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Abstract

Does a country's level of inequality affect its ability to win Olympic medals? If it does, is it conditional on institutional factors? We argue that the ability of economically free societies to win medals will not be affected by inequality. In these societies, institutions generate incentives to invest in the talent pool of individuals at the bottom of the income distribution (people who are otherwise constrained in the ability to expend resources on athletic training). These effects cancel out those of inequality. In unfree societies, the incentives that promote investments in skills across the income distribution are weaker. Consequently, the effects of inequality on the ability to win are stronger. Using the Olympics of 2012 and 2016 in combination with the Economic Freedom of the World Index, we find that inequality only matters in determining medal numbers for unfree countries. We link these results to the debates on inequality.

JEL classification: D63, E02, O43
Keywords: Olympics, Inequality, Economic Freedom, Institutions

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1 Introduction

The study of inequality as a subfield within economics has soared in recent years. The number of studies dedicated to the proper measurement of inequality (Piketty and Saez, 2003; Kopczuk et al., 2010; Burkhauser et al., 2012; Atkinson et al., 2011; Frank, 2014; Kopczuk, 2015; Armour et al., 2014; Piketty et al., 2017) has prompted studies trying to link inequality to the evolution of living standards (Deaton, 2003; Bowles, 2012; Frank, 2013; Cingano et al., 2014). Some of these studies have found that inequality deters growth (Alesina and Perotti, 1996; Atems and Jones, 2015; Halter et al., 2014) while others have found no significant effects, (Ferreira et al., 2018) or even positive effects (Forbes, 2000).

This range of different results implies that something else may be at play. One rich and prominent explanation for the discordance relates to the role of the institutional settings within which inequality takes place (Ashby and Sobel, 2008; Aspergis et al.; Bennett and Vedder, 2013; Hall and Lawson, 2014; Sturm and De Haan, 2015; Bennett and Nikolaev, 2017). In essence, this line of argument states that inequality will affect outcomes conditional on the quality of institutions within a country: a Gini coefficient of 0.5 will not have the same effect on living standards in a repressive dictatorship as in a liberal democracy.

To test this statement, we propose to concentrate on the microcosm of outcomes in Olympic games. Microcosms have often been used in the literature on inequality. Examples include: in the sociology of science with regard to the scholarly reputations of researchers (DiPrete and Eirich, 2006); in public health with regard to the life expectancy of Oscar prize winners (Redelmeier and Singh, 2001b,a) and British civil servants (Marmot et al., 1984, 1991; Marmot and Shipley, 1996); and in the study of labor markets with regard to guard labor (Bowles, 2012). All of these microcosms concentrate on one particular channel through which inequality affects outcomes.

The Olympics are a particular fruitful microcosm for tying inequality, institutions and outcomes together. The innate talent required to compete in the Olympics is not related to wealth; rich and poor alike can be high-performing athletes. The costs of developing those talents are subjectively greater for the poorest. In such a setting, all else being equal, inequality would affect the likelihood of winning medals. As higher inequality suggests fatter tails of the income distribution, there is a greater share of the population that falls below a certain absolute threshold. As a result, the greater inequality entails that a greater share of the population faces a significant cost hurdle to participation in the Olympics. Thus, some potentially medal-winning athletes cannot participate. And there is some evidence that inequality does reduce medal counts (Berdahl et al., 2015; Bai et al., 2015). However, this expected effect of inequality can be mitigated, or even overturned, by greater institutional quality. The main reason for this is that there are returns from participating in the Olympics. As such, the gains can be disproportionately large for the poorest (relative to their incomes) which creates a strong incentive to participate and invest efforts. Countries with greater levels of institutional quality, most notably with respect to the protection of private property rights, secure these returns and thus incentivize participation. If well-established property rights increase and secure the returns from the Olympics, it stands to reason that this would mitigate the effects of inequality described above.

To test this possibility, we use the most recent Rio 2016 Olympics. The data regarding medal numbers and the characteristics of participating countries were combined with the data from the Economic Freedom of the World (EFW) database (produced by the Fraser Institute in Canada). We use economic freedom as a proxy for the simple reason that it speaks to institutional quality (Sobel, 2008; Hall et al., 2010; Hall and Lawson, 2014). As the index of economic freedom includes components that speak to the security of property rights, it relates to the issue of institutional quality regarding the ability to secure gains from participating in the Olympics. Thus, we expect economic freedom to matter to Olympic performance. We broadly confirm our intuition: countries with lower levels of economic freedom experienced larger negative effects of inequality on medals won per 1 million inhabitants while those with higher levels experienced no statistically significant effects. Because a large number of countries obtained zero medals we also employ a hurdle model to further solidify our findings. We find that the marginal effect of economic freedom is quite large and overshadows that of inequality, thus confirming our hypothesis.

We divide our paper as follows. In section 2 we discuss the literature on inequality and the Olympics in order to properly frame our theoretical proposition. In section 3, we highlight the data and methodology that we used. In section 4, we present our results. In section 5, we discuss and conclude.

2 Inequality, Future Outcomes and the Olympics

Many arguments regarding the negative relationship between inequality and outcomes speak to relative capabilities. Consider the example provided by the work of Robert Fogel (1994) regarding health history in Europe. Fogel pointed out that food production in France was so low that, given distributions of net nutrition, those at the bottom of the income distribution were so undernourished that it was impossible for them to do more than six hours of light work every day. Chronic malnutrition among the poorest meant that they faced a heavier constraint when attempting to increase their incomes. Elsewhere, Angus Deaton (2003, pp. 130-131) rephrased the argument by stating that guaranteeing "basic needs" by redistribution enables those at the bottom "to participate gainfully in the labor market" and, as such, "destitution is therefore seen as a problem that can be dealt with by a more equitable distribution."[1] Channels that emphasize greater credit constraints at the bottom of the income distribution (Bowles and Gintis, 2002), or limit the ability to make investments in human capital (Galor and Moav, 2004), amount to a similar argument that higher levels of inequality, all else being equal, entail greater constraints on those at the bottom of the distribution.

The argument for linking inequality to the ability to win medals is the same. Innate skills in sporting activities are distributed independently of income. However, the training of an athlete is a costly endeavor—a cost which is also independent of a household's income. Athletes from richer households have an easier time jumping over that hurdle because the opportunity cost

[1] Deaton was speaking of the case of nutrition in India and how the unequal distribution of land contributed to undernourishment which lowered the marginal product of labor of the poorest. Thus, Deaton's "redistribution" refers to land redistribution.

of the resources needed to train for Olympic competitions is smaller for them. This means that the pool of the best athletes in a country is limited by this ability to leap over the cost hurdle. All else being equal, we must expect high inequality to limit the ability of a country to send its best athletes to international competitions such as the quadrennial Olympic games (Krishna and Haglund, 2008). The typical study of Olympic outcomes concentrates on factors such as income and dummies variables to capture host status and political regimes (Bernard and Busse, 2004; Johnson and Ali, 2004; Trivedi and Zimmer, 2014). Few studies have considered the role that inequality might play, but those that have found an effect whereby greater income inequality reduced medal numbers (Bai et al., 2015; Berdahl et al., 2015).

On the other hand, we ought to consider the gains of winning a medal as well. There are great monetary and non-monetary rewards from Olympic participation (e.g. prizes, prestige, advertisement contracts etc.). Thus, while inequality may act as a greater constraint, it may also act simultaneously as a greater motivator for effort. In fact, if the rewards are roughly equal in monetary terms, it stands to reason that they are subjectively more valuable for those at the bottom of the income distribution. In such a framework, the issue becomes one of the appropriability of the benefits on the supply of effort (Alchian, 1965; Shughart and Tollison, 1993; Campbell et al., 2005). This hinges on a well-established regime of private property rights (which we take as a proxy for institutions). Secure property rights animate individuals to allocate productive resources to the most valued ends. Expanding on Alchian (1965) by using the Olympic performance of former communist countries during their transition to market economies, Shughart and Tollison (1993) argued that private property rights were "not sufficiently well established to permit these athletes to capitalize the returns from Olympic victory in ways available to their Western counterparts." The result was that athletes "tended to supply less medal winning effort" in the 1992 Olympic games which they used as their example (as these Olympics occurred during a transition).[2]

Campbell et al. (2005) extended on Shughart and Tollison's insights by testing whether or not economic freedom (the proxy measure for the ability to capitalize on winning medals) affected medal counts. They found that a one-point change from the median value of economic freedom indexes (out of 10) increased a countrys medal count by 3.8 (2005, p. 244). Their use of economic freedom as a measure of institutional quality is also quite relevant. Indexes of economic freedom have been shown to relate very closely with other measures of institutional quality (Scully, 1988; Gwartney et al., 2006; Stroup, 2007; Sobel, 2008; Hall et al., 2010). For our purposes, it is the "legal system and property rights" component of the economic freedom index that is relevant. That component of the index attributes values based on the protection of property rights, the legal enforcement of contracts, the reliability of police forces and the regulatory costs of the sale of property (Fraser Institute, 2018).[3] All of these elements speak to whether or not athletes can appropriate the returns from their efforts. A weak property rights regime (i.e. a regime with low economic freedom) will create fewer incentives to invest efforts

[2]Prior to the collapse of the Soviet Bloc, athletes did receive large benefits from winning which in a way provided a form of appropriability. In the transition, these benefits disappeared, but property rights were not sufficiently well-established to compensate.

[3]Other components of the index are indirectly related to property rights. For example, the regulation component considers the administrative requirements and the extra payments (bribes) needed to acquire the right to operate a firm.

in athletic performance. There is already corollary support in the form of the finding that corruption reduces medal counts (Pierdzioch and Emrich, 2013). As corruption undermines the quality of property rights, it reduces the ability to appropriate returns from winning a medal and, consequently, deters effort. As such, we are expanding upon the previous efforts of Campbell et al. (2005) and Pierdzioch and Emrich (2013).

The link that can be established is that bad institutions amplify the effect of inequality on medal numbers and good institutions mitigate that effect. At the same level of inequality, the countries with better institutions provide a stronger incentive for those at the bottom to invest resources toward winning medals. The countries with bad institutions are unable to generate the same expense of effort. Thus, we can expect that, if grouped by level of inequality, countries with better institutions win more medals (all else being equal). Conversely, if grouped by quality of institutions, we can expect that countries with less inequality win more medals. Finally, there is the possibility that the effect of one of those channels is larger than the other. All these possibilities are the ones we consider in this paper.

3 Methods and Data

The starting point of our discussion relates to the heterogeneous impact of inequality on performance of athletes. Therefore, the empirical strategy has to reflect this underlying assumption. In terms of estimation strategy the heterogeneous impact of inequality can be captured using multiple equilibria analysis. We start with an assumption that there are at least two institutional regimes, under which inequality can either be detrimental to performance of athletes (regime of low level of economic freedom), or irrelevant for the performance of athletes (regime of high level of economic freedom). Under the regime of low economic freedom, athletes cannot easily appropriate the gains from winning a medal and thus there are fewer incentives to invest in improving Olympic performance. Under the regime of high economic freedom, these incentives are stronger and more numerous. In both regimes, the cost that inequality imposes is the same so that only the benefits that athletes can capture (i.e. those which stem from institutional quality) generate differences in performance. In order to do so, we apply the Hansen (2000) threshold model, which allows us to estimate the threshold between the two regimes, rather than making an arbitrary decision. The model takes the following form:

$$\begin{aligned} y_i &= \theta_1 x_i + \beta_1 c_i + u_i\,, \quad q_i \leq \gamma \\ y_i &= \theta_2 x_i + \beta_2 c_i + u_i\,, \quad q_i > \gamma \end{aligned} \tag{1}$$

Where y_i is the outcome variable, namely medals per one million population; x_i is the level of inequality; c_i are diverse controls for income, saving, expenditures on health and military, life expectancy, age, weight and number of athletes; u_i is the error term; θ and β are coefficients for the related regimes. It follows that q_i represents the threshold variable, namely the index of economic freedom, whereas γ is the threshold separating the two regimes.

In the model above, institutions do not enter the estimation equations directly, but rather as a regime identifier. Comparing θ_1 and θ_2 would provide information on the impact of institutional regimes on the interplay between inequality and the outcome variable. However, we might be interested in the direct impact of institutions on the outcome variable. In addition, the multiple equilibria analysis should be applied to the outcome variable as well: countries with zero medals should be considered in a separate equation, which would resemble a hurdle model. We reformulate the estimation model with respect to a natural threshold of zero in the outcome variables and define two equations: The first equation explains the non-zero part, whereas the second equation explains the probability of winning at least one medal (zero against non-zero outcome). However, the given hurdle model does not imply a threshold. Countries not scoring any medals would most likely have a different set of slopes for the same variables. The hurdle model can be specified in the following way, where the first equation is estimated using a gamma regression[4] and the second equation is estimated using a logit model:

$$\begin{aligned} y_i &= \pi_x x_i + \pi_c c_i + e_i\,, & y_i &> 0 \\ nonzero_i &= \phi_x x_i + \phi_c c_i + v_i\,, & nonzero_i &= \begin{cases} 1, & \text{if } y_i > 0 \\ 0, & \text{if } y_i = 0 \end{cases} \end{aligned} \tag{2}$$

Where y_i would be the number of medals per one million population, excluding zeros, and $nonzero_i$ would be the binary outcome for zero and nonzero cases. π and ϕ are the coefficients, whereas e and v are the errors. Due to the nonlinear nature of the gamma and logit models, average marginal effects (AMEs) are calculated and reported.

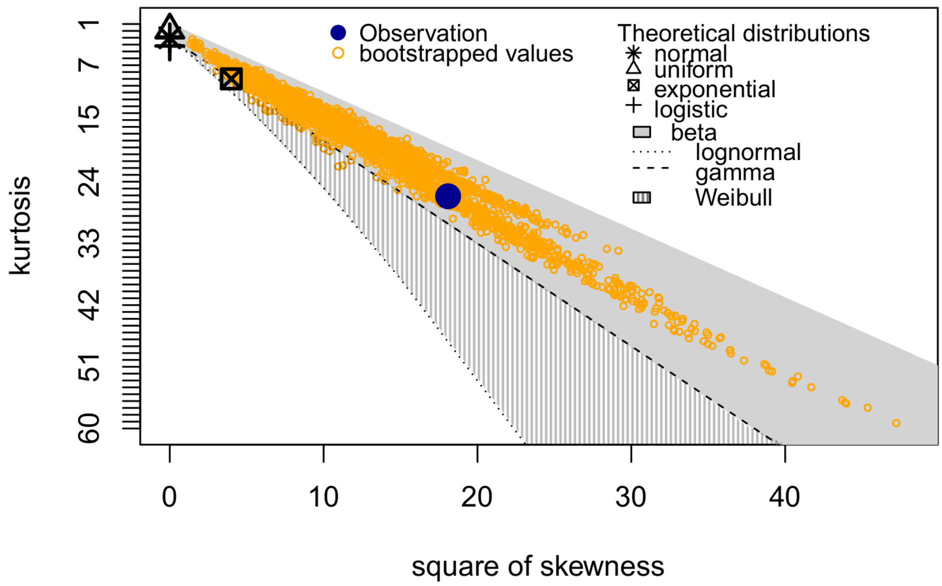
Table 1: Descriptive statistics

Variable	Mean	SD
Medals per 1 mln. pop. (Rio)	0.34	0.63
Nonzero medals	0.55	0.50
Medals per 1 mln. pop. (London)	0.38	0.67
Gini coefficient	39.47	8.76
Top 10% income share	31.17	6.94
Economic freedom index	6.71	0.81
GDP pc ppp	12.821	19.08
Saving rate	22.46	20.37
State expenditures on health (share in GDP)	3.75	2.03
State expenditures on military (share in GDP)	1.72	1.05
Life expectancy	68.89	9.70
Life expectancy sqaured	4838.97	1275.80
LN age of athletes	3.28	0.08
LN average weight of athletes	4.26	0.10
Share of athletes	0.69	1.01

By combining diverse sources and datasets we were able to select appropriate proxies for inequality and choose relevant controls (see Table 1). The data on medals were taken from IOC (2012) and IOC (2016), whereas the data on population was obtained from The World Bank

[4] According to distribution tests (see the Cullen et al. (1999) plot as in Delignette-Muller and Dutang (2015), also known as the Pearson plot on Figure 1) the medals per one million population belong to either the Gamma or the Beta distribution and therefore the choice of an appropriate model is crucial. Traditionally the Beta distribution is used for research questions with a fractional outcome limited from zero to one, however, the number of medals per million does not have such restrictions. Therefore, Gamma distribution seems to be a more suitable candidate.

Figure 1: Distribution fitting: medals per 1 mln. pop. (Rio); 2 000 bootstrapping rounds.



(2018). The population denominator is important to tackle the size effects. For simplicity, we calculate the number of medals per one million population. The proxy for economic freedom was taken from the Fraser Institute (2018): the values of the overall index were averaged for the period of 2000–2014. The Fraser Institute's Economic Freedom of the World (EFW) is particularly well-suited for our purposes. Because of its focus on property rights (which carry an important weight in the index), it speaks to the ability of athletes to appropriate the rents from Olympic participate. As a result, it is an efficient proxy for institutional quality - which is crucial to our argument that inequality's effects are offset by greater institutional quality. The averaging of the EFW values is also an important feature of the present paper. Athletes decide whether or not to invest efforts based on property *before* the Olympics take place. Their ability to win is thus contingent to economic freedom many years *prior to* the Olympics. This is why we average the values of economic freedom in the years leading up to the outcomes of the Rio Olympics of 2016 which we use as our dependent variable.

The proxies for macroeconomic variables, as well as the proxies for inequality (Gini index and the income share of the top 10%) were taken from The World Bank (2018). The values for these variables were averaged for the period of 2000–2014 or 2000–2015, where applicable. Data on athletes taking part in the Rio games (age, weight and number) were taken from IOC (2016) and Riggott (2018). We also included a variable for the London Olympics. This is meant to stand-in a proxy for a country's resources. Because our variable of interest is medals won relative to population, including a variable for population size would be problematic. However, population is a relevant indicator because it speaks to the availability of resources for competitions. For example, Monaco may be rich per capita, but at the recent Olympics and because of its small population, it entered three athletes in three events. The medals won in the previous Olympics allow to capture this effect as the resources available for a country to compete in the Olympics did not change dramatically between 2012 (when the London

Olympics occurred) and 2016. Thus, the addition of the outcomes of the London Olympics allows us to capture the normal inclusion of a country's size (Bernard and Busse, 2004). In addition, this variable represents persistence, or a certain path dependence.

4 Main Results

Basic OLS regressions (Table 2) show that even after controlling for the results of the previous games, inequality tends to be a significant negative determinant of contemporary olympic outcomes. Residual diagnostics show absence of serial correlation, yet presence of heteroscedasticity. Therefore, throughout the analysis robust standard errors are used. The results of the threshold regression are crucial to our analysis. The findings confirm heterogeneous slopes for inequality proxies. The coefficients for the inequality proxies from the overall analysis (Table 2, columns 1 and 2) are negative and significant. These effects remain significant at the 10% level even after controlling for the results during the lagged Olympic games (columns 3 and 4). From the basic threshold regressions (columns 5–8) it follows that countries with poor economic freedom tend to be less stable in their performance (lower coefficient of the medals won during the previous games) and are exposed to negative significant impact of inequality, whereas countries with better economic freedom tend to be more stable in their performance and are less exposed to negative impacts of inequality. Although these results are in line with our key arguments on the role of economic freedom in sports, further controls should be added. Since achievements in sports are path dependent, controlling for the number of medals per one million population during the previous summer Olympic games seems intuitive: this variable has a positive significant effect in all estimations. However, the inclusion of the results from the previous games may correlate with some of the explanatory variables and therefore we report the estimations with and without this variable.

The results for model 1 with further controls are presented in Tables 3 and 4: it follows that below the estimated economic freedom threshold ($\hat{\gamma}$) inequality has a detrimental impact on the performance of athletes, even after controlling for income, saving rate, health and military expenditures, life expectancy and average athlete characteristics. Figure 2 helps to visualize the relationship between the medals and the inequality levels for countries with economic freedom below the threshold. The effect of inequality is -0.021 per each point increase in the Gini index and -0.0204 per each percentage increase in the top 10% share of income (Table 3). After controlling for the results during the previous Olympic games, the effects become more moderate: -0.014 for the Gini index and -0.0127 for the top 10% share of income. Countries above the institutional threshold do not exhibit a significant relationship between inequality and the number of medals, with the exception of the share of top 10%: in Table 4 the impact is positive, although the significance level is weak. Government expenditures on health have a positive significant effect for the countries with low economic freedom only without controlling for previous results (Table 3). Another effect worth noting is the significant role of military expenditures for the number of medals for countries with more pronounced economic freedom, which is observed only for the specification with top 10% (Table 4). Per capita income has a significant positive effect on performance in sports for countries with weak economic freedom.

After controlling for the results of the previous Olympic games, this effect becomes weaker, but remains significant. For both specifications the institutional threshold ($\hat{\gamma}$) is estimated with 50 bootstrapping rounds.[5] After controlling for regional effects, we did not find any significant results for Latin American countries, although the Olympic games of interest were held in Brazil.

While the estimation based on institutional thresholds provides empirical findings about the heterogeneous impact of income inequality on performance in sports, where economic freedom is divided into regimes, the estimations based on a hurdle model (see Tables 5, 6, 7 and 8) allow us to assess the continuous impact of economic freedom on the probability of winning at least one medal (columns 19, 23, 27 and 31) and on the number of medals (columns 17, 21, 25 and 29). The persistence, or the path dependence, in the probability of winning medals, as well as the persistence in the number of those, is still one of the strongest effects. We report average marginal effects (AME) for both non-linear regressions. It follows that a one-point increase in the Gini coefficient is associated with a decrease in probability of winning at least one medal by 1.48% and a decrease in the number of medals per million population by 0.0208. Controlling for the previous Olympic games results does not substantially change the results. Economic freedom is statistically significant for the number of medals, but it does not govern the probability of winning at least one medal: a one-point increase in the economic freedom index yields a 0.454-point increase in medals per million population and a 0.33-point increase after controlling for the previous achievements. Saving rate was significant only in the equation for the probability: a one-point increase in the saving rate is associated with a 0.92% increase in the probability of winning at least one medal and a 1.17% increase after controlling for the previous achievements. The shares of public spending on health and military turned out to be significant predictors only for the number of medals. The military spending were significant only in the specification with the previous achievements. One of the most crucial controls for the logit regression is the share of athletes among all participating athletes—it follows that inequality is still a robust predictor of the probability of winning at least one medal even after controlling for the given effect. Similar results are obtained for the specification with the share of top 10%. In Table 7 a one-point increase in the income share of top 10% is associated with a decrease in the probability of winning at least one medal by 2.19%. However, the effect with respect to the number of medals is not significant. In Table 8 the income share of top 10% is significant for the probability of winning at least one medal and for the number of medals: the effects are -2.59% for the probability and -0.327 for the number of medals. From the threshold analysis and from the hurdle models it follows that inequality is a robust determinant of the performance during the Olympic games and the effects have substantial magnitudes.

It follows that the countries with relatively high number of medals per capita, low inequality and high economic freedom are the true *champions* in our study: surprisingly, these are not only the OECD countries, known for high levels of economic freedom in the long run (Prados De La Escosura, 2016), like Australia, Denmark, Sweden, but also smaller developing countries like Armenia, Mongolia and Slovenia. The first three countries, at the time of the Rio Olympics, stood at the 8th, 13th and 33rd positions in the ranking of economic freedom with respective

[5] Estimation of the threshold was cross-validated using 100, 150 and 200 bootstrapping rounds.

scores of 8.07, 7.88 and 7.63 on a scale from 1 to 10. The latter three countries were not far behind. Armenia actually outranked Sweden (in 29th position), While Mongolia and Slovenia were in 47th and 67th positions, they were not far behind in terms of distance in points: only 0.54 and 0.75 points separate Mongolia and Slovenia from Denmark. Similarly, high inequality accompanied with low economic freedom is associated with relatively poor Olympic performance in terms of per capita medals for Argentina, Brazil and Cote D'Ivoire. The three countries stand at the 151st, 128th and 132nd positions in the economic freedom ranking. Moreover, the distance in ranks is reflected by a strong distance in points of economic freedom. For example, at 5.40 out of 10, Argentina is more than 1.5 standard deviations below the global average for economic freedom and 2.5 standard deviations below Sweden. The names of the top and bottom performers in this constellation of variables may change, yet the intuitive relationship between economic freedom, inequality and sports holds.

Figure 2: Relationship between the Olympic performance and inequality if economic freedom is below the threshold

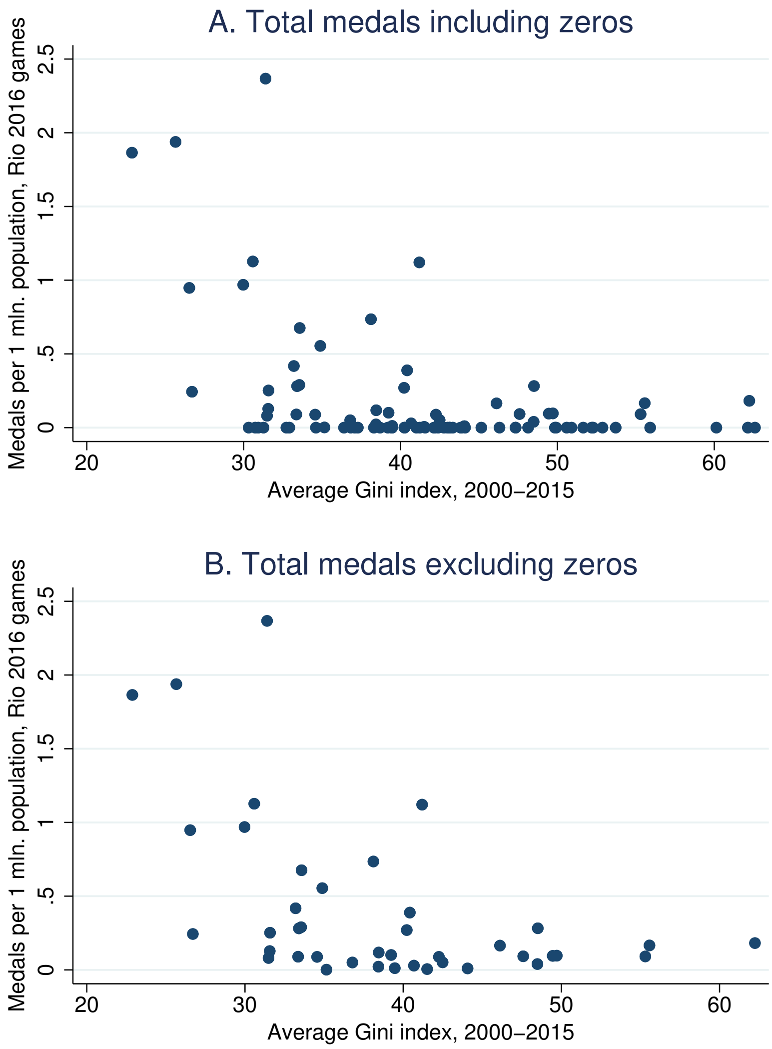


Table 2: OLS and threshold regressions of the determinants of Olympic performance, controlling for previous results

Variables	(1) All	(2) All	(3) All	(4) All	(5) Below	(6) Above	(7) Below	(8) Above
Medals (London)			0.738***	0.739***	0.371**	0.824***	0.368**	0.823***
			(0.122)	(0.122)	(0.159)	(0.0801)	(0.163)	(0.0802)
Gini coefficient	-0.0259***		-0.00731*		-0.0152*	-0.00392		
	(0.00578)		(0.00892)	(0.00291)				
Top 10% share		-0.0326***		-0.00878*			-0.0206*	-0.00497
		(0.00723)		(0.00461)			(0.0121)	(0.00342)
Constant	1.347***	1.343***	0.348*	0.333*	0.681*	0.203	0.724*	0.203
	(0.246)	(0.242)	(0.179)	(0.170)	(0.382)	(0.133)	(0.405)	(0.124)
Threshold ($\hat{\gamma}$)					6.579		6.579	
Observations	132	132	132	132	132		132	

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 3: Threshold regression based on economic freedom

Variables	(9) Below	(10) Above	(11) Below	(12) Above
Gini coefficient	-0.0211***	0.0645		
	(0.00725)	(0.0579)		
Top 10% share			-0.0204***	0.0655
			(0.00735)	(0.0792)
GDP pc ppp, thsd.	0.04390***	0.00238	0.04350***	0.00246
	(0.01480)	(0.00606)	(0.01550)	(0.00573)
Saving rate	0.000232	0.0391**	0.000280	0.0367*
	(0.000780)	(0.0195)	(0.000717)	(0.0195)
State expenditures on health	0.0769**	-0.0609	0.0694*	-0.0650
	(0.0367)	(0.0983)	(0.0389)	(0.106)
State expenditures on military	-0.0135	-0.157	-0.0115	-0.122
	(0.0372)	(0.156)	(0.0389)	(0.140)
Life expectancy	0.0900*	5.778	0.0964**	5.135
	(0.0476)	(3.590)	(0.0486)	(3.405)
Life expectancy squared	-0.000777**	-0.0378	-0.000827**	-0.0337
	(0.000388)	(0.0235)	(0.000396)	(0.0223)
LN age of athletes	0.342	-9.336**	0.319	-8.351*
	(0.252)	(4.727)	(0.248)	(4.342)
LN average weight of athletes	0.617	1.612	0.601	1.830
	(0.399)	(1.858)	(0.403)	(1.804)
Share of athletes	-0.00249	0.159	-0.00673	0.178
	(0.0400)	(0.112)	(0.0409)	(0.112)
Constant	-5.488**	-198.6	-5.702**	-177.4
	(2.580)	(122.1)	(2.638)	(116.4)
Threshold ($\hat{\gamma}$)	7.177		7.177	
Observations	123		123	

Controlled for regions (Sub-Saharan Africa, East Asia, Latin America, Europe)
Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 4: Threshold regression based on economic freedom, controlling for previous results

Variables	(13) Below	(14) Above	(15) Below	(16) Above
Medals (London)	0.356***	0.915***	0.370***	0.920***
	(0.129)	(0.0629)	(0.138)	(0.0598)
Gini coefficient	-0.0140**	0.0259		
	(0.00546)	(0.0176)		
Top 10% share			-0.0127**	0.0351*
			(0.00554)	(0.0205)
GDP pc ppp, thsd.	0.03146***	0.001266	0.03068**	0.00141
	(0.0012)	(0.00375)	(0.00124)	(0.00384)
Saving rate	0.000422	0.0124	0.000455	0.0125
	(0.000714)	(0.0120)	(0.000682)	(0.0119)
State expenditures on health	0.0406	0.105	0.0332	0.110
	(0.0312)	(0.0681)	(0.0329)	(0.0689)
State expenditures on military	0.00963	0.0514	0.0117	0.0645*
	(0.0308)	(0.0358)	(0.0324)	(0.0341)
Life expectancy	0.0468	1.077	0.0483	0.904
	(0.0457)	(0.969)	(0.0477)	(0.980)
Life expectancy sqaured	-0.000426	-0.00719	-0.000437	-0.00607
	(0.000373)	(0.00633)	(0.000391)	(0.00641)
LN age of athletes	0.00897	-4.149***	-0.0212	-3.941***
	(0.184)	(1.539)	(0.193)	(1.486)
LN average weight of athletes	0.426	-0.789	0.411	-0.764
	(0.351)	(0.674)	(0.352)	(0.712)
Share of athletes	0.00116	0.00793	-0.00162	0.0137
	(0.0282)	(0.0452)	(0.0281)	(0.0466)
Constant	-2.580	-25.19	-2.603	-19.42
	(2.373)	(33.30)	(2.410)	(33.69)
Threshold ($\hat{\gamma}$)	7.138		7.138	
Observations	123		123	

Controlled for regions (Sub-Saharan Africa, East Asia, Latin America, Europe)
Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 5: Hurdle model with Gini

Variables	(17) Medals > 0 (Rio)	(18) AME	(19) Nonzero logit (Rio)	(20) AME
Gini coefficient	-0.0343*	-0.0208*	-0.282**	-0.0148**
	(0.0197)	(0.0118)	(0.119)	(0.00710)
Economic Freedom Index	0.750***	0.454***	0.332	0.0174
	(0.176)	(0.123)	(0.952)	(0.0496)
GDP pc ppp, thsd.	-0.01540*	-0.00933	0.0212	0.00111
	(0.00881)	(0.00572)	(0.0277)	(0.00152)
Saving rate	7.25e-05	4.39e-05	0.175***	0.00921***
	(0.00219)	(0.00133)	(0.0584)	(0.00296)
State expenditures on health	0.185**	0.112**	0.326	0.0171
	(0.0811)	(0.0535)	(0.367)	(0.0185)
State expenditures on military	0.00825	0.00500	-0.201	-0.0105
	(0.141)	(0.0854)	(0.324)	(0.0176)
Life expectancy	0.276	0.167	-0.614	-0.0322
	(0.254)	(0.153)	(0.905)	(0.0462)
Life expectancy squared	-0.00183	-0.00111	0.00240	0.000126
	(0.00186)	(0.00112)	(0.00666)	(0.000344)
LN age of athletes	-1.483	-0.898	-8.156	-0.428
	(4.058)	(2.473)	(6.943)	(0.382)
LN average weight of athletes	6.153***	3.727***	1.470	0.0772
	(1.846)	(1.303)	(4.726)	(0.246)
Share of athletes	-0.182**	-0.110*	26.35***	1.383***
	(0.0851)	(0.0568)	(5.450)	(0.344)
Constant	-36.25**		50.01	
	(14.52)		(32.01)	
Observations	68		123	

Controlled for regions (Sub-Saharan Africa, East Asia, Latin America, Europe)
Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 6: Hurdle model with Gini, controlling for previous results

Variables	(21) Medals > 0 (Rio)	(22) AME	(23) Nonzero logit (Rio)	(24) AME
Medals (London)	0.758***	0.482***	2.047**	0.0986**
	(0.116)	(0.0804)	(0.926)	(0.0481)
Gini coefficient	-0.0387**	-0.0245**	-0.388***	-0.0187**
	(0.0161)	(0.0104)	(0.129)	(0.00727)
Economic Freedom Index	0.525***	0.333***	0.526	0.0253
	(0.155)	(0.102)	(1.028)	(0.0490)
GDP pc ppp, thsd.	0.00166	0.00105	0.0280	0.00135
	(0.00889)	(0.00566)	(0.0394)	(0.00197)
Saving rate	-0.00155	-0.000987	0.243***	0.0117***
	(0.00165)	(0.00105)	(0.0699)	(0.00328)
State expenditures on health	0.137*	0.0869*	0.504	0.0243
	(0.0722)	(0.0464)	(0.396)	(0.0182)
State expenditures on military	0.237**	0.150**	0.0142	0.000683
	(0.0998)	(0.0643)	(0.324)	(0.0156)
Life expectancy	0.245	0.155	-0.660	-0.0318
	(0.240)	(0.154)	(0.885)	(0.0415)
Life expectancy sqaured	-0.00186	-0.00118	0.00181	0.00009
	(0.00177)	(0.00113)	(0.00656)	(0.000313)
LN age of athletes	-1.091	-0.693	-10.15	-0.489
	(3.075)	(1.955)	(8.094)	(0.410)
LN average weight of athletes	5.123***	3.253***	0.202	0.00974
	(1.542)	(1.045)	(5.522)	(0.266)
Share of athletes	-0.0562	-0.0357	27.79***	1.339***
	(0.0742)	(0.0477)	(5.699)	(0.348)
Constant	-30.77***		66.70*	
	(10.95)		(35.82)	
Observations	68		123	

Controlled for regions (Sub-Saharan Africa, East Asia, Latin America, Europe)
Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 7: Hurdle model with top 10% income share

Variables	(25) Medals > 0 (Rio)	(26) AME	(27) Nonzero logit (Rio)	(28) AME
Top 10% share	-0.0415	-0.0253	-0.420**	-0.0219**
	(0.0286)	(0.0174)	(0.171)	(0.0100)
Economic Freedom Index	0.751***	0.458***	0.219	0.0114
	(0.182)	(0.127)	(0.975)	(0.0504)
GDP pc ppp, thsd.	-0.01500*	-0.00916	0.0215	0.00112
	(0.00878)	(0.00572)	(0.02780)	(0.00152)
Saving rate	0.000469	0.000286	0.180***	0.00940***
	(0.00213)	(0.00131)	(0.0598)	(0.00299)
State expenditures on health	0.196**	0.119**	0.257	0.0134
	(0.0818)	(0.0546)	(0.360)	(0.0182)
State expenditures on military	0.00946	0.00577	-0.230	-0.0120
	(0.148)	(0.0899)	(0.345)	(0.0186)
Life expectancy	0.313	0.191	-0.717	-0.0374
	(0.253)	(0.154)	(0.922)	(0.0465)
Life expectancy squared	-0.00214	-0.00130	0.00319	0.000166
	(0.00185)	(0.00112)	(0.00675)	(0.000344)
LN age of athletes	-1.576	-0.962	-10.34	-0.539
	(4.083)	(2.504)	(7.039)	(0.392)
LN average weight of athletes	6.002***	3.661***	1.253	0.0653
	(1.838)	(1.315)	(4.881)	(0.253)
Share of athletes	-0.187**	-0.114*	26.18***	1.365***
	(0.0872)	(0.0586)	(5.582)	(0.331)
Constant	-36.49**		64.11*	
	(14.65)		(35.43)	
Observations	68		123	

Controlled for regions (Sub-Saharan Africa, East Asia, Latin America, Europe)
Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 8: Hurdle model with top 10% income share, controlling for previous results

Variables	(29) Medals > 0 (Rio)	(30) AME	(31) Nonzero logit (Rio)	(32) AME
Medals (London)	0.768***	0.492***	2.045**	0.0977*
	(0.119)	(0.0856)	(0.956)	(0.0502)
Top 10% share	-0.0510**	-0.0327**	-0.542***	-0.0259**
	(0.0239)	(0.0157)	(0.199)	(0.0107)
Economic Freedom Index	0.545***	0.349***	0.258	0.0123
	(0.160)	(0.107)	(1.036)	(0.0491)
GDP pc ppp, thsd.	0.00173	0.00111	0.02672	0.00128
	(0.00887)	(0.00570)	(0.04035)	(0.00198)
Saving rate	-0.00114	-0.000730	0.243***	0.0116***
	(0.00165)	(0.00106)	(0.0744)	(0.00352)
State expenditures on health	0.149**	0.0957**	0.410	0.0196
	(0.0730)	(0.0473)	(0.404)	(0.0188)
State expenditures on military	0.240**	0.154**	-0.0393	-0.00188
	(0.107)	(0.0707)	(0.328)	(0.0158)
Life expectancy	0.280	0.180	-0.697	-0.0333
	(0.240)	(0.156)	(0.930)	(0.0436)
Life expectancy sqaured	-0.00216	-0.00139	0.00220	0.000105
	(0.00176)	(0.00115)	(0.00694)	(0.000329)
LN age of athletes	-1.260	-0.808	-12.99	-0.621
	(3.097)	(1.987)	(8.571)	(0.433)
LN average weight of athletes	4.985***	3.196***	-0.0628	-0.00300
	(1.548)	(1.061)	(5.691)	(0.272)
Share of athletes	-0.0597	-0.0383	26.71***	1.276***
	(0.0750)	(0.0487)	(5.876)	(0.329)
Constant	-30.72***		81.67*	
	(11.16)		(42.05)	
Observations	68		123	

Controlled for regions (Sub-Saharan Africa, East Asia, Latin America, Europe)
Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

5 Conclusions

Using the microcosm of Olympic performance, we attempted to study the impact of inequality conditional on institutional quality. This is in line with a long tradition of papers that attempt to use microcosms to illustrate the channels through which inequality affects later life outcomes (Marmot et al., 1984, 1991; Marmot and Shipley, 1996; Redelmeier and Singh, 2001a,b; Bowles and Gintis, 2002; Bowles, 2012). In our case, the intuition behind our use of the Olympics as a microcosm is that athletes face high training costs so that inequality hinders the ability of the innately talented at the bottom of the distribution to invest in developing their skills. On the other hand, that the gains from winning a medal create a strong incentive to invest in developing skills. However, that latter effect may offset the downside of inequality. The potency of this offsetting force hinges on how easily these gains can be appropriated by those who invest in increasing their odds of winning. As this appropriation of gain speaks to property rights, this mitigating channel depends entirely on the quality of institutions, and particularly, economic freedom, in an athlete's home country. Thus, in our study, the *champions* are the countries with relatively good per capita Olympic performance, low inequality and high level of economic freedom.

Using the Economic Freedom of the World Index as our proxy for institutional quality of the economic freedom (i.e. the protection of property rights) and the Rio de Janeiro 2016 Olympics data as our outcome variable, we find that the effects of inequality on Olympic performance are statistically significant only in cases where institutions are below a certain threshold of quality. Using threshold regressions, we show that countries above that threshold (those with higher levels of economic freedom) were unaffected by the level of income inequality. The negative effect of inequality on Olympic performance is found for countries below the economic freedom threshold. These results holds regardless of the measure of inequality used and is robust to controlling for the achievements during the previous games. Applying the hurdle model to account for the large number of zeros in the sample confirms the negative effect of inequality and the positive role of economic freedom with respect of Olympic outcomes.

We argue that these results from this microcosm are important to debates on inequality for two interlinked reasons. First, inequality may be hurtful to outcomes if certain key conditions are met, as Finis Welch (1999, p. 2) pointed out when he stated that "inequality is destructive whenever the low-wage citizenry views society as unfair, when it views effort as not worthwhile, when upward mobility is viewed as impossible or as so unlikely that its pursuit is not worthwhile." Second, these key conditions are intimately linked to institutions which means that inequality is but a channel through which poor institutions generate bad outcomes.

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