1992-1996 WITH 2012-2016

VARIABLE	1992-96	2012-16
Low Barriers	(base)[5]	
Some Barriers	-.0988*	-.110**
	(.0654)	(.0420)
High Barriers	-.132**	-.113**
	(.0683)	(.0443)
GII	-1.05***	-.384***
	(.151)	(.101)
GDP	-.0000174***	9.75e-07
	(5.39e-06)	(1.96e-06)
Population	9.48e-10 ***	9.48e-10***
	(3.42e-10)	(1.39e-10)
GDP^2	3.91e-10***	-6.36e-12
	(1.19e-10)	(1.60e-11)
$Population^2$	-9.99e-19***	-5.56e-19***
	(2.83e-19)	(1.08e-19)
Host	.0928	.0250
	(.0876)	(.0416)
Constant	.647***	.514***
	(.103)	(.0601)
Observations	2,761	3,716
R-Squared	0.0253	0.0130

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: author's calculations.

[5] "Low Barriers" variable is used as the "base" value by which the variables "some barriers" and "high barriers" are calculated.

APPENDIX D

TABLE 4.2

RESULTS FOR PROPORTION OF FEMALE ATHLETES (BY COUNTRY, YEAR, AND SPORT) COMPARING EQUIPMENT AND FACILITY

VARIABLE	GII
Equipment	-.198***
	(.0311)
Facility	-.0348
	(.0281)
GII	-.481***
	(.0702)
GDP	3.90e-06**
	(1.49e-06)
Population	1.24e-09***
	(1.60e-10)
GDP^2	-1.90e-11
	(1.81e-11)
$Population^2$	-7.31e-19***
	(1.26e-19)
Host	.0516
	(.0498)
Constant	.376***
	(.0425)
Observations	11,100
R-Squared	0.0290

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: author's calculations.

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