Effect of Hosting Olympic Games on Prosperity:

An Empirical Study using Two-Way Fixed Effects

Abdelkader Temani, Akmarzhan Abylay, Albion Krasniqi

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Table of contents

1. Abstract

In this paper, we studied the effect of hosting the Olympic Games on the host country's GDP per capita. Several studies have explored a similar link, but the results weren't consistent, which is why it is of interest to explore this topic further to compare the results. The paper uses the two-way fixed effects model with differential timing for the treatment to take care of the nature of the data and the events (i.e., different countries hosted the Olympics throughout different periods). There are 3 main methods used to explore the connection between hosting and prosperity proxied by GDP per capita, including a simple pooled OLS regression, one-way fixed effects, and two-way fixed effects models that include and exclude the confounding variables we controlled for. We found a small positive effect (i.e., 1.005-1.016 times increase) on GDP per capita for the combined dataset using two-way fixed effects. Interestingly, in the uncontrolled version, the Summer Olympic Games showed a larger positive effect (i.e., 1.2 times increase). In contrast, the Winter Olympic Games showed a negative effect (i.e., multiplication by 0.873, or a 13% reduction). However, the results weren't significant, which is why we proposed using a different method called synthetic difference in differences to explore this question further.

Keywords: Difference-in-Difference (DD), Two-Way Fixed Effects, Olympic Games, Synthetic Difference-in-Differences, Prosperity

2. Introduction[1]

The Olympic Games are an international sports event held every four years and hosted by a different country each time. Countries that want to host the event go through a bidding process, and then the committee votes for the potential host. Sports teams worldwide participate in the Olympic Games, and the host country will gain international exposure from holding the event. For instance, countries are usually eager to host the Olympics to gain publicity and potentially attract tourists as that is the shared idea about the benefits of hosting the Olympic Games. Consequently, academics looked into this question, and many papers studied the effect of hosting the Olympic Games on the host country's prosperity. For instance, the studies we analyzed in this paper found different results, which can be attributed to various reasons. Some found that hosting the Olympic Games positively affects the host country's development, while others found that hosting the Olympic Games can negatively affect the host country's GDP. The findings might be different because they used different methods for the analysis or because they have used different datasets. Due to this discrepancy in the findings, we were interested in analyzing the effect of hosting the Olympic Games on the host country's GDP per capita using two-way fixed effects to test results from the existing literature.

3. Literature review

Several studies have examined the benefits of hosting the Olympic Games, and usually, they predict large economic benefits. Humphreys and Plummer (1995) estimate the short-term economic impact to Atlanta from hosting the 1996 Olympic Games to be around $5 billion.

[1] All of the code is added to this Github repository: https://github.com/akmarzhan1/ss154-fp.

Similarly, Andersen (2000) claims a 6.5 billion dollar extra economic activity in Australia right after hosting the 2000 Olympic Games. However, on the other hand, many rigorous studies are skeptical of the net economic benefits of hosting the Olympic Games (Baade and Matheson, 2002; Owen, 2005). The requirements (e.g., sports venues, infrastructure investment, etc.) that the host city should meet are very costly. For example, the total cost of the Summer Olympic Games that were held in China in 2008 is estimated to be around $50 billion (Lorenzoni, 2011).

A study conducted by Österreichisches Institut für Wirtschaftsforschung explored the causal effects of Olympic Games on host regions' GDP using synthetic control methods. They have constructed a counterfactual for Olympic Games hosts using the runner-ups for the corresponding years and found a general increase in GDP (i.e., 3 to 4 percent in the short-term). Furthermore, it explored the differences between the Summer and Winter Olympics (i.e., the latter led to a decrease in GDP). However, they didn't find statistically significant results in the long-term effects of hosting the Olympic Games on economic growth. Thus, there is still room for improvement and further research (Firgo, 2019).

Similarly, Billings and Holladay (2012) analyze the long-run economic effects on the host countries of the last 12 Summer Olympic Games. Using difference-in-difference (DD) methodology and assigning hosting cities as a treatment and finalist bidding cities as controls, they were able to calculate the long-run economic effects of the Olympic Games. The results that they found are insignificant effects for economic indicators at the country level (e.g., GDP per capita). Unlike Billings and Holladay, Dolan et al. (2019) consider only one country to determine the effects of the Olympics on well-being on the host country's population. They assessed the London 2012 Olympics impact on well-being by using panel data collected from more than

26,000 individuals in London, Berlin, and Paris during the summer of 2011, 2012, and 2013. The authors used a difference-in-differences design with London as the treatment and Paris and Berlin as controls. There were three main reasons why they chose Paris and Berlin as control cities since both cities resemble London by:

1. Being capitals of large Northwestern European countries (just like London)
2. Having hosted Olympic games in the past
3. Having bided to host the Olympics in recent years

According to the results, they concluded that the Olympics increase the well-being of the host city's residents during the event, especially during the opening and closing ceremonies. For instance, this paper added to the field by empirically assessing the subjective well-being of the host city residents and found that Olympics affected the well-being of the residents in the short run as they were unable to claim any substantial evidence of legacy effects, one year after the event.

Ultimately, Kite (2015) studied the economic effect of hosting an Olympic game on the host nation and its international exports using an OLS regression. The independent variables used in the regression were the GDP per capita and the total amount of exports with an eight-year lag from the year that a country hosted or bid for the Olympic Games. The paper found that winning a bid to host an Olympic game has a negative effect on the host country's per capita GDP when compared to "runner-up" countries, while it has a positive impact on the nation's total exports when compared to "runner-up" countries. This suggests that it is more beneficial for a country to win the bid to host the Olympic Games in terms of total exports.

4. Data

To estimate the true causal effect of the Olympics on the economy of hosting countries, we had to control for a list of confounders. This list of confounders includes variables that have been proven to affect both the hosting of the Olympics and a country's economy directly in numerous studies (Billings and Holladay 2012; Firgo, 2019; Rose and Spiegel, 2009). Omitting such variables is problematic since you will not address all of the possible backdoor paths. The confounding variables for which we are controlling for are:

- **Year**: Controlling for the year is a must because, through different periods, countries experience different economic developments (e.g., in 2008, there was a financial crisis; thus, we need to control for it; otherwise, it will bias our estimates). We wouldn't add that as a separate confounder for other models, but this is done in the two-way fixed effect since we are considering the time-specific effects.
- **Type of Olympics**: Multiple studies have found that the economic impact of the winter games is much smaller compared to the summer Olympics. The summer Olympics are much bigger events and occur over a longer time than the winter Olympics. Hence, we wanted to control for the type of Olympics to avoid the discrepancy between the two types of events (Firgo, 2019).
- **Political Stability**: Economic growth and political stability are highly correlated to each other. The uncertainty associated with an unstable political environment reduces investment and the speed of economic development. Furthermore, political stability affects the host country since the committee wants to organize the Olympics in a country where it will be safe for millions of tourists (Aisen and Veiga, 2011).

- **Financial Stability**: the risk associated with an unstable financial environment reduces the number of investors; thus, it affects one country's economy (Adrian et al., 2020).
- **Economic advancement**: this variable affects both the potential host country and the country's GDP that we are looking at. Countries with higher economic advancement (e.g., better structure, freer economy) tend to have a higher GDP per capita (Short, 2008; Cebula et al. 2013).

Let us represent the relationship of variables mentioned above in a Directed Acyclic Graph.

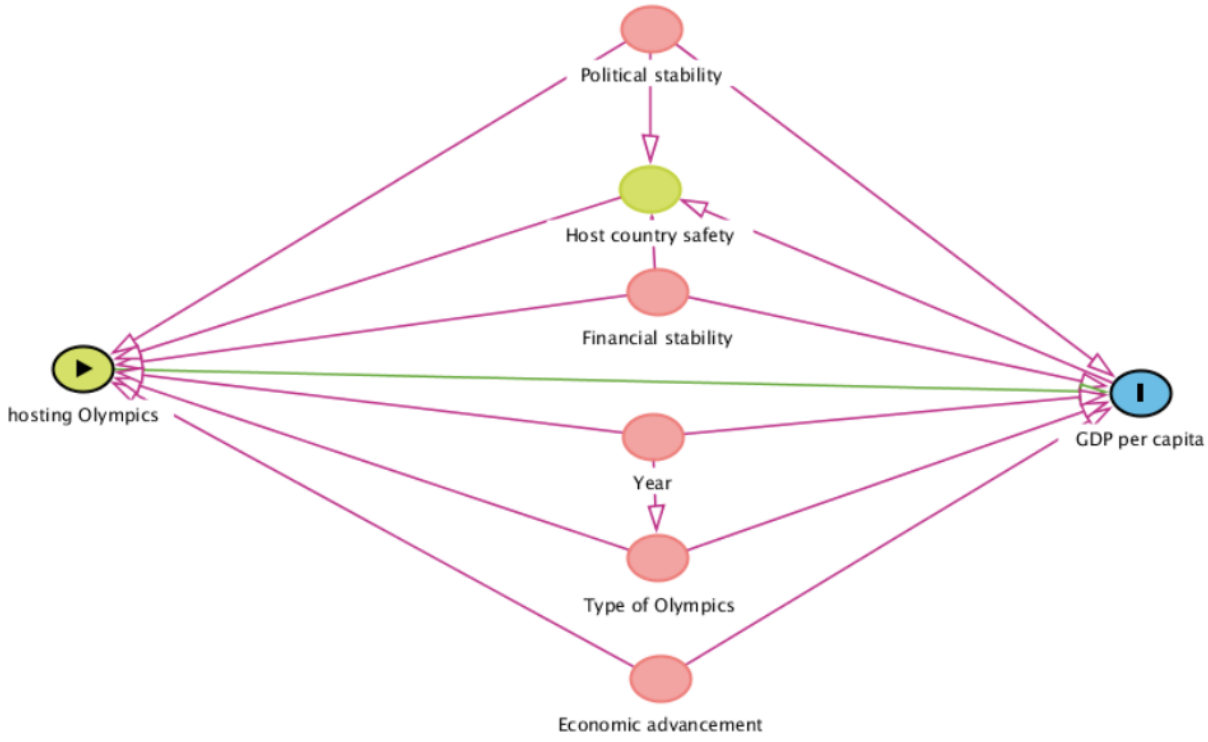


Figure 1. Directed acyclic graph (DAG) illustrating the causal relationship between the variables used in this study

We obtained the data for this project from multiple publicly available sources online based on what variables are important from the DAG above. Below is the summary of where each variable comes from.

Table 1. Summary of variables used to estimate the causal effect of hosting Olympics

Variable	**Source and explanation**
Post, Year	"Olympic Hosts" dataset from Kaggle (Petro, 2020). This dataset contains all of the previous Olympic Games' hosts. The Post variable is 0 before the Olympic Games are hosted and 1 after the year it has been hosted. For the Olympics year, the Post is a fraction of the time left until the year ends. For example, if the Olympics were hosted on July 1st, then Post for that year is 0.5. The way we defined this variable suggests that our analysis will only focus on events happening right during and after the Olympic Games, such as tourism and gains for local businesses. Thus, although the countries start to prepare for Olympics right from the moment they are announced as hosts, our analysis is not considering the effects due to related factors, such as infrastructure.
FinStability	This variable represents the bank Z-score from the World Bank's Global Financial Development Database, which captures the country's commercial banking system's default probability ("Global Financial Development Database," n.d.). We use it as a proxy for financial stability since although it has some limitations (e.g., purely based on accounting data), it is a common measure of financial stability ("Financial Stability," n.d.). It measures the bank's solvency risk by comparing the capitalization and returns with the volatility of returns, and a higher score implies a lower chance of insolvency.
PolitStability	This variable is a proxy for political stability and country safety taken from the World Bank's Worldwide Governance Indicators dataset. It estimates the likelihood of political instability and violence/terrorism in units of standard normal distribution (i.e., ranging from -2.5 to 2.5) ("Worldwide Governance Indicators," n.d.).
Freedom	This variable represents the economic freedom index from the Heritage Foundation (Heritage Foundation, n.d.). It is a proxy for the economic advancement defined in the DAG as higher economic freedom is strongly linked with higher economic growth and a better economy in general (Hackelman, 2000). It covers 12 freedoms (e.g., from financial freedom to property rights) and is given on a scale of 0 to 100, with a

	higher score representing freer countries.
GDP per capita	This variable represents the GDP per capita for countries from the World Bank Database ("GDP per capita (current US$)," n.d.). We will use the log of GDP per capita (i.e., already adjusted for population size) for the analysis since we are interested in showing percent changes instead of absolute gains/losses from hosting the Olympics for convenience.

After cleaning the data and incorporating all of the variables, we are left with 8 countries and 120 observations (15 each for years 2002-2016) since most of the additional variables only cover the most recent 20 years. Furthermore, for convenience, we got rid of the countries which hosted the Olympics more than once in the given period as it is more complicated to deal with data where units of analysis (i.e., countries) received the treatment several times in different periods. We added all of the code and datasets into this GitHub repository.

Half of the observations are from the Winter Olympics, and the rest is from the Summer Olympics. Below is the excerpt from the table of summary statistics for the variables in the combined dataset.

Table 2. Summary Statistics Table. This is an excerpt of the full table, which could be found in the Github repository (i.e., summary_table.md).

Year	Variables	Mean	SD	Median	Min	Max
2002	Log GDP/capita	9.160388	1.355122	9.782832	7.046219	10.54595
	Post	.1116438	.3157765	0	0	.8931507
	FinStability	14.71342	5.462714	14.10185	8.47158	25.6634
	PolitStability	.3979603	.6518581	.5044633	-.7211835	1.221569
	Freedom	64.65	11.44265	62.55	48.7	78.5

Year	Variables	Mean	SD	Median	Min	Max
...						
2016	Log GDP/capita	9.942137	.8096507	10.07219	9.00552	10.96736
	Post	.9255464	.2105864	1	.4043716	1
	FinStability	14.39874	7.801259	12.8979	5.91815	29.5835
	PolitStability	.0554777	.6848445	.1194275	-.9462103	1.256059
	Freedom	62.9125	11.79921	58.85	50.6	78

5. Methodology

Even though the studies described above provide estimates about the economic effect of hosting the Olympics, they fail to provide reliable results since most of them are insignificant and lack a greater level of specificity. For example, Kite (2015) uses only one variable, trade openness, to measure the effects of the Olympics, which is not the best indicator of the economic performance. On the other hand, Dolan et al. (2019) use subjective data collected through surveys and interviews. That process of data collection is highly subject to bias (e.g., the time when people were surveyed). Last but not least, Billings and Holladay (2019) offer a more specific model by comparing the host countries to candidate countries, but they use very complex mathematical models and data from multiple sources, which may affect their variables. Our model tries to estimate the economic impact of hosting the Olympics with a greater level of specificity and accuracy since it considers the data for the last 20 years and controls for a wide variety of covariates (which can bias the estimates).

In order to see if the Olympics have an economic impact on host countries, we used the difference-in-difference (DD) methodology. DD is one of the most common quasi-experimental

research designs. The difference-in-differences estimate is calculated by taking the difference between the change in outcomes before and after treatment of the treated and control group. The usual DD method enables us to find the causal effect at a specific point in time. However, in the context of our study, we have to calculate the causal effect at different timings (e.g., in 1996, 1998, 2000, etc.). To do so, we will use a recently introduced method by Goodman-Bacon (2019), which is called the difference-in-differences with variation in treatment timing. The basic idea is that different countries are treated at different times, and when a country hosts the Olympics, for that year, the other countries serve as controls, which continues for all years (Cunningham, 2021).

5.1 Assumptions

- **Common trends assumption**: Difference-in-difference (DD) method assumes that in the absence of treatment, the difference between control and treatment groups would be constant or 'fixed' over time. This applies to all of the countries through the differential timing for treatment.
- **DAG**: We assume that it is correct (i.e., the links and absence of links make sense) and includes the required variables that could have biased our results.
- **Regression assumptions**: All of the regression assumptions apply as well since we are using it to estimate the effect using the DD. They include linearity, constant error variance (i.e., at each slice, the error term is the same), independent error terms (i.e., no autocorrelation), normality of errors, no multicollinearity (i.e., the independent variables are not highly correlated), no omitted variable bias, which is tied to the DAG being correct and us controlling for all the required variables.

- **Bidding process**: In 2012, The committee made significant changes to the Olympic bid process (Gannett Satellite Information Network, 2019), and that may affect the variables that we are controlling for. However, we will assume that the bidding criteria were the same for the last 20 years.

6. Analysis

We used STATA for the analysis and had used 6 models, including the simple pooled OLS regression, one-way fixed effects with differential timing and two-way fixed effects with differential timing, both including and excluding the confounding variables that we need to control for (see Appendix for code). We repeated the analysis for the combined dataset and the Winter and Summer Olympic Games individually.

6.1 Assumptions Check

The common trends assumption is not directly testable, so we have checked it for two-way fixed effects with time-varying treatment by visually inspecting the figure below (i.e., Year and Log of GDP per capita). We highlighted the times the Olympic Games were hosted. From the graph alone, it is unclear whether the assumption holds since there is not a clear cut increase or decrease when the Olympics are hosted. There is a clear downward trend during the 2008 crisis, but disregarding that, there is still no evidence that the assumption holds. For the purpose of this study (i.e., learning new methods and exploring links through these methods), we will proceed, but this is a substantial limitation of the paper.

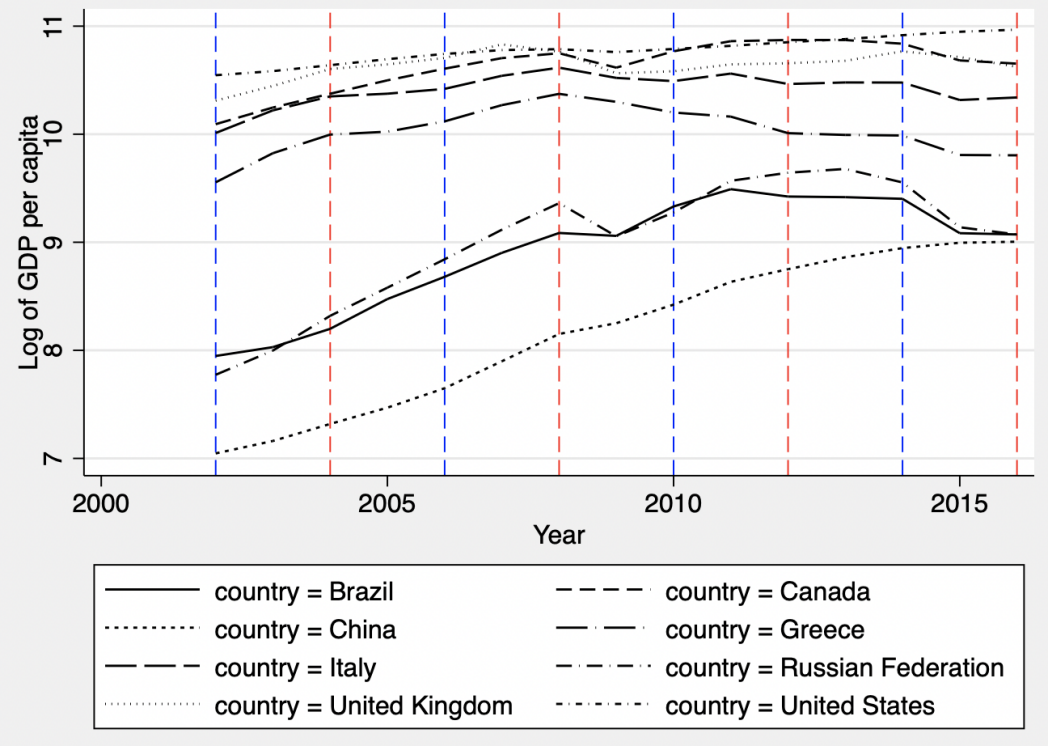


Figure 2. The progression of the log of GDP per capita for different countries throughout time. The Blue dashed line represents the Winter Olympics, and the red dashed line represents the Summer Olympics.

As for the regression assumptions, particular attention is paid to the heteroskedasticity assumption, which could be fixed by using $vce(robust)$, but since we have very few data points, it wouldn't help us that much. As for multicollinearity, we could check it using $corr variables$ where variables represent the independent variables. After doing so, there has been a relatively high correlation between freedom and political stability (i.e., 0.7), but it is only on the borderline of being worrisome, which is why we decided to proceed further. For the omitted variable bias, there is really no reliable method to test it other than field knowledge.

6.2 Expectations

All of the previous papers have found some positive effect of hosting the Olympic Games on the country's GDP and other prosperity indicators, which is why we would expect to see something similar. Thus, for easier testing, our null hypothesis would be that the coefficient on the post variable is 0 (i.e., no effect), while the alternative hypotheses would be that the Olympic Games have at least some non-zero effect (i.e., the coefficient is positive or negative). Given the $\alpha=0.05$ significance level, if we get a p-value below the threshold, we would reject the null hypothesis and explore whether the relationship is negative or positive. However, if the results are not significant, we would not be able to make any further conclusions except for not being able to reject the null hypothesis.

7. Results

Table 3 below represents the results. The dependent variable in our case is the log of GDP, while the treatment variable is Post, which defines whether the country hosted the Olympic Games in a given year. The variables PolitStability, FinStability, Freedom and Subtype are the confounding variables which we control for.

7.1 OLS regression

We did pooled OLS regressions for different variations of data (i.e., combined, only Winter Olympics, only Summer Olympics) and controls (i.e., no control and controlling for several variables). The results suggest that hosting the Olympic Games will, on average, lead to a 1.52-2.48 (i.e., $e^{0.420}$ to $e^{0.908}$) times increase in the GDP per capita (i.e., due to tourism and related reasons). Almost all of the results are significant at 0.1%, but these estimates are likely

biased since the pooled OLS handles every observation as if it is an independent from others (e.g., Greece in 2004 is handled as if it wasn't connected to Greece in 2002), which is not the case for panel data when the indicators for certain years are highly correlated within the units. Adding to not considering individual effects, the simple regression also doesn't take the time-variant effects into account.

Table 3. Results of the three models

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A [a]						
Post	0.837***	0.590***	0.469	0.473	0.0162	0.00528
	(0.175)	(0.0902)	(0.201)	(0.217)	(0.215)	(0.201)
Subtype		-0.437***		0[b]		0[c]
		(0.0936)		(.)		(.)
FinStability		-0.0366***		0.00803		0.0228
		(0.00639)		(0.0350)		(0.0223)
PolitStability		0.348***		0.136		0.173
		(0.0888)		(0.152)		(0.316)
Freedom		0.0532***		-0.0303		0.0173
		(0.00508)		(0.0464)		(0.0317)
Panel B[d]						
Post	0.534*	0.793***	0.654	0.608	0.185	-0.162
	(0.266)	(0.168)	(0.391)	(0.333)	(0.372)	(0.269)
Panel C[e]						
Post	0.908***	0.420***	0.292**	0.260	-0.135	-0.255
	(0.196)	(0.0820)	(0.0235)	(0.149)	(0.199)	(0.269)
Observation	120	120	120	120	120	120

	(1)	(2)	(3)	(4)	(5)	(6)
Controls[f]		Yes		Yes		Yes
Unit FE			Yes	Yes	Yes	Yes
Time FE					Yes	Yes

Standard errors in parentheses. $^{*}p < 0.05,^{**}p < 0.01,^{***}p < 0.001$.

[a] Combined - Winter and Summer Olympics.
[b] Omitted.
[c] Omitted.
[d] Summer Olympics only.
[e] Winter Olympics only.
[f] Controls for subtype, financial stability, political stability and freedom.

7.2 One-way fixed effects

The combined and individual one-way fixed effects models suggest that hosting the Olympic Games will multiply the GDP per capita (i.e., due to tourism and related reasons) by 1.3-1.92 (i.e., $e^{0.260}$ to $e^{0.654}$). Only one of the estimates for the winter panel without controls was significant at 1%, while the others had very large standard errors. Still, these estimates are less biased since they take the individual differences among individual countries into account, although without considering the time-variant variables.

7.3 Two-way fixed effects

For the third model, we obtained very different results as the estimates were much smaller than the previous models and some of the coefficients were even negative. For the combined model, the uncontrolled two-way fixed effects model found that hosting the Olympic Games only increases the GDP per capita (i.e., due to tourism and related reasons) by 1.005-1.016 (i.e., $e^{0.00528}$ to $e^{0.0162}$), which is small but still a positive effect. The Summer Games

showed positive effects (i.e., increases by 1.2, $e^{0.185}$) for the uncontrolled version and a negative (i.e., multiplication by 0.850, which is basically a 15% reduction $e^{-0.0162}$) effect for the controlled one. The Winter Olympics showed even lower results, the uncontrolled model leading to a 13% reduction (i.e., multiplication by 0.873, $e^{-0.135}$) and the controlled version suggesting a 22.5% reduction in GDP per capita due to tourism (i.e., multiplication by 0.775, $e^{-0.255}$). None of the estimates was significant (i.e., due to lack of data). However, they are unbiased since we are taking both the individual-variant and time-variant effects into account, which then eliminates the influence of unobserved covariates almost entirely (i.e., excluding the covariates, which are both time and individual-specific).

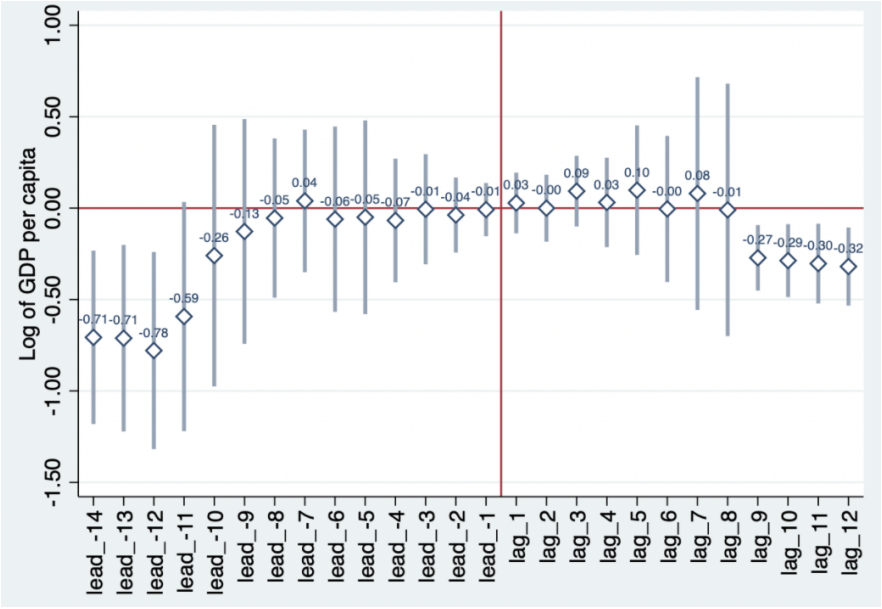


Figure 3: GDP per capita plots using coefplot. The effects are based on each previous year.

The above graph plots the event studies based on leads (i.e., years prior to hosting the Olympics) and lags (i.e., years after hosting the Olympics). We can disregard the significantly lower levels of GDP per capita (i.e., log) 14 to 9 years prior to the treatment since we only have

1-2 observations for that period. For the nine years prior to treatment, there is virtually no difference between the treatment countries and control countries. The first year after the treatment, the log of GDP per capita begins rising, but it is still negligible, with the next seven years not showing significant increases either. The graphs below show the same thing but for Winter and Summer Olympics separately. We can see how for the Summer Olympics, we can see a more defined rise in the log of GDP per capita, while for the Winter Olympics, it increases in the first year after the treatment and then decreases back and fluctuates. This is consistent with what we were expecting since the Summer Olympics were said to have a positive effect, and the Winter Olympics were previously found to have negative effects. This might be because people mostly care about Summer Games, and there is a higher gain in tourism for that, while the Winter Olympic Games might not be as profitable.

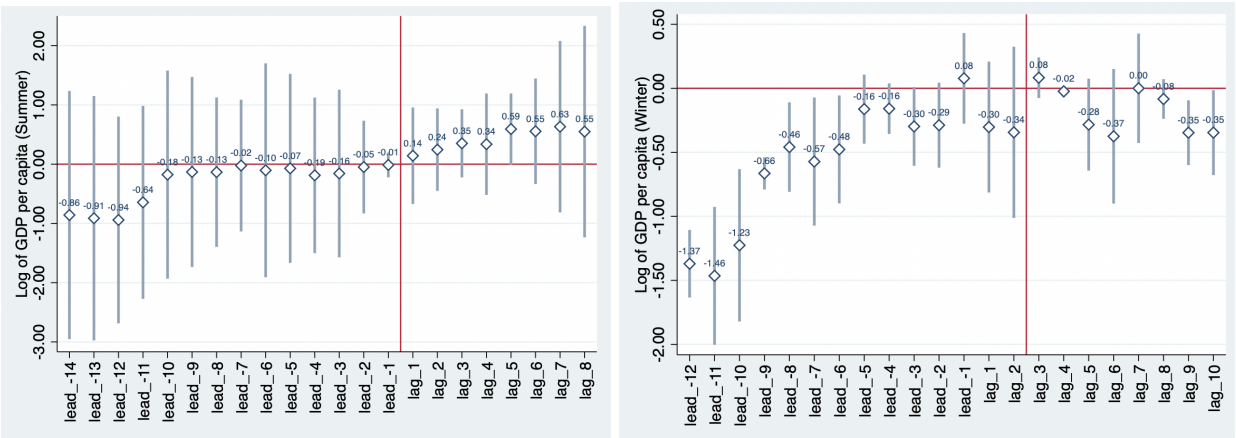


Figure 4. Winter and Summer Olympics plots using coefplot.

7.3 Robustness Check

Robustness checks are needed to test how reliable our results would be in case some of our assumptions are violated. There are different ways of checking the results for robustness, some of which include:

- Changing the way the outcome variable is defined/measured. We are dealing with GDP per capita hence there isn't much we can do to change the way we represent it.
- DDD (Difference in differences in differences). We would find another control for our analysis and use it to check whether the results are reliable. For example, we could check the effect of the Summer Olympics in the United Kingdom on a country's GDP per capita and use the other countries not hosting the Olympics as control and another city other than London as an additional control. Thus, we could make the difference between the GDP per capita for London and let's say, Manchester (i.e., although there might be spillover effects, it might be negligible) and then a similar procedure for the control country. Then, we would take these differences in differences to get an estimate of the effect and compare it to the ones we have gotten. If they show similar trends, then we pass the check.
- Controlling for an additional variable, which is not very related to the analysis (i.e., but not irrelevant either) and seeing whether including it affected the estimates. For example, we could consider the level of education (e.g., secondary school enrollment).

In this paper, we will not specifically address the robustness through actual calculations since a) we have few data points, b) our results are not significant, which eliminates the need to check how robust our results are. The purpose of robustness checks are to see how our conclusions would change given the change in assumptions, but it is unnecessary if our conclusion is undefined and we are proposing to conduct different studies.

7.4 Discussion

Although we included the subtype into both of the fixed effects models, it got omitted since the type of the Olympic Games doesn't change over time, so it is fixed throughout the time of interest. We also repeated the analysis separately for the Winter and Summer Olympics to see the difference. Additionally, although we have gotten some estimates for the effects of hosting the Olympic Games on prosperity (i.e., proxied by GDP per capita given the effects on tourism and related fields), they weren't unbiased or weren't significant due to the lack of data. Thus, we can't reject the null hypothesis that the effect of the Olympic Games on prosperity is 0, which means that there is room for additional exploration through different methods.

8. Limitations

This study has several limitations, which need to be addressed before thinking about the applicability of the results.

Lack of data: One of the most important limitations is the lack of data since we only had 15-time points for 8 countries. This factor mainly contributed to our results not being significant and generalizable since there is simply not enough data to make any relevant conclusions.

Confounders: There might have been other confounding variables that varied across countries and time and needed to be controlled. If that is the case, our analysis would be violating one of the fundamental assumptions.

Outcome variable: The log of GDP per capita is more skewed than the simple GDP per capita, which could be problematic when dealing with regression since it assumes a normal distribution (see Figure 6). Additionally, the effects are only due to things that happened during

and after hosting the Olympics, such as tourism and the gains for local businesses. Furthermore, the GDP per capita is only a good measure of economic performance but doesn't capture important developmental factors, such as the level of inequality, environmental condition, and more, which can define prosperity in countries.

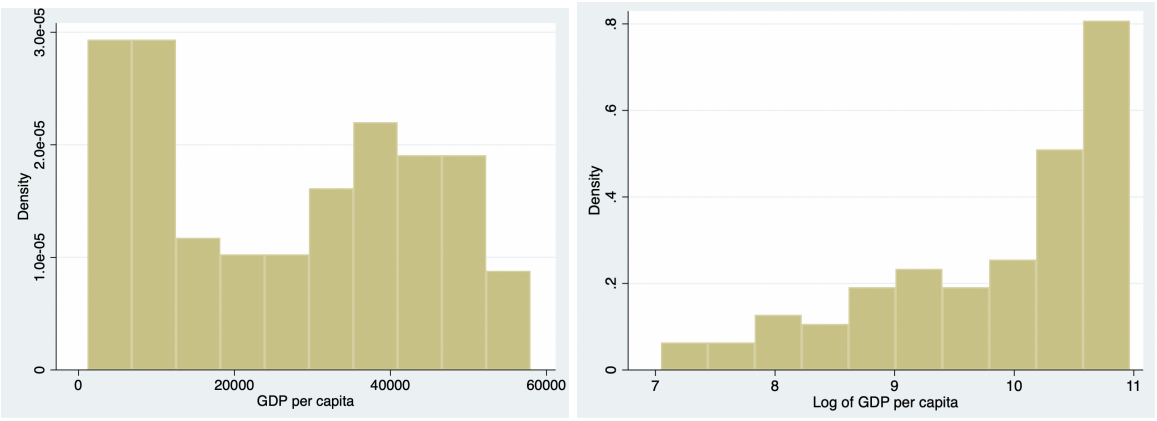


Figure 5. The distribution of GDP and log of GDP.

Spillover effects: The neighbors' countries may experience the economic impact of the Olympics as well, which could have skewed our results. For example, in 2010, the Olympic Games were hosted in Canada, and some substantial fraction of people may have wanted to visit the neighboring United States too, boosting their GDP per capita due to tourism too and thereby interfering with the analysis.

8.1 Synthetic difference-in-differences

To further explore the question, we can use the Synthetic Difference in Differences (SDID) method. The proposed method combines the Synthetic Control (SC) and Difference in Differences (DID) to combine the benefits of both approaches by introducing weights, similar to SC, into the DID method to construct a more robust estimator (Arkhangelsky et al., 2020).

In application, the DID is a specific case of fixed-effect models in that it is a two-way fixed effects model where the parallel trends assumption holds. The SC method essentially operates through creating a "synthetic" control unit as a weighted combination of non-exposed units with similar traits. Compared to DID, this weighting process creates a better control unit for the treatment group. The SDID method creates a localized version of DID by applying the weights, as obtained from the SC method, into the two-way fixed effect regression done by the DID method. As a result of adding the weights, the result is a more robust estimator since it creates a more reliable control unit (Arkhangelsky et al., 2020).

We can use this method to analyze the effect of hosting the Olympics on GDP per capita by basically carrying out the same process - finding a synthetic control for each treated country, calculating the DD, and combining all of the findings (see Appendix for further discussion).

9. Conclusion

Our paper analyzed the effect of hosting the Olympic games on the host country's GDP per capita using the two-way fixed effects model with differential timing for the treatment due to the nature of the data. As explained throughout the paper, the three models we have used had different results attributed to having controlled and uncontrolled versions. Ultimately, our results were not significant. Hence, we suggest exploring this causal question more through implementing other methods to analyze the effects of hosting the Olympic games on the host country's economy.

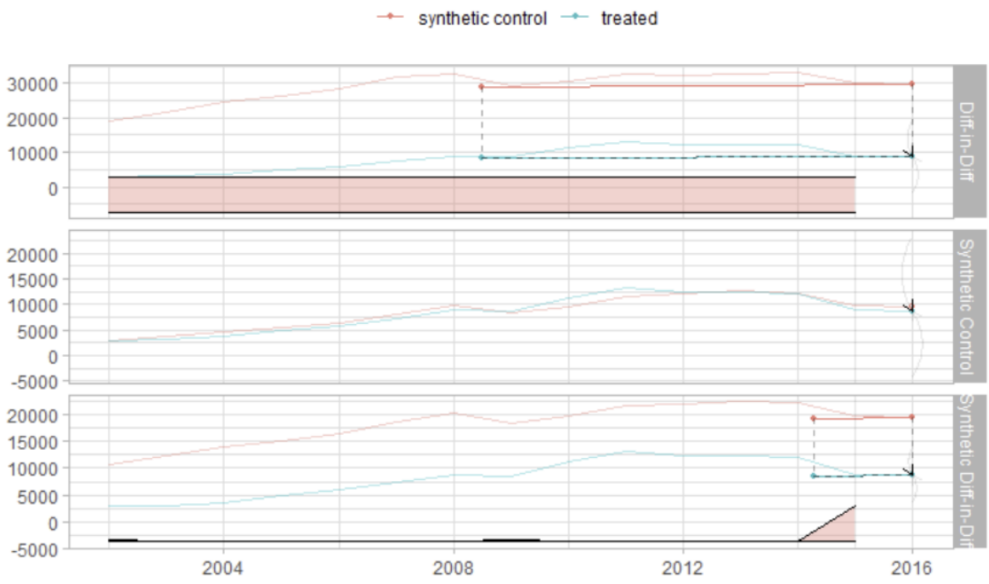
10. Statement of contribution

- **Abdel**: Introduction, Conclusion, SDID explanation
- **Akma**: Abstract, Data, Analysis, Results, Limitations, Assumptions
- **Albion**: Literature Review, Methodology, Limitations, SDID code

Note: We tried formatting this paper in LaTex; however, many complications arose and it was taking so much time.

11. Appendix

We also tried to do the SDID in R, but it wasn't very successful due to the lack of time and this topic not being familiar to us. However, here are some of the graphs we produced as part of our trial. They represent the SDID plots for Brazil. Further exploration is required to make this code reliable and working. All of the code is added to this Github repository: https://github.com/akmarzhan1/ss154-fp.



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