Saïd Business School
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Saïd Business School working papers

JUNE 2012

Olympic Proportions: Cost and Cost Overrun at the Olympics 1960-2012

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The authors would like to thank Sarah-Ann Burger, Alexander Budzier, Atif Ansar, Chantal Cantarelli, and Daniel Lunn for their help with quality check and analysis of the data presented in the paper.

DRAFT 3.3

List of Abbreviations

AFC	Anticipated Final Cost
GDP	Gross Domestic Product
IBC	International Broadcast Centre
ICT	Information and Communications Technology
IOC	International Olympic Committee
GBP	British Pounds Sterling
LOCOG	London Organising Committee for the Olympic Games
MPC	Media and Press Centre
NCU	National Currency Unit
OGKM	Olympic Games Knowledge Management
OCOG	Organising Committee for the Olympic Games
ODA	Olympic Delivery Authority
RCF	Reference Class Forecasting
USD	United States Dollar

Abstract

Do different types of megaprojects have different cost overruns? This apparently simple question is at the heart of research at the University of Oxford aimed at understanding the characteristics of megaprojects, particularly in terms of how they are established, run and concluded.

In this study, we set out to investigate cost overruns in the Olympic Games. To do so, we examined the costs of the Games over half a century, including both summer and winter Olympics. We looked at the evolution of final reported costs and compared these to the costs established in the Games bids, submitted to the International Olympic Committee (IOC) up to seven years before the Games occurred. In so doing we established the largest dataset of its kind, and documented for the first time in a consistent fashion the costs and cost overruns for the Olympic Games, from 1960 to 2012.

We discovered that the Games stand out in two distinct ways compared to other megaprojects: (1) The Games overrun with 100 per cent consistency. No other type of megaproject is this consistent regarding cost overrun. Other project types are typically on budget from time to time, but not the Olympics. (2) With an average cost overrun in real terms of 179 per cent – and 324 per cent in nominal terms – overruns in the Games have historically been significantly larger than for other types of megaprojects, including infrastructure, construction, ICT, and dams. The data thus show that for a city and nation to decide to host the Olympic Games is to take on one of the most financially risky type of megaproject that exists, something that many cities and nations have learned to their peril.

For the London 2012 Games, we find that: (1) With sports-related real costs currently estimated at USD14.8 billion, London is on track to become the most costly Olympics ever. (2) With a projected cost overrun of 101 per cent in real terms, overrun for London is below the historical average for the Games, but not significantly so. (3) The London cost overrun is, however, significantly higher than overruns for recent Games since 1999. London therefore is reversing a positive trend of falling cost overruns for the Games.

Understanding the Olympics

The competition for hosting the Olympic Games has become a hotly debated political arena, in which cities pitch their ideas for urban development against each other to win the opportunity to host the world's biggest sporting event (Andranovich, Burbank and Heying, 2001). To demonstrate their ability to achieve these goals, bidding cities are required to develop detailed plans in the form of Candidature Files that are submitted to the International Olympic Committee (IOC). These Candidature Files, or 'bid books' as they are more commonly known, form part of the basis of the IOC's decision for the next host city.

One of the requirements for these bid books is that they include budgets that form the basis of the expected investment by the host country and city's governments, in addition to funds generated as revenue (IOC, 2004). In the bid book, the governments of candidate countries are also required by the IOC to provide guarantees to 'ensure the financing of all major capital infrastructure investments required to deliver the Olympic Games' and 'cover a potential economic shortfall of the OCOG' (*ibid*: p 93), where the OCOG is the Organising Committee of the Olympic Games, which leads the Games planning in the host city. The Candidature File is a legally binding agreement, and as such represents the baseline from which future costs and cost overruns should be measured. However, this is rarely done; new budgets are developed after the bid has been awarded to the city, which are often substantially different to those presented at the bidding stages (Jennings, 2012). These new budgets are often used as new baselines, rendering measurement of cost overrun inconsistent and misleading. New budgets continue to evolve and develop over the course of planning for the Games, until the final actual costs are perhaps presented, often several years after the Games' completion, if at all, as we will see.

The objective of this study is to consistently examine the degree to which final costs reflect projected budgets at the bid stage, and to examine how cost overruns in the Games are evolving over time. We have searched for valid and reliable cost data from both summer and winter Games, starting with the Rome 1960 summer and Squaw Valley 1960 winter Olympics, and continuing until bid data for Beijing 2008 summer and Vancouver 2010 winter Games. We also wanted to see whether the IOC's introduction of the Olympic Games Knowledge Management (OGKM) programme in 2000 (IOC, 2008), has had an impact on improving the Games' execution, including size of cost overrun. Finally, we

compared the current London projections against our benchmarks, to provide insight into how London's costs are progressing as compared to previous Games.

Cost Overruns

Interest in the costs of the Games has been high since the establishment of the modern Olympics in 1896. As long ago as 1911 Baron Pierre de Coubertin, the man responsible for establishing the modern Games, referred to '…the often exaggerated expenses incurred for the most recent Olympiads…' (Coubertin, 1911), and in 1973 Jean Drapeau, the mayor of Montreal, famously stated 'The Montreal Olympics can no more have a deficit, than a man can have a baby,' (CBC, 2006). Unfortunately, Drapeau was wrong, and problems with costs and cost overruns are as prevalent today as they were in Drapeau's time, and in Coubertin's time before him.

Despite substantial interest in the costs of the Games, however, attempts to specifically and systematically evaluate the costs and cost overruns of the Games are few (see e.g. Preuss, 2004; Essex and Chalkley, 2004; Chappelet, 2002), while those that do attempt them are often focussed on a specific Games (e.g. Bondonio and Campaniello, 2006; Brunet, 1995). Previous research on the costs of the Olympic Games has instead focussed on whether the Games present a financially viable investment from a cost-benefit analysis perspective. However, what to measure when determining the costs and benefits of the Games to a host country is open to debate. In particular, legacy benefits described in the bid are often intangible, and as such pose a difficulty in ex-post evaluations. The benefits of increased tourism revenue, jobs created by Olympic needs, or national pride are hugely varied and similarly difficult to quantify. Costs are equally hard to determine; for example, one could argue that if hotels in the city have invested in renovations, and benefits of increased tourist revenues to those hotels are included in the analysis, then these costs should also be included in any accounting. Similarly, the percentage of work that an employee in an outlying city spends on Games-related work would be exceptionally difficult to estimate.

Preuss (2004) has developed the most comprehensive multi-Games economic analysis to date, looking at the final costs and revenues of the summer Olympics from 1972 to 2008. In his work, he finds that every OCOG since 1972 has produced a positive benefit as compared to costs, when investments are removed from OCOG budgets. Note that this, however, restricts the analysis to only OCOGs, which generally represent a fairly small portion of the overall Olympic cost. Further, other authors disagree with Preuss' findings, and have suggested that the net economic benefits of the Games are negligible at best, and rarely offset by either revenue or increases in tourism and business (see e.g. Malfas, Theodoraki

and Houlihan, 2004). Furthermore, none of these studies have compared the projected costs to the final costs, which is a problem, because experience from other types of megaprojects show that cost overruns may, and often do, singlehandedly cause positive projected net benefits to become negative (Ansar, Flyvbjerg, and Budzier, in progress). Finally, while it is important to note that increased revenues would potentially allow organisers to increase their costs for the Games, this in itself does not preclude an analysis based solely on costs; rather, we should consider that increased revenues could be returned to be used to reduce the funding required by the host city and country governments.

In research more broadly looking at megaprojects, a number of studies have examined cost overruns. Flyvbjerg, Holm and Buhl (2002), for example, provide an examination of rail, fixed-link and road megaprojects, which finds that cost overruns are both prevalent and predictable, with overruns of 44.7, 33.8 and 20.4 per cent in real terms for each type of megaproject respectively. Their work has led to the development of a technique called 'reference class forecasting' (RCF) (see Flyvbjerg 2008), which advocates developing budgets through a comparison with similar completed projects, rather than the bottom-up planning approach for each individual project that is commonly used. The RCF approach has been endorsed by the American Planning Association, and has been used in the UK, the Netherlands, Denmark, and Switzerland, among others, to predict megaproject costs and benefits. Research into major IT programmes has confirmed similar results (Budzier and Flyvbjerg, 2011). Daniel Kahneman (2011, p 251), Nobel Prize winner in economics, has called Flyvbjerg's advocacy for reference class forecasting 'the single most important piece of advice regarding how to increase accuracy in forecasting through improved methods.'

Drawing on these insights, this research seeks to develop a better understanding of cost overruns in the Games. Given that each of the Games hosted in the last 15 years has cost at least USD 2 billion – not including road, rail, airport, and hotel infrastructure – the size and financial risks of these programmes warrant further attention (see Table 5). Furthermore, a focus on the cost overruns as compared to the budget is critical for future host cities, countries, and citizens to understand the implications of the investment that they are undertaking. The IOC's requirement that the bid documents contain a guarantee that cost overruns will be paid by the host city and government means that this is a critical point of comparison for the Games' final costs, and the likely overrun should be taken into account in planning for the Games, as in the RCF approach used for other megaprojects. Finally, given the current global economic climate and subsequent tightening of government

spending in many countries, understanding the implications of major investments like the Games is critical for governments to make sound fiscal and economic decisions about these major events. For instance, cost overrun and associated debt from the Athens 2004 Games has contributed to a Greek 'double dip' in the financial and economic crises of 2007-2012 (Flyvbjerg, 2011). Other countries may want to make sure they do not end up in a similar situation by having a realistic picture of costs and risks of cost overruns before they bid for the Olympic Games. The data presented in this paper will allow such assessment.

Budget at Bid vs. Final Outturn Costs

Costs for hosting the Olympic Games fall into three categories:

1. OCOG costs, which are the operational costs incurred by the Organising Committee for the purpose of 'staging' the Games. The largest components of this budget are technology, transportation, workforce, and administration costs, while other costs include items like security, catering, ceremonies and medical services.
2. Non-OCOG direct costs, which are the construction costs incurred by the host city or country or private investors to build the competition venues, Olympic Village(s), International Broadcast Centre (IBC) and Media and Press Centre (MPC), which are required to host the Games.
3. Non-OCOG indirect costs, such as road, rail or airport infrastructure, or private costs such as hotel upgrades or business investment incurred in preparation for the Games.

The first two items constitute the sports-related costs of the Games and are covered in the present analysis. Non-OCOG indirect costs have been omitted, because (a) data on such costs are rare, (b) where data are available, their validity and reliability typically do not live up to the standards of academic research, and (c) even where valid and reliable data exist, they are typically less comparable across cities and nations than sports-related costs, because there is a much larger element of arbitrariness in what is included in indirect costs than in what is included in sports-related costs.

Thus, our analysis compares OCOG costs and non-OCOG direct costs at two distinct points in time, bid budget and final cost, for all Games in which each of these four data points exist, since 1960. We were able to obtain 94 data points from the period 1960 until 2012, which produced cost comparisons of bid and final sports-related costs for 16 Games, in addition to current estimated values for London. This is out of a total of 27 Games held between 1960 and 2010. For the remaining 11 Games, valid and reliable data have not been reported that would make it possible to establish cost overrun for these Games. This is an interesting research result in its own right, because it means, in effect, that for 41 per cent of Olympic Games between 1960 and 2010 no one asked how well the budget held for these Games, thus hampering learning regarding how to develop more reliable budgets for

the Games. From a rational point of view such learning would appear to be a self-evident objective for billion-dollar events like these, but it is not for the Olympics. This problematic is studied further in Stewart (forthcoming).

The final data used in this analysis are shown in Table 1, which has been reported in real terms, with final costs controlled for inflation over the Games planning period.

Table 1: Sports-related cost overruns, Olympics 1960-2012; original currencies, real terms

Games	Country	Type	% Cost Overrun
London 2012	UK	Summer	101*
Vancouver 2010	Canada	Winter	17
Beijing 2008	China	Summer	4
Torino 2006	Italy	Winter	82
Athens 2004	Greece	Summer	60
Salt Lake City 2002	USA	Winter	29
Sydney 2000	Australia	Summer	90
Nagano 1998	Japan	Winter	56
Atlanta 1996	USA	Summer	147
Lillehammer 1994	Norway	Winter	277
Barcelona 1992	Spain	Summer	417
Albertville 1992	France	Winter	135
Calgary 1988	Canada	Winter	59
Sarajevo 1984	Yugoslavia	Winter	173
Lake Placid 1980	USA	Winter	321
Montreal 1976	Canada	Summer	796
Grenoble 1968	France	Winter	201

** Projected final London 2012 cost is used; sources are listed in the references*

The difference between bid budget and final costs is statistically significant ($V = 153$, $p < 0.0001$). Further detail on the procedure used to convert these data from nominal to real terms is available in the Research Methodology section below. Based on the data in Table 1, we have established average and median cost overruns, as shown in Table 2.

Table 2: Average and median percentage cost overruns (not including London 2012), real terms

Metric	Summer, %	Winter, %	Total, %
Average cost overrun	252	135	179
Median cost overrun	118	109	112
Maximum cost overrun	796 (Montreal 1976)	321 (Lake Placid 1980)	796
Minimum cost overrun	4 (Beijing 2008)	17 (Vancouver 2010)	4

Note that the difference between summer and winter Games is not statistically significant, and is presented for comparison purposes only

It will be immediately obvious to many readers that some of these costs may not represent the complete costs of the Games for every city. Beijing, for example, is unofficially estimated to have spent much more on the Games than represented by these data, although these may be in the category of non-OCOG indirect costs. However, using the offi-

cial data will have the effect of making our estimates of costs and cost overruns more conservative, and as such the following analysis represents the 'best case scenario' for cost overruns.

The data presented in Tables 1 and 2 suggest a number of arresting trends with relation to cost overruns in the Games:

1. Notably, every Games, without exception, has experienced cost overruns. While it is not unusual for observers to suggest that this is 'obvious', it is worth considering this point carefully. A budget is typically established as the maximum – or, alternatively, the expected – value to be spent on a project. However, in the Games the budget is more like a fictitious minimum that is consistently overspent. Further, even more than in other megaprojects, each budget is established with a legal requirement for the host city and country government to guarantee that they will cover the cost overruns of the Games. These data suggest that this guarantee is akin to writing a blank cheque for a purchase, with the certainty that the cost will be more than what has been quoted.
2. With an average cost overrun of 179 per cent in real terms, the extent of cost overruns in the Olympic Games appear to be substantially higher than in other types of megaprojects. In comparison, Flyvbjerg et al (2002) found average cost overruns in major transportation projects of between 20 and 45 per cent, and similar studies on major IT projects found average overruns of 27 per cent, both in real terms (Budzier and Flyvbjerg, 2011). The high average overrun for the Olympic Games, combined with the existence of extreme outliers, should be cause for caution for anyone considering hosting the Games, and especially small or troubled economies with little capacity to absorb escalating costs and related debts. Even a small risk of an 800 per cent overrun on a multi-billion dollar project should be cause for concern when a guarantee to cover cost overruns is issued, because such overrun may have fiscal implications for decades to come, as happened with Montreal, where it took 30 years to pay off the debt incurred by cost overruns on the 1976 summer Games (Vigor, Mean and Tims, 2004: 18), and Athens where Olympic cost overruns and debt have exacerbated the 2007-12 financial and economic crises, as mentioned above (Flyvbjerg, 2011).

3. Finally, it is important to note that the data appear to show that cost overruns have decreased over time. Thus for Games after 1999, cost overruns are significantly less than for Games before 1999 ($W = 27$, $p = 0.009$). The decreasing cost overruns may be related to the IOC's introduction of the Olympic Games Knowledge Management (OGKM) programme in 2000 (IOC, 2008). However, London 2012 appears to be reversing the trend towards lower cost overruns, as discussed in the next section of this paper.

For comparison purposes, nominal results, which are not controlled for inflation over the Games planning period, are shown in Table 3.

Table 3: Sports-related cost overruns, Olympics 1960-2012; original currencies, nominal terms

Games	Country	Type	% Cost Overrun
London 2012	UK	Summer	133*
Vancouver 2010	Canada	Winter	36
Beijing 2008	China	Summer	35
Torino 2006	Italy	Winter	113
Athens 2004	Greece	Summer	97
Salt Lake City 2002	USA	Winter	40
Sydney 2000	Australia	Summer	108
Nagano 1998	Japan	Winter	58
Atlanta 1996	USA	Summer	178
Lillehammer 1994	Norway	Winter	347
Barcelona 1992	Spain	Summer	609
Albertville 1992	France	Winter	169
Calgary 1988	Canada	Winter	131
Sarajevo 1984^	Yugoslavia	Winter	1257
Lake Placid 1980	USA	Winter	502
Montreal 1976	Canada	Summer	1266
Grenoble 1968	France	Winter	230

**Projected final London 2012 cost is used; sources are listed in the references*
^The Yugoslavian dinar experienced hyperinflation during the Games planning period; therefore, nominal cost overruns are significantly more than constant cost overruns

These data show slightly different average and median overruns, as shown in Table 4.

Table 4: Average and median percentage cost overruns (not including London 2012), nominal terms

Metric	Summer, %	Winter, %	Total, %
Average cost overrun	347	288	324
Median cost overrun	133	150	150
Maximum cost overrun	1266 (Montreal 1976)	1257 (Sarajevo 1984)	1266
Minimum cost overrun	35 (Beijing 2008)	36 (Vancouver 2010)	35

Note that the difference between summer and winter Games is not statistically significant, and is presented for comparison purposes only

However, as can be seen from these data as compared to Tables 1 and 2, there is little substantial difference in the profile of costs using real vs. nominal amounts. Given that convention dictates that real costs are used, we have relied on these data for our analysis.

Finally, to provide a perspective for comparison, we have converted the costs of each of the Games listed above into USD2009, using local GDP indices and National Currency Units as compared to USD2009 for conversion. This methodology is described more fully in the last section of this paper. The comparative data are shown in Table 5.

Table 5: Final actual sports-related costs, Olympics 1960-2012, USD2009

Games	Country	Type	Final Actual cost, billion USD
London 2012*	UK	Summer	14.8
Vancouver 2010	Canada	Winter	2.3
Beijing 2008	China	Summer	5.5
Torino 2006	Italy	Winter	4.1
Athens 2004	Greece	Summer	3.0
Salt Lake City 2002	USA	Winter	2.3
Sydney 2000	Australia	Summer	4.2
Nagano 1998	Japan	Winter	2.3
Atlanta 1996	USA	Summer	3.8
Lillehammer 1994	Norway	Winter	1.9
Barcelona 1992	Spain	Summer	11.4
Albertville 1992	France	Winter	1.9
Calgary 1988	Canada	Winter	1.0
Sarajevo 1984^	Yugoslavia	Winter	0.01
Lake Placid 1980	USA	Winter	0.4
Montreal 1976	Canada	Summer	6.0
Grenoble 1968	France	Winter	1.0

Sources are listed in the references
** Current projected London 2012 cost is used*
^Since the Yugoslavian dinar experienced hyperinflation while the Games were being planned and ceased to exist in 1990, we have converted the cost to USD in the year incurred, prior to inflating it to 2009; therefore, the final costs appear to be lower than the budgeted costs. However, Table 1 shows the appropriate constant cost overruns in the original local currency.

As can be seen in Table 5, Barcelona 1992, Montreal 1976, and Beijing 2008 are relatively the most expensive Games to date, while London 2012 is on track to exceed them all. In the next section, we provide a more detailed discussion of London's costs.

In sum, the data show that the Olympic Games stand out in the following ways:

1. The Games overrun with 100 per cent consistency. No other type of megaproject is this consistent regarding cost overrun. Other project types are typically on budget from time to time, but not the Olympics.
2. With an average cost overrun in real terms of 179 per cent – and 324 per cent in nominal terms – overruns in the Games have historically been significantly larg-

er than for other types of megaprojects, including infrastructure, construction, ICT, and dams.

3. Cost overruns for the Games have been decreasing over time, with significantly lower overruns post-1999 as compared to pre-1999. However, London 2012 appears to be reversing this trend.

Given these observations, for a city and nation to decide to stage the Olympic Games is to decide to take on one of the financially most risky type of megaproject that exists, something that many cities and nations have learned to their peril.

London 2012 Compared with Previous Games

There have been numerous articles in UK and worldwide media over the last several years highlighting the progression of costs for London 2012's summer Olympic Games. It is therefore important to clarify where these costs have originated, how they compare to our data, and how London's costs compare to previous Games.

In 2005, the London 2012 Bid Committee submitted a Candidature File to the IOC, as required by the candidature process. In this bid, the committee specified a projected cost of £1.54 billion for OCOG operational costs, and £2.67 billion for non-OCOG direct costs (London 2012 Bid Committee, 2005: p 103-105), for a total sports-related cost of £4.21 billion. An additional £7.2 billion was earmarked for roads and railway development (*ibid*). These costs represent the baseline cost for the London 2012 Games.

In February 2012, the anticipated final cost (AFC) for the Olympic Delivery Authority (ODA), which administers non-OCOG direct costs for the government, was estimated at £5.83 billion in real terms, which we have used as the expected final cost (Department for Culture, Media and Sport, 2012). As of March 2012, during testimony to the recent Commons Public Accounts Committee, Paul Deighton, Chief Executive Officer of the London Organising Committee for the Olympic Games (LOCOG), reported that the current budget for LOCOG is £2.61 billion in real terms (UK Public Accounts Committee, 2011). This represents a total sports-related cost of £8.44 billion in real terms, which is a cost overrun of 101 per cent as compared to the budget in the bid. It is also worth noting that the government is also paying for other indirect costs, which are currently the subject of much debate; a recent report suggested that the total cost of the Games to the government could reach £11 billion (UK Public Accounts Committee, 2012). However, these costs do not form part of the current analysis. A summary of the total sports-related costs for London 2012 is included in Table 6.

Table 6: London 2012 bid and current projected costs, GBP2004

	OCOG Costs	Non-OCOG Direct Costs	Total Sports-Related Costs
Bid	£1,538,750,000	£2,670,000,000	£4,208,750,000
Current	£2,608,691,248	£5,832,761,659	£8,441,452,907
Overrun	70%	118%	101%

The difference between London's 101 per cent cost overrun and the overall average overrun for all Olympics of 179 per cent is not significant ($V = 88.5$, $p = 0.301$). Statistically, London is therefore doing neither better nor worse in terms of cost overrun than all previous Games. However, London's projected cost overrun is statistically significantly higher than the seven Games held since 1999 (B(0.5, 6), $p = 0.0312$). Therefore, London is on track to reverse the trend of Games since 1999 of having statistically significantly lower cost overruns than pre-1999 Games ($W_s = 27$, $p = 0.009$). Finally, the total sports-related cost of the London Games is projected to be more than any previous Games by a considerable margin.

In sum, we find for the London 2012 Olympic Games:

1. With sports-related costs currently estimated at USD14.8 billion, London is on track to be the most costly Olympics ever.
2. With a cost overrun of 101 per cent in real terms, overrun for London is below the historical average for the Games, but not significantly so.
3. However, the London cost overrun is reversing a positive trend of falling cost overruns for the Games since 1999.

Research Methodology

To investigate the question of costs in the Olympic Games, we conducted an extended search of all data available on the costs. As previously mentioned, we collected data on two cost components for the Games: the OCOG cost and non-OCOG direct costs. For these two components, costs at bid were primarily determined through primary data such as the OCOG Candidature Files. Final OCOG costs are often available from the Official Reports submitted to the IOC following each Games. Where primary sources were not available, secondary sources including audits and other research data were used, with primary sources taking precedence over secondary sources where available. We have used only the most reliable data in our work, and as such, the findings that we have produced can be said to be conservative; this is illustrated by the case of the Beijing 2008 summer Games where the best, officially available data indicate a cost overrun of 4 per cent in real terms (35 per cent nominal), but unofficially the real overrun is thought to be substantially higher.

Using these data, we then proceeded with nominal and real cost comparisons. For nominal cost comparisons, we used the cost listed in local currency in the year in which it was reported (e.g. bid year or Games year) for our analysis. This allows us to compare the data on a like-versus-like basis. Then, to control for inflation over the period from which the bid documents were prepared until the reporting of the final costs, for constant (real-term) cost comparisons, we adjusted the data using Local GDP Deflator values to deflate the cost in local currency to the bid year, using a distribution of costs over the seven years of Games planning based on known profiles of OCOG and non-OCOG direct costs. This allowed us to calculate the total cost of the Games in the year of the bid, thereby eliminating the impact of inflation. This then represents the most conservative comparison of the bid and final data, since it does not assume that the bid was able to predict inflation. In other words, if final costs are significantly greater than bid costs when the effects of inflation are removed, there is a cause for concern in the process of developing bid estimates. Finally, for cost comparisons in USD2009, we used the same Local GDP Deflator values to inflate the nominal bid and final cost data in the year in which it was incurred to 2009 local currency, and then used World Bank National Currency Unit (NCU) values (World Bank, 2012) to convert the data from 2009 local currency to USD 2009. For Yugoslavia, which ceased to exist in 1990, we converted the data to USD1990 and then inflated it using the Local US GDP Deflator.

Based on the constant data in local currency, we then conducted a number of statistical tests to understand the differences present in the data. First, we wanted to test whether there was a significant difference between the bid and final costs. To do so, we began by testing the data for normality. As the Shapiro-Wilk test was significant ($p < 0.01$), the data do not fulfil the assumptions for normal parametric tests. Thus, we used the non-parametric Wilcoxon signed rank test, which confirmed that final costs are significantly greater than bid costs ($V = 153$, $p < 0.0001$).

Then, we wanted to test whether there was a difference between summer and winter Games cost overruns. To do so, we used the Mann-Whitney-Wilcoxon test. The test showed that there was no significant difference between cost overrun for summer Games (*median* = 118 per cent) and winter Games (*median* = 109 per cent) ($W = 56$, $p = 0.588$).

Next, we assessed the data to see if cost overruns of the Games have changed with IOC's introduction in 2000 of the Olympic Games Knowledge Management (OGKM) programme in conjunction with the Sydney Olympic Games (IOC, 2008),. We used the Mann-Whitney-Wilcoxon test to compare the Games post-1999 (Sydney 2000 to Vancouver 2010, *median* = 44 per cent) with the Games pre-1999 (Grenoble 1968 to Nagano 1998, *median* = 187 per cent). The test showed the post-1999 Games to have significantly lower cost overruns than the pre-1999 Games ($W = 27$, $p = 0.009$).

We then compared the difference between the current projected cost overrun of the London Games and the cost overrun of each of the previous Games using the Wilcoxon signed rank test. We found that the difference between all of the previous Games (*median* = 112 per cent) and the London Games (*median* = 101 per cent) was not significantly different ($V = 88.5$, $p = 0.301$).

Finally, we compared the London Games' projected cost overrun to that of the six other post-1999 Games (Sydney 2000 to Vancouver 2010), using the sign test. For this test, our null hypothesis is that, given a random comparison between London and each of the Games of the previous decade, there is an equally likely probability that London's overrun would be greater or less than each of the previous six Games' overruns. Since London's projected overrun is higher than each of these six Games, the difference between London's projected overrun and that of the Games post-1999 is statistically significant ($B(0.5, 6)$, $p = 0.0312$). Thus, we conclude that London's projected cost overrun of 101 per cent is signifi-

cantly greater than that of the Games since 1999. London 2012 is therefore on track to reverse the trend of post-1999 Games towards lower cost overruns.

Future research on this data set is planned to include a more detailed exploration of the trends in the data, including the incremental development of budgets over the course of the Games, trend analysis, and comparisons of Games by outcome, such as viewership and city size.

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