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Quantifying the Intangible Impact of the Olympics Using Subjective Well-Being Data

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Abstract
Hosting the Olympic Games costs billions of taxpayer dollars. Following a quasi-experimental setting, this paper assesses the intangible impact of the London 2012 Olympics, using a novel panel of 26,000 residents in London, Paris, and Berlin during the summers of 2011, 2012, and 2013. We show that hosting the Olympics increases subjective well-being of the host city's residents during the event, particularly around the times of the opening and closing ceremonies. However, we do not find much evidence for legacy effects. Estimating residents' implicit willingness-to-pay for the event, we do not find that it was worth it for London alone, but a modest wellbeing impact on the rest of the country would make hosting worth the costs.

Key words: subjective well-being, life satisfaction, happiness, intangible effects, Olympic Games, sport events, quasi-natural experiment
JEL Codes: I30; I31; I38; L83; Z20; Z28

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1 Introduction

A question that should be at the heart of any decision to use taxpayer dollars to host a mega event is: do the benefits justify the costs? This is a simple question but one that is notoriously difficult to answer, especially in the presence of intangible (hard to quantify) benefits. One such benefit is the "feelgood factor." We use subjective well-being data to quantify the intangible impact of the 2012 Summer Olympics on the residents of London, the host city.

Until the 1960s, the Olympics were relatively modest events, but in the television and social media era the capacity to reach a global audience has enhanced their prestige, cost, and potential impact. Reuters reported that up to 900 million people watched the 2012 opening ceremony of the London Summer Olympics.[1] Over time, a fierce competition among cities to host the event has emerged and expenditures have risen significantly. For example, the 1956 Olympic Summer Games in Melbourne cost $60 million in 2012 prices (Official Report of the Organizing Committee for the Games of the XVI Olympiad, 1956).[2] In contrast, the 2012 Summer Olympics in London cost taxpayers in the region $14-$15 billion (NAO, 2012).[3] There are signs that the costs of hosting the Olympics have become prohibitive. In the bidding to host the 2024 Olympic Games, three out of five bidders withdrew, largely on the grounds of cost (Boston, Budapest, and Hamburg).

Given the public interest in the Olympics and the large taxpayer subsidies that they require nowadays, a significant academic literature has sought to measure the economic impact of hosting the event. Much of this literature is devoted to rebutting the claim that the Olympics generate substantial multiplier effects by stimulating investment and tourism.[4] Most academic studies find little evidence of any significant tangible long-term economic impact. In a recent review, Baade and Matheson (2016: 202) state that "*the overwhelming conclusion is that in most cases the Olympics are a money-losing proposition for host cities.*"

[1] See https://uk.reuters.com/article/uk-oly-ratings-day11/london-2012-opening-ceremony-draws-900-million-viewers-idUKBRE8760V820120807 (retrieved January 23, 2019).

[2] If not stated otherwise, prices in £($) are always stated in 2012 levels.

[3] According to the NAO (2012), which reported an official government estimate, the total public sector funding package amounted to £9.3 billion. It was anticipated that the final cost would be £8.9 billion. On the opening day of the Olympics, the sterling-dollar exchange rate stood at 1.57, and on the day of the closing ceremony stood at 1.60. Depending on which figure you use, this yields an estimated cost to the taxpayer in the region of $14-15 billion.

[4] The general economic principles are addressed by Crompton (1995), Porter (1999), and Siegfried and Zimbalist (2000). General equilibrium modelling has identified negligible or even negative impacts for London 2012 (Blake, 2005) and Sydney 2000 (Giesecke and Madden, 2007). *Ex-post* studies of local employment and wages find little or conflicting effects related to sports infrastructure (Baade and Matheson, 2002; Coates and Humphreys, 1999, 2003; Jasmand and Maennig, 2008; Billings and Holladay, 2012; Rose and Spiegel, 2011). Tiegland (1999) and Fourie and Santana-Gallego (2011) find short-term increases in tourist arrivals related to sports events but no long-run impacts. Sports facilities and construction seem to positively affect property values in the host city (Ahlfeldt and Maennig, 2010; Feng and Humphreys, 2012; Ahlfeldt and Kavetsos, 2014).

In the face of these findings, many proponents of the Olympics have suggested that one of the main benefits of hosting would be the *intangible impact* on people in the host city. The UK government's assessment of the 2012 Olympic Summer Games in London focused on intangibles such as "*inspiring a generation of children and young people*", community engagement, and enthusiasm for volunteering (DCMS, 2013). There is also evidence that citizens may be willing to pay substantial amounts of money to host such events (Atkinson et al., 2008). A national opinion poll conducted immediately after London 2012 found that 55% of respondents believed that the public expenditures on the Games had been well worth the investment.[5]

This paper studies the nature and the extent of these hypothesized "intangible" impacts of the Olympics on residents in the host city. It also assesses the possibility of legacy effects, and whether such effects persisted for at least one year after the Games ended.[6] To quantify the intangible benefits, we exploit measures of subjective well-being. Of course, the totality of potential intangible benefits of the Games is not limited to subjective well-being effects. According to the Olympic Charter (2015: 13), the Games are intended as a manifestation of Olympism, which is a philosophy of life, "*exalting and combining in a balanced whole the qualities of body, will and mind... Blending sport with culture and education,... social responsibility and respect for universal fundamental ethical principles*". Hence, our subjective well-being measures only capture a subset of the universe of potential intangible benefits. However, they are close to the concept of *experienced utility*, which economists often conceptualize as an appropriate measure of welfare (Kahneman et al., 1997; Stevenson and Wolfers, 2009; Kahneman and Deaton, 2010; Sachs et al. 2012; Benjamin et al., 2014b; Deaton, 2018).

For decades, subjective well-being measures have been developed, tested, and applied by economists.[7] Researchers have illustrated the power of these measures to assess the impact of markets, public policy, and the value of public goods or bads for which no market prices exist (Winkelmann and Winkelmann, 1998; van Praag and Baarsma, 2005; Frey et al., 2007; Luechinger, 2009; Luechinger and Raschky, 2009; Metcalfe et al., 2011; Levinson, 2012; Ludwig et al., 2012; Bayer and Juessen, 2015; Goebel et al., 2015; Aghion et al., 2016; Danzer and Danzer, 2016; Krekel and Zerrahn, 2017; Allcott et al., 2019; Perez-Truglia, 2019). Policy-makers are increasingly interested in subjective well-being measures to monitor social progress (Stiglitz et al., 2009, 2018; HM Treasury, 2011; Dolan and Metcalfe, 2012; OECD, 2013; National Research Council, 2013).

[5] See www.theguardian.com/sport/2012/aug/10/london-2012-team-gb-success-feelgood-factor (retrieved August 17, 2017)

[6] The concept of "legacy" has become increasingly important in the rationalization and celebration of the Olympics. This was particularly true for London 2012. The Final Report of the IOC Coordination Commission mentions the word "legacy" no less than 90 times in its 127-page report.

[7] Accordingly, a rich literature has discussed whether subjective well-being could be rationalized as the ultimate objective of individual choice (Rayo and Becker, 2007; Benjamin et al., 2012, 2014a, 2014b; Adler et al., 2017), and whether feeling happy may influence people's choice (Ifcher and Zarghamee, 2011).

Using subjective well-being measures to value intangibles has two main advantages: first, it avoids the complexity of contingent valuation studies, which require the expression of the monetary value of a multi-dimensional public good or bad in a hypothetical situation that includes several non-explicit trade-offs and alternative uses of resources. Second, the assumption that markets are competitive or in equilibrium is not required (Welsch and Kühling, 2009). Exploiting subjective well-being measures in a difference-in-differences framework elicits the causal impact of an event once it has occurred, without specifically asking about it and making assumptions about people's rationality or the market structure (Dolan and Kahneman, 2008). Our paper contributes to establishing the potential usefulness of subjective well-being measures for policy evaluation. In addition, we use our estimates to calculate the well-being monetary equivalent of hosting the Olympics—what the literature interprets as the implicit willingness-to-pay for hosting this event.

To study the intangible impact of hosting the Olympics, we designed our own surveys and collected panel data in three European capitals, interviewing more than 26,000 individuals during the summers of 2011, 2012, and 2013; that is, before, during, and after the event (totalling 50,000 interviews). Our empirical strategy rests on a difference-in-differences design: our treatment city is London, which hosted the event; Paris and Berlin are our two control cities. To identify causal effects, we exploit the choice of the host city in a quasi-experimental setting: in the years and months prior to the decision, Paris was the odds-on favorite to win the bid, but unexpectedly lost to London by a 50 to 54 vote. Berlin, which never expressed any interest in bidding, is also a suitable alternative control city. We experiment with both pooling Paris and Berlin and using them separately. In addition to exploiting the choice of the host city as a quasi-natural experiment, we randomized in all three cities the day when we surveyed respondents; that is, before, during, or after the precise period of the Olympics.

Concerning the legacy effect, although we evaluate the impact of hosting the Olympics one year after the event, *a priori*, we did not expect that a possible effect would persist over a long time period. This is because one of the main findings of the subjective well-being literature is the importance of adaptation and the tendency of people to return to their baseline level of well-being (Clark et al., 2008).

Our main result is that the Olympics increased the subjective well-being of Londoners during the event, relative to Parisians and Berliners. We find that hosting the Olympics raises the life satisfaction of Londoners by around 0.11 standard deviations, translating to 0.21 points on the eleven-point Likert scale. This is equivalent to increasing gross annual household income by around £650 ($1060). The impact of the Olympics on subjective well-being is independent of age or gender but tends to be higher among higher-income households.

In terms of potential "legacy" effects, we find that the intangible impact of the Olympics appears to be short-lived: while the effects are especially strong around the opening and closing ceremonies, we do not find strong evidence of lasting changes in subjective well-being in the host city one year after the event.

All our results are robust to controlling for a rich set of observables, including macroeconomic and meteorological conditions, selection into the survey and attrition, and the choice of the counterfactual. They also withstand a series of placebo tests.

Finally, we estimate residents' implicit willingness-to-pay and arrive at a range between £2.2 and 7.4 billion ($3.6 and 12 billion) for the monetary equivalent of the effect of hosting the Olympics on the life satisfaction of Londoners. If UK residents outside of London had a willingness-to-pay that was, say, half that of Londoners', then a case could be made that hosting was actually worth the costs.

This paper's findings are important for several reasons: first, the paper contributes to the literature demonstrating the impact of sporting events on welfare (Depetris-Chauvin et al., 2018; Metcalfe et al., 2019). The Olympics seek to provide excitement, inspiration, and entertainment. It is unclear, however, whether the Games increase subjective well-being in the host city; unintended consequences such as congestion or fear of terrorism could, in fact, reduce subjective well-being among residents. Any comprehensive cost-benefit analysis of hosting the event should take intangible effects into account, especially given the negligible tangible effects, for example on local job creation (Baade and Matheson, 2002; Coates and Humphreys, 2003). To our knowledge, this is the first study to formally employ subjective well-being measures to estimate the implicit willingness-to-pay for hosting the Olympics from responses before, during, and after the event.

More generally, our results provide important insights for those seeking to value mega events—or indeed any intangible effects—using subjective well-being measures. Such measures are increasingly recognized as an important device in the economist's toolkit of valuation as reflected, for example, in the revised guidance found in the UK Treasury Green Book for policy and project appraisal and evaluation (HM Treasury, 2011). At the very least, we establish that subjective well-being measures, where attention is not focused on the intangible good in question, are responsive to changes in that non-market good, suggesting that they provide a valid valuation method.

We proceed as follows: Section 2 describes the data collection in the three cities. Section 3 explains the empirical approach and identification strategy. Section 4 presents the main results. Section 5 examines their robustness with respect to selection into the survey and attrition, the choice of the counterfactual, and extended controls. Section 6 calculates residents' implicit willingness-to-pay and Section 7 concludes.

2 Data

2.1 Sample

We surveyed a panel of more than 26,000 individuals in London, Paris, and Berlin during the summer months of 2011, 2012, and 2013.[8] We chose Paris and Berlin as control cities because all three cities (a) are capitals of large Northwestern European countries; (b) have hosted the Olympics in the past (London in 1908 and 1948, Paris in 1900 and 1924, and Berlin in 1936); (c) expressed interest in hosting the Olympics in recent years (Berlin bid for the 2000 Olympics and lost to Sydney; Paris bid for the 2008 and 2012 Olympics and lost to Beijing and London); (d) have broadly similar size and wealth (for example, a Eurostat survey in 2006 ranked London, Paris, and Berlin respectively 1st, 2nd, and 10th among European metropolitan areas).

Our panel covers three interview waves: (a) 2011 (8th August to 30th September), the year before the Olympics; (b) 2012 (20th July to 2nd October), the year in which the Olympics took place (Olympics: 27th July to 12th August; Paralympics: 29th August to 9th September); and (c) 2013 (23rd July to 12th September), the year after the Olympics, capturing legacy effects or adaptation. Note that our sampling period in 2012 does not coincide with any other major events in the three countries at that time.

We employed a mixed-methodology approach using a combination of online surveys and telephone interviews. In all cities, each respondent was interviewed using the same mode in all three waves—either online or over the phone.[9] The online sample made use of the Ipsos Interactive Services Panel (IIS), without imposing any quota in the first wave. It was released on a rolling weekly basis over the duration of one wave. The phone sample was generated via random digit dialling. The sample is broadly representative to the broadband (London) and general (Paris and Berlin) population profile of the three cities with respect to characteristics of age, gender, and work status.[10] The samples are, however, not representative of the populations of the cities as a whole.[11]

[8] The full text of our surveys is available in the UK Data Archive at: https://beta.ukdataservice.ac.uk/datacatalogue/studies/study?id=8267#!/details

[9] Running our Model 3 below and using a survey mode indicator as outcome, we find no evidence that the survey mode shifted significantly during the Olympics. Interacting the mode of interview with demographic controls also produces robust results (only age is predictive of conducting a phone interview).

[10] The slightly different sampling periods in the three cities is unfortunate but note that we control for socio-demographics and individual fixed effects. Also, it is unlikely that differences in baseline sampling in 2011 were significantly related to the anticipated excitement about the Olympics one year later. Recall that we deliberately abstained from framing the survey as an Olympics-related survey. The survey mode did not change between the years for the same respondents and Section 5.1 tests and corrects for selective attrition between the years.

[11] In our baseline specification, we consider all nationals who live in the respective cities. Restricting the sample to nationals of each country yields similar results.

To minimize attrition, we incentivized respondents by including them in lotteries. Separate prize draws of £/€500, £/€1000 and £/€1500 were offered in each of the three cities and waves, respectively. In total, our sample contains 49,528 completed interviews (16,922 in London; 19,246 in Paris; and 13,360 in Berlin). Table 1 shows descriptive statistics of outcomes and covariates by city and wave. As with all panels, attrition reduces the number of observations over the three waves. In the first wave (2011), 25,958 unique respondents were interviewed in the three cities. A little bit more than half of those respondents, 14,500 or 56%, also participated in the second wave (2012). In the third wave (2013), slightly more than one third, 9070 or 35% are left. In Appendix B, we investigate panel attrition more closely and carry out several robustness checks in Section 5.1.

2.2 Subjective well-being questions

The survey, specifically designed for this study, contains three different types of measures of subjective well-being: (1) evaluation (life satisfaction); (2) experience (both happiness and anxiety on the day before the interview); and (3) eudemonia (sense of purpose in life). To date, the subjective well-being literature has focused on high-level evaluative measures such as life satisfaction (Dolan et al., 2008), mainly due to data availability in large-scale surveys.

Our study primarily focuses on this standard measure of life satisfaction but we will also show results based on the other measures. Following Dolan and Metcalfe (2012), Stiglitz et al. (2009), OECD (2013), and the National Research Council (2013), we included the following four subjective well-being questions in our surveys[12]:

(a) *Evaluative*: Overall, how satisfied are you with your life nowadays?
(b) *Experience*: Overall, how happy did you feel yesterday?
(c) *Experience*: Overall, how anxious did you feel yesterday?
(d) *Eudemonic*: Overall, how worthwhile are the things that you do in your life?

Responses are measured on 11-point Likert scales—with experimental evidence suggesting that this is more reliable than shorter scales (Kroh, 2006)—with zero denoting "not at all" and ten denoting "completely/very much". The subjective well-being questions are placed in the beginning of the survey to avoid responses to these being influenced by preceding questions, as has been shown to be the case in previous studies (Deaton, 2012).

[12]The joint use of these four measures of subjective well-being for the purpose of impact evaluation is novel, although some of them, in particular life satisfaction, have been used for this purpose before. In fact, large-scale, nationally representative panels like the German Socio-Economic Panel (SOEP) (Wagner et al., 2007, 2008) have asked life satisfaction questions since 1984.

3 Empirical strategy

3.1 Models

To estimate the effect of the 2012 Olympics on subjective well-being, we employ a difference-in-differences design. More specifically, we use four different models. Model 1 uses 2012 data only. It compares the periods before, during, and after the Olympics in London with those in Paris and Berlin. It can be written as:

$$\begin{aligned} SWB_i = \beta_0 &+ \beta_1 London \times Olympics + \beta_2 London \times PostOlympics \\ &+ \beta_3 London + \beta_4 Olympics + \beta_5 PostOlympics \\ &+ X_i'\gamma + GDP_q + \rho_m + \phi_{dow} + \epsilon_i \end{aligned} \tag{1}$$

where SWB_i is the subjective well-being of individual i (note that we omit the time subscript t to emphasize that we do not use a panel in Model 1). We standardize all subjective well-being outcomes to have mean zero and a standard deviation of one.[13]

London is a time-invariant dummy that equals one for London respondents, and is zero otherwise. *Olympics* and *PostOlympics* are dummies that equal one if the interview was during and after the exact period of the Olympics in 2012, respectively, and are zero otherwise. In this model, the base category is the 2012 pre-Olympics period. We count 1272 interviews during the pre-Olympics period (July 20 to 26, 2012); 6049 during the Olympics period (July 27 to August 12, 2012); and 7179 during the post-Olympics period (August 13 to October 2, 2012).

All our models routinely control for calendar-month fixed effects, ρ_m, and day-of-week fixed effects, ϕ_{dow}, as reports of subjective well-being might differ systematically between different months of the year and different days of the week (Taylor, 2006).[14] GDP_q controls for the development of the quarterly GDP since the first quarter of 2008. In robustness checks, we include additional economic and meteorological controls to further account for possibly divergent economic developments between and meteorological conditions in cities. X_i represents a set of socio-demographic individual-level control variables (see Table 1), and also includes the mode of interview. Robust standard errors are clustered at the interview date

[13] Note that we standardize non-conditionally on city. Standardizing conditionally on city, however, leads to very similar results.

[14] In some years and cities, we randomized the framing and ordering of the happiness, anxiety, and worthwhileness measures. We routinely control for such variations in the respective regressions.

level.

In our main specifications, we disregard potentially endogenous regressors such as employment status or income (Angrist and Pischke, 2009). However, our findings are robust to including all variables in Table 1. In extended analyses, we also show that there is not much evidence that the Olympics had an impact on these potentially endogenous outcomes, for example employment status.

In contrast to Model 1, Models 2 and 3 make use of the panel structure. These models use the years 2011 and 2012 along with individual fixed effects μ_i and SWB_{it} as outcome (with subscripts i and t). By netting out time-invariant unobserved heterogeneity via individual fixed effects, these models compare individual-level *changes* in subjective well-being of Londoners between 2011 and 2012 with individual-level changes in subjective well-being of Parisians and Berliners. We estimate two specifications, depicted in Equations 2 and 3, respectively. Note that time-invariant covariates in X_{it} drop out in these specifications.

Model 2 in Equation 2 takes the entire 2012 sampling period as the treatment period, both before, during, and after the Olympics. Given the identifying assumption, $London \times 2012$ can then be interpreted as the average causal effect of the Olympics on the subjective well-being of residents in the host city.

$$
\begin{aligned}
SWB_{it} = & \beta_0 + \beta_1 London \times 2012 + \beta_2 2012 \\
& + X'_{it}\gamma + GDP_q + \rho_m + \phi_{dow} + \mu_i + \epsilon_{it}
\end{aligned} \tag{2}
$$

where SWB_{it} represents subjective well-being of individual i in year t and 2012 is a dummy that equals one in 2012, and zero otherwise. All other variables are defined as the above.

Model 3 in Equation 3 follows Equation 1 by exploiting sharp cut-off dates, dividing 2012 into three time periods: before, during, and after the Olympics. *PreOlympics*, *Olympics*, and *PostOlympics* are all interacted with the *London* dummy.

$$
\begin{aligned}
SWB_{it} = & \beta_0 + \beta_1 London \times PreOlympics_{2012} + \beta_2 London \times Olympics_{2012} + \\
& + \beta_3 London \times PostOlympics_{2012} + \beta_4 PreOlympics_{2012} + \beta_5 Olympics_{2012} \\
& + \beta_6 PostOlympics_{2012} + X'_{it}\gamma + GDP_q + \rho_m + \phi_{dow} + \mu_i + \epsilon_{it}
\end{aligned} \tag{3}
$$

Given the similarities of the cities and our primary interest in estimating the effect of hosting on subjective well-being, Equations 2 and 3 pool Paris and Berlin and treat them as one joint control group. We still control for individual-level socio-demographics, X_{it}, and given their similarity, pooling both cities as one joint control group should not mask important differences (Table 1).[15] Moreover, in the robustness section, we use Paris and Berlin as single and separate control groups.

Finally, when testing for legacy effects, we add the year 2013 to Equation 2 along with an additional 2013 year dummy and a *London* $\times$ 2013 interaction term. We call this final model *Model 4*: it is identified by comparing changes in subjective well-being in London in 2013 relative to 2011 and to the analogous changes in Paris and Berlin. In other words, by construction, we cannot exploit sharp Olympics cut-off dates as in Equations 1 and 3, and thus interpret the findings with more caution.

3.2 Identifying assumption

Regardless of model, our empirical strategy rests on a difference-in-differences design in which we compare changes in subjective well-being of Londoners with that of Parisians and Berliners over time. To estimate causal effects, we have to make the following identifying assumption.

Controlling for time-varying observables, calendar-month and day-of-week fixed effects as well as individual fixed effects, in the absence of the Olympics, the subjective well-being of Londoners would have followed the same time trend as that of Parisians and Berliners. As this counterfactual is not observable, the common trend assumption is not formally testable. (Note that stable level differences between cities do not pose a problem for our identification strategy as city fixed effects net out systematic differences in levels between cities.) We can, however, provide suggestive evidence for its plausibility by plotting the coefficients from a regression of life satisfaction on week dummies, a London dummy, and an interaction between week dummies and the London dummy in the pre-treatment period (i.e. the weeks in 2011 around which, in 2012, the Olympics were held). Figure C5 in Appendix C shows the result of this exercise: 95% confidence bands including zero suggest that there were no significant differences in life satisfaction between London and Paris and Berlin (pooled together) in the pre-treatment period, thus lending credibility to the common trend assumption. We also conduct placebo regressions using the year 2011 and pretending the Olympics took place a year earlier, which show no impacts (Table 3, Panel B). Recall that Paris can be seen as an adequate control city as it was the favorite to win the bid to host the Olympics, unexpectedly

[15] We also test the comparability between Paris and Berlin formally, by looking at normalized differences in the set of covariates we routinely include in our regressions: both cities are largely balanced in terms of covariates.

losing to London in a 50 to 54 vote. We exploit Berlin, which has hosted the Olympics before and also contemplated to host again in the early 2000s, as an additional control city.

Table A1 in Appendix A lists potentially confounding events in the UK, France, and Germany in July, August, and September 2012, that is, during the relevant observation period. Overall, these are unlikely to be confounding events. Some sports success in the UK (notably the Tour de France victory of Bradley Wiggins) fall just into the beginning of our observation period but are unlikely to explain the effects identified by our specification which exploits the exact cut-off dates of the Olympics. Moreover, the Olympics began five days after the Tour de France ended, and nine days after it became clear that Wiggins would win. If anything, the Tour de France victory would increase subjective well-being in the pre-Olympics period, thus yielding a lower bound estimate. Finally, no major terrorist attacks, natural disasters, and general or local elections occurred during the observation period.

4 Baseline results

4.1 Nonparametric graphical evidence

We begin the analysis by plotting the responses to the life satisfaction measure by city for 2012 in Figure 1. This approach can be seen as the nonparametric visual representation of Model 1 in Equation 1, where we do not make use of the panel structure yet. Figure 1 plots the raw life satisfaction means by interview date as scatter plots for each city separately. The solid and dashed lines that overlay the daily means stem from a kernel-weighted local polynomial smoothing, which we apply separately to each time period (see the notes to the figures for more details). The first vertical line in Figure 1 depicts the day of the opening ceremony (July 27), whereas the second vertical line depicts the day of the closing ceremony (August 12, 2012).

Figure 1 shows a visible increase in subjective well-being during the Olympics in all three cities. However, the effect is clearly most pronounced in London, where we observe an instantaneous increase in life satisfaction by almost an entire point on the Likert scale, from a pre-Olympics level of about 6.3 to about 7.3 during the first days of the Olympics, right after the opening ceremony. This increase is substantially smaller in Paris and Berlin, with a minor increase by about 0.1 points in Paris and about 0.3 points in Berlin. Overall, in London, the increase in life satisfaction appears to be strongly related to the opening and closing ceremonies. Both events were the two most watched and most expensive events in terms of ticket prices.[16] The increase in life satisfaction in London during the Olympics falls off rapidly after the closing ceremony (a decrease which is almost invisible in Paris and Berlin). This apparent return to "normality" immediately after the Olympics is suggestive of small or missing legacy effects.

Next, exploiting the panel dimension, we plot the *individual-level changes* in subjective well-being for each respondent observed in both 2011 and 2012, by interview date in 2012. This can be seen as the nonparametric visual representation of Models 2 and 3 in Equations 2 and 3, both of which include individual fixed effects and are identified by *changes* in individual-level responses over just two years. We average the reported individual-level changes in life satisfaction by response dates in 2012 and plot them in Figure 2. As in Figure 1, we overlay the raw data values, displayed as dots, with solid and dashed smoothed values stemming from a kernel-weighted local polynomial smoothing, which we apply separately to each time period. Again, the x-axis displays the 2012 interview date and the vertical lines indicate the opening and closing of the Olympics. Consequently, a value of 0 on the y-axis indicates that, on average, individual-level responses have not changed between 2011 and 2012.

Figure 2 reinforces the main take-away from Figure 1: in London, in the pre-Olympics period, the dotted raw values closely align around the zero line, indicating not much trending in life satisfaction before the Olympics. We find a similar pattern in the post-Olympics period in London, also for the control cities of Paris and Berlin. However, life satisfaction increased clearly right after the opening ceremony in London, as witnessed by the substantial rise in year-on-year differences in life satisfaction responses. This movement levels off somewhat during the Olympics and then increases again leading up to the closing ceremony.

Figure C1 in Appendix C reinforces this interpretation: it is equivalent to Figure 2 but pools responses in Berlin and Paris, equivalently to how we use them as one joint control group in our regressions. In Figure C1, the absence of individual-level changes in life satisfaction is even more obvious, given the straight flat lines in Paris and Berlin, whereas, in London, we see a clear increase in life satisfaction during the Olympics. Again, this rise is particularly pronounced around the opening and closing ceremonies.

4.2 Parametric regression results

Table 2 presents our regression results: it shows the regression coefficients for life satisfaction in Models 1 to 4. For each model, we report two sets of results, with and without individual-level controls X_{it}, to ascertain the relative importance of controlling for observables. Table A2 in Appendix A presents the full set of covariate coefficients. Columns (1) and (2) show

[16]See www.theguardian.com/media/2012/aug/13/top-olympics-tv-events-ceremonies and http://news.bbc.co.uk/2/shared/bsp/hi/pdfs/15_10_10_athletics.pdf (retrieved August 17, 2017).

the estimates for Model 1 in Equation 1. This model focuses on 2012 and differentiates the periods before, during, and after the Olympics. Responses of Londoners are compared to responses of Parisians and Berliners over time, equivalently to Figure 1. Columns (3) to (4) show the estimates for Model 2 in Equation 2, and Columns (5) and (6) show the estimates for Model 3 in Equation 3. In case of positive legacy effects, which are largely absent in Figures 1 and 2, this model would provide lower-bound estimates. Finally, Columns (7) and (8) show estimates for Model 4 by adding 2013 to Equation 2 in order to assess potential legacy effects.

The findings in Table 2 can be summarized as follows: all eight main regression coefficients in our four models show highly statistically significant positive effects of the Olympics on life satisfaction of residents in the host city of London. The effect sizes range between 0.07 and 0.12 of a standard deviation and are not statistically significantly different from each other. Adding time-variant individual-level controls does not alter the effect sizes in a systematic or statistically significant way. In addition, the inclusion of individual fixed effects which net out time-invariant unobservables between respondents barely alters the effect sizes (Model 1 vs. Model 3). The fact that the cross-sectional results are basically identical to the panel results (where we identify the effect by individual-level changes in life satisfaction between 2011 and 2012) is very reassuring: it suggests not only that attrition between the years is not a major threat to our estimates, but also reinforces the notion that the event is exogenous to individual-level characteristics.

Table A3 in the Appendix A uses Model 2 (to maximize statistical power) and stratifies the main effect by age, gender, and household income to investigate possible heterogeneous effects. The findings show no difference by age or gender. There is evidence, however, that higher-income households saw larger increases in life satisfaction during the Olympics.

We draw several conclusions from our findings: first, we find clear evidence for a significant increase of one tenth of a standard deviation in the subjective well-being of Londoners, relative to Parisians and Berliners. Second, the effect clearly relates to the opening and closing ceremonies of the Olympics. Third, the results do not differ much between several model specifications that (a) use the exact timing of the event vs. not, (b) control for socio-demographics vs. not, and (c) control for individual-level unobservables between two years vs. not, which strongly suggest that the event was exogenous to observables and unobservables. The robustness of the findings together with the nonparametric visual evidence also strongly reinforces our identification assumption.

4.3 Legacy effects

The concept of "legacy" has become increasingly important in the rationalization and celebration of the Olympics. However, the graphical evidence in Figures 1 and 2 already suggests a limited legacy effect for London after the Olympics in 2012. On the other hand, the *PostOlympics* $\times$ *London* coefficients in Models 1 and 3 suggest a smaller but still statistically significant positive subjective well-being effect in the period right after the Olympics relative to before in Paris and Berlin.

To assess whether there is statistical evidence for a legacy effect in 2013, in Columns (7) and (8) of Table 2, we make use of the third wave—2013—and add a *London* $\times$ 2013 interaction term along with a year fixed effect for 2013 to Equation 2. Identification of this effect, however, rests on all conditional subjective well-being changes in London in 2013, relative to those in Paris and Berlin, as a function of hosting the Olympics in the year before. Admittedly, as we cannot exploit the sharp cut-off dates of the beginning and end of the Olympics as in Models 1 and 3, this is a relatively strong assumption. Consequently, we treat the results of this exercise with caution.

Both *London* $\times$ 2013 coefficients in Columns (7) and (8) are negative but not statistically significant. The size is around 0.02 of a standard deviation. However, note that, when entirely omitting all control variables, including individual, day-of-week, and calendar-month fixed effects, the coefficient turns positive and becomes significant. One potential explanation could be that the sample composition systematically changed between the second and the third wave of the panel. Despite our efforts and incentives to retain participants in the panel, attrition rates are quite high in the third wave. We cautiously conclude that we are unable to find much evidence for long-term legacy effects that lasted at least one year after the Olympics. Of course, it is entirely possible that the Olympics affect other intangible channels, such as national pride or social capital, which might persist or accrue in the future and, in turn, might feed into future subjective well-being.

Although we are mainly interested in the impact of hosting the Olympics, we nonetheless note that life satisfaction increased in all three cities during the Olympics, although considerably more in London. The event might therefore be seen as an international public good that each country is contributing in turn. Even though at each point of time, each country would be better off letting other countries host and free-ride on their organization, it may nonetheless be driven to cooperate instead, out of reputation concerns, as shown by repeated sequential equilibrium reputation models à la Andreoni and Miller (1993) or Dal Bo (2005). One may also see it as a kind of *potlatch* (Barnett, 1938), i.e. a communal exchange practiced by the indigenous peoples of the Pacific Northwest, whereby one family hosts a celebration (of a birth, marriage, or other life event) and acquires status by the extravagance of their hospitality. Equivalently, we find evidence that the Olympics generated increases in subjective well-being for both hosts and guests. Furthermore, any particular instance of potlatch contributes not only to current subjective well-being, but implicitly also to future well-being by supporting the institution of potlatch. Thus, while we do not find much evidence for a lasting positive impact of hosting the Olympics in the host city, we are also unable to entirely reject the possibility that legacy effect exists through other channels.

4.4 Alternative subjective well-being outcomes

After a thorough investigation of the impact of the Olympics on life satisfaction, the major and dominant measure in the subjective well-being literature, we move on to more recent and alternative outcomes. As noted above, we also surveyed measures for happiness, anxiety, and worthwhileness (Section 2.2). The nonparametric figures akin to Figure 1 are Figures C2 to C4 in Appendix C.

There is clear visual evidence for an increase in reported happiness specifically during the times of the Olympics in London, whereas findings for Paris and Berlin are less clear and noisier (Figure C2). There also appears to be evidence that reported anxiety decreased in London during the Olympics, although similar developments are also visible in Paris and Berlin, again slightly noisier and less distinct (Figure C3). Finally, in Figure C4 – again in line with Figures C2 and C3 – reported worthwhileness appears to clearly rise in London during the Olympics, whereas the effects are less pronounced in Paris and Berlin.

The parametric regression results for alternative outcomes and Model 3 using Equation 3 and the sharp cut-off dates model are presented in Panel A of Table 3, Columns (1) to (3). As can be seen, the finding for happiness clearly reinforces the finding for life satisfaction. The estimate is large, highly statistically significant, and positive. The effect size is 0.11 of a standard deviation (Column 1, Panel A). Columns (2) and (3), however, do not provide regression coefficients that are statistically significantly different from zero. This is likely a result of the noisier outcomes for anxiety and worthwhileness in Paris and Berlin (Figures C3 and C4).

4.5 The role of sporting success

The primary focus of the Olympics is the competition for medals. This is embodied in the medal table, which is a measure of national success. In deciding to fund the Olympics, the UK government considered the number of medals won by athletes from Great Britain to be an important indicator of success.[17] Overall, Great Britain exceeded expectations in 2012

[17] The official target, set by UK Sport, a government agency, was 40-70 medals (DCMS (2012: 14).

and ranked 3rd in the final medal table with a total of 65 medals (including 29 gold); a significant improvement over the previous two summer Olympics (Beijing 2008, 47 medals; Athens 2004, 30 medals). By comparison, the performance of France and Germany had been stable since 2004. Anyone following the Olympics in the UK was acutely aware of the medal counts and Great Britain's progress. Nightly news bulletins on TV screened the medal table and dwelt at length on British success or failure, while print and online media often headed their coverage with images of the medal table.[18]

Was subjective well-being affected by the evolving medal count? To answer this question, in Table A4 (Appendix A), we re-run Model 2, Equation 2, additionally interacting the main effect with the daily number of medals won by respondents' nation on the day before the interview, i.e. medals won by Great Britain for Londoners, by France for Parisians, and by Germany for Berliners. In other words, we assess whether the positive treatment effect for London is amplified by the relative performance of British athletes on the day before the interview. Panel A of Table A4 considers all lagged medals (gold, silver, and bronze), whereas Panel B considers lagged gold medals only as these carry more weight in the medal table and attract considerable media attention.

Table A4 shows little evidence of any sporting success effect. Although our statistical power may be limited to analyze high frequency events at the daily level, recall that we have enough power to identify opening and closing ceremony effects. Moreover, these null results for sporting success also hold if we consider lagged (gold) medals accumulated up to the day before an interview took place (results available upon request). While this finding might be surprising given the blanket media coverage, it is in line with Kavetsos and Szymanski (2010), who found no evidence that national team success in hosting major soccer tournaments had any effect on subjective well-being.

5 Robustness checks

5.1 Selective attrition

One possible concern is that the identified effects could be driven by selective attrition. Note that no question in either wave explicitly asked about the Olympics.[19] Hence, there is no *ex-ante* reason to believe that respondents in London in 2011 were initially primed, selected,

[18] A search of Lexis Uni, a global database of newspaper reports, for mentions of the combined terms "medal table" and "Great Britain" published in the UK between July 27 and August 12, 2012, generated 6,960 hits, an average of 409 for each day of the Olympics (including 212 on day one, before any medals had been won).

[19] An exception are some questions towards the end of the 2013 (final) survey.

or selected themselves into the panel based on a favourable disposition to hosting the event. However, if more positively (or negatively) disposed individuals were more likely to respond to the second wave of the panel, there would be potential for bias.

Table B1 (Appendix B) shows that only 35% of respondents in 2011 were also interviewed two years later, in 2013. To assess whether attrition is selective, we check whether a statistical link between subjective well-being and responding to all three surveys exists. This is tantamount to asking whether "happier" individuals are more likely to remain in the panel or drop out, and whether this differs by city. As shown in Table B2 (Appendix B), there is some evidence for this: individuals who are happier and less anxious are more likely to be present in all three years. There is, however, not much evidence for differences across the three cities.

Next, we run three robustness checks to test for and correct for differential attrition: first, we regress the likelihood to be interviewed in 2012, either during the entire observation period or only during the Olympics period, on a dummy for London. This model is equivalent to our baseline specification in Table 2, Columns (3) and (4), but modelled as an attrition test. In an additional model, we interact the London dummy with life satisfaction, pre-treatment, to test whether different pre-treatment levels in relative life satisfaction are predictive of being interviewed in the follow-up survey. The results can be seen in Table B3 (Appendix B): we do not find evidence for selective attrition, neither for being interviewed in the follow-up survey in general – Columns (1) and (2) – nor for strategic rescheduling of interviews relative to the Olympics period – Columns (3) and (4). The interaction between London and life satisfaction, pre-treatment, is insignificant – Columns (5) and (6) – suggesting that it is not predictive of the likelihood to participate in the follow-up survey either.

Second, we adopt a propensity-score-matching approach: we match respondents in the three cities one-to-one based on their likelihood to participate in the follow-up survey, which we predict using our standard set of covariates. Table B4 (Appendix B) shows that this matching was successful: observables appear to be balanced after matching as indicated by the "normalized difference." Then, we re-estimate our difference-in-differences model using only the matched statistical twins. Panel A of Table 4, Columns (1) and (2), shows the result: identified effects are similar in terms of size and significance to those in our baseline specification in Table 2, Columns (3) and (4).

Third, we weigh regressions by the inverse probability of individuals to participate in the follow-up survey.[20] Because we know, based on observables, who responded initially and then again in 2012 during the Olympics, re-weighting corrects for possible biases by overweighting respondents who were less likely to participate in the survey during the Olympics. Theo-

[20]To create inverse probability weights, we first predict the likelihood to participate in the follow-up survey based on our standard set of covariates (Table 1), and then weigh all regressions by the inverse of this likelihood (Kalton and Flores-Cervantes, 2003).

retically, bias could go in either direction, and we remain agnostic about it. For example, it is possible that respondents who are very excited about the Olympics (and carry a larger treatment effect) are less likely to participate in the survey because they were watching the event in the stadium. However, it could also be the case that they were actually *more likely* to participate. This could be the case because they took vacation and were more likely to be at home or online while watching the event. Panel A of Table 4, Columns (3) and (4), shows the result: identified effects are again similar in terms of size and significance to those in our baseline models.

Note that, when applying propensity-score matching and inverse-probability weighting to estimate legacy effects, we arrive at the same conclusion as in our baseline specification in Table 2, Columns (7) and (8): there is not much evidence for legacy effects. The results of these robustness checks are presented in Table B5 (Appendix B).

5.2 Choice of counterfactual

Paris bid to host the 2012 Olympics and was the favorite to win the bid, whereas Berlin never intended to host the event. So far, we have used both capitals as one joint control group. This subsection assesses the robustness of our findings to separating the Olympics effect and just using one of them as a single control group. To maximize statistical power, we re-estimate Model 2 in Equation 2. Specifically, we (a) include $Paris \times 2012$ as an additional control to $London \times 2012$; (b) exclude Paris and use only Berlin as control city; and (c) exclude Berlin and use only Paris as control city. The results are shown in Panels B and C of Table 4.

As seen in Columns (1) and (2) of Panel B, the $Paris \times 2012$ effect is negative and statistically significant, while the effect size for $London \times 2012$ decreases to 0.05 of a standard deviation but remains significant. Similarly, in Columns (1) and (2) of Panel C, when excluding Paris from the sample, the effect size nearly halves. Conversely, the Olympics effect in London remains stable and highly significant when Berlin is the only control city. This is evidence in support of a "disappointment effect" in Paris, who lost as the favorite and could not host the event. However, the positive and highly significant effect of hosting in London still exists, even when considering this disappointment effect. In addition, one could argue that the treatment effect should include a potential disappointment effect of the marginally losing city, because the effect of interest is precisely the subjective well-being impact of the successful host city (relative to the marginally losing competitor).

5.3 Extended economic and meteorological controls

Recall that our regressions routinely control for the quarterly real GDP change since the first quarter of 2008. To further control for potentially divergent economic developments between the three cities, we add—in addition to the controls in Model 2—data on the number of unemployed in each city and month as well as the daily stock market index closing values. For the UK, we took the FTSE100, for France the CAC40, and for Germany the DAX30.[21]

Moreover, given that we have daily data, we also control for weather-related factors, which could exert an instantaneous effect on subjective well-being and thus explain differences in responses between cities (Feddersen et al., 2016). We obtained data on daily precipitation (in inches) and daily maximum temperature (in Fahrenheit) from the National Center for Environmental Information of the National Oceanic and Atmospheric Administration.[22] We gather measurements from different weather stations in and around the three cities and average them to obtain a daily representative measure for each city.

Panel B in Table 4, Columns (3) and (4), shows the results when including these additional economic and meteorological controls in Model 2. The results remain robust: the coefficients for life satisfaction have the expected sign and show similar size and significance when compared to Columns (3) and (4) in Table 2.

5.4 Placebo tests

Next, we conduct a series of placebo tests. In Column (4) of Panel A in Table 3, we test the impact on a placebo outcome—*thoughts about finances*—which is equal to one if the respondent had thought about her finances the day before the interview. This column uses the exact cut-off date specification of Model 3 in Equation 3 but runs a linear probability model on this binary outcome. Although not impossible, it is not very likely that the Olympics would systematically affect respondents' thoughts about finances. In line with this prior, we do not find significant impacts. Neither do we find significant impacts on two more specific responses about finances, elicited on 11-point Likert scales (results available upon request): these items elicit feelings of happiness and anxiousness which respondents report to feel when thinking about their finances. Overall, these results from our placebo tests are reassuring that we do not pick up any confounding effects. We also interpret them as *prima facie* evidence that our identified effect of hosting the Olympics is unlikely to be driven by divergent economic developments between the three cities.

[21] See Yahoo Finance: http://finance.yahoo.com.

[22] See National Center for Environmental Information of the National Oceanic and Atmospheric Administration: www.ncdc.noaa.gov.

Panel B of Table 3 uses 2011 as placebo time period for the same outcomes as in Panel A. Again, we use Model 3 but apply the exact cut-off dates of the Olympics in 2012 to define treatment periods in 2011. As can be seen, all models in Panel B suggest that there was no "Olympics effect" in the summer of 2011.

5.5 Economic outcomes

As mentioned in Section 3.1, our regressions exclude potentially endogenous controls, such as employment status. To test more formally for the potential endogeneity of economically relevant regressors, we estimate the impact of the Olympics on these regressors as outcomes. The results of this exercise are shown in Table B6 (Appendix B). As can be seen, there is not much evidence that the Olympics had a significant effect on any of these outcomes, with one exception: the likelihood of being part-time employed in the saturated specification including all controls. The effect size, however, is small: the Olympics increased the likelihood to be part-time employed by about 0.7 percentage points.

6 Was it worth it?

The London Organising Committee of the Olympic Games (LOCOG) generated approximately £2 billion ($3.3 billion) in revenues, including ticket sales and its share of broadcasting rights and sponsorship sales, which was equal to its operating costs excluding security (LOCOG, 2013). All other costs, including security, construction costs, and subsidies to sports organizations amounted to approximately £9.3 billion (see footnote 3 for details).

There may be tangible benefits from hosting the Olympics, such as boosting GDP and the tourism industry, more participation in sports, increased volunteering, and an improved physical environment of East London (DCMS, 2012). There is considerable debate about the degree to which mega events crowd out other economic activity, but our survey of subjective well-being obviously cannot capture all of these potential benefits nor speak to the issue of crowding out. Nonetheless, the enhancement of subjective well-being is both a legitimate outcome in its own right and may have indirectly triggered actions causally linked to the other claimed effects. We next compare the increase in subjective well-being associated with hosting the Olympics to the financial costs of staging them, to better understand whether the intangible benefits of hosting were worth the costs.

To do so, we will use three different approaches. The first will calculate income compensations from the life satisfaction coefficients to estimate the monetary equivalent benefits from the Olympics. The second will calculate break-even multipliers to understand the impact of different effect size assumptions across the UK. The third will conduct a cost-effectiveness analysis.

6.1 Income compensations

We start by using our life satisfaction estimates from Model 3, which employs the exact cut-off dates of the Olympics, as defined by the opening and closing ceremonies (16 days or 4% of a year). We take an established coefficient for income from the literature (Stevenson and Wolfers, 2010): log annual gross household income is estimated to raise life satisfaction by about 35% of a standard deviation, translating into an increase of about 0.68 points on the life satisfaction scale (standard deviation of about 1.96). Hosting raises life satisfaction of residents in the host city by about 11% of a standard deviation, translating into an increase of about 0.21 points on the life satisfaction scale. The mean annual gross household income in London in 2012 was about £51,770 ($84,173) (Greater London Authority, 2012), equivalent to £2071 ($3367) over the period of the Olympics.[23] A one percent change in income (about £21), therefore, raises life satisfaction by about 0.0068 points. This implies that a household would be willing to pay about £$(21\times 0.21)/(0.0068) \approx$ £650 ($1060) in order to host the Olympics. There were around 2.4 individuals per household in London in 2012 (Census Information Scheme, 2012), which yields an implicit willingness-to-pay of about £270 ($440) per individual.[24] Aggregating over all individuals in London in 2012 (8.3 million), we obtain an aggregate willingness-to-pay for hosting the Olympics of about £2.2 billion ($3.6 billion)—well below the actual costs of hosting (but slightly above the originally anticipated costs of £2.1 billion or $3.4 billion).[25]

This estimate does not account for anticipation and adaptation effects, nor does it account for potential increases in subjective well-being across the UK as a whole. The Olympics were seen by many UK citizens as a national experience and some events were staged before or after the actual Olympics period as well as outside of London. Taking the life satisfaction estimate from Model 2, which covers the entire 73-day period of our surveys (20% of a year), we find that hosting raises life satisfaction of residents in the host city by about seven percent of a standard deviation, translating into an increase of about 0.14 points on the life satisfaction scale. Using the same approach, we find an implicit willingness-to-pay for

[23] The mean annual gross household income in our estimation sample is slightly smaller (£43,293 or $70,390). Using this smaller income yields qualitatively the same results.

[24] Our survey sampled adults. There is hence some uncertainty about how to deal with those under 18. It is plausible that impacts on teenagers could have been even greater as the Olympics focused heavily on youth involvement. Impacts on the 6% of the population aged 0-4 are less clear. On the one hand, their experience and understanding of the Olympics would have been very limited. On the other hand, if everyone around them was happier, there surely would have been significant spillover effects.

[25] London population data available at: www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland.

hosting the Olympics of about £2141 ($3481) per household or £892 ($1450) per individual. This yields an aggregate willingness-to-pay of about £7.4 billion ($12 billion)—still short of the actual costs of hosting. An assumption in these estimates is that the rest of France and Germany experienced the same changes in life satisfaction as Paris and Berlin (which is untestable with our data).

We thus arrive at a range between £2.2 and 7.4 billion ($3.6 and 12 billion) for the monetary equivalent of hosting the Olympics on the life satisfaction of Londoners, or between £1.5 and 9.5 billion ($2.4 and 15.4 billion) when exploiting the full range of the 95% confidence bands around our point estimates.[26] Monetary equivalent ranges for subjective well-being benefits to Londoners are hence well below the costs of hosting.

6.2 Break-even multipliers

We can calculate the break-even multiplier for the national subjective well-being effect required to make hosting the Olympics worthwhile. Our quasi-experimental design cannot causally estimate the impact on the entire UK population, so we will provide an estimation of how large the subjective well-being benefits for the rest of the UK need to be for the Olympics to be worthwhile from a well-being cost-benefit perspective.

Figure C6 (Appendix C) shows scenarios for various multipliers, measured as the percentage of the original impact of hosting on the subjective well-being of residents in London, to the rest of the UK, under both Models 3 and 2. The flat, horizontal line illustrates the actual costs of hosting. The case of restricting the unit of analysis to London, which has so far been the baseline scenario for our analysis, is shown in the first column on the left-hand side: for both Models 3 and 2, the costs of hosting clearly exceed the monetized subjective well-being benefits. Columns (2) to (6) then assume multipliers ranging between 1 and 0, where "1" means that the impact on the subjective well-being of UK citizens outside of London exactly equals the impact on Londoners, and "0" means that the impact is felt only by Londoners.

Based on Model 3, the break-even value of the multiplier is 0.47, while under Model 2 it is as low as 0.04.[27] How likely is it that the multiplier would have been large enough to justify the costs of hosting based on the increase in subjective well-being across the UK? Atkinson et al. (2008), in an *ex-ante* contingent valuation study in which respondents in the UK were asked directly about their willingness-to-pay in order to host the 2012 Olympic Games, find that respondents in London were willing to pay about £220 ($358), whereas

[26] Conducting a bounding exercise that exploits the 95% confidence bands around our point estimates yields a range between £1.5 and 2.9 billion ($2.4 and 4.7 billion) for Model 3 and £5.3 and 9.5 billion ($8.6 and 15.4 billion) for Model 2.

[27] The population in the rest of the UK (excluding London) is about 55,530,000.

those in Manchester were willing to pay about £120 ($195) and those in Glasgow about £110 ($179). This aggregated to a total willingness-to-pay across the entire UK of £2.4 billion ($3.9 billion). The estimated willingness-to-pay outside of London in their study was about half of that in London, and hence similar to the more conservative multiplier of 0.47 required for break-even in Model 3. Considering the plausible range of break-even multipliers for the national subjective well-being effect required to make hosting the Olympics worthwhile, a case can be made that hosting was actually worth the costs: if at least half of the impact of hosting on the subjective well-being of Londoners can be felt by UK residents outside of London, the monetized impact aggregated across the entire UK probably made the Olympics worthwhile to host.

An important assumption in our calculations is the correct estimation of the marginal utility of income when monetizing subjective well-being benefits. Unfortunately, there are not many "good" (in the sense of both internally and externally valid) causal estimates of income on life satisfaction in the literature. Related, life satisfaction regressions have been shown to yield relatively small income coefficients, leading to a relatively large willingness-to-pay. We work around this issue in three ways. First, we use an established income coefficient from the literature (Stevenson and Wolfers, 2010).[28] Second, we calculate the income coefficient estimate that would be required to make hosting the Olympics worthwhile. Using, for simplicity, Model 3 and a scaling multiplier of zero, this income coefficient equals 0.94[29]—slightly larger than ours (0.68) but not unrealistic.[30] Third, we conduct a cost-effectiveness analysis in Appendix D. Contrary to our cost-benefit analysis above, this analysis does not rely on the income coefficient but yields qualitatively the same result: for a plausible range of break-even multipliers (0.17 to 0.33), it is again likely that hosting was actually worth the costs.

According to our cost-benefit and sensitivity analyses, the monetized life satisfaction impact of hosting the Olympics was probably sufficient to cover the costs if it is assumed to have been felt to a reasonable extent by the entire population of the UK, but not if it is restricted to the population of London alone. This is separate from all of the other tangible benefits that might have accrued due to the Olympics.

[28] We assume a coefficient estimate for income of 0.68. Kahneman and Deaton (2010) report an estimate of 0.64 using Gallup Healthways data, Deaton (2008) of 0.84 using Gallup World Poll data. Pischke (2011) reports a coefficient estimate for income of 0.78 using the German Socio-Economic Panel Study.

[29] In this simple case, the required income coefficient can be calculated by equating the costs of hosting with the aggregate willingness-to-pay in London. That is, $9{,}300{,}000{,}000 = ((21\times0.21\times8{,}300{,}000)/Y)/2.4$. Solving for Y yields $Y=((21\times0.21\times8{,}300{,}000\times2.4)\ /\ 9{,}300{,}000{,}000) = 0.0094$. Considering that the estimate comes from a level-log specification yields a coefficient estimate of 0.94.

[30] For example, Deaton (2008) reports an income coefficient of 0.83 for average income, with 95% confidence bands being [0.74; 0.94], and a coefficient of up to 0.92, with bands being [0.70; 1.14], when basic controls are included.

7 Discussion

Around the world, cities spend billions of dollars to first bid for, and then host, the Olympics. To date, most evidence suggests that the tangible benefits of hosting are small. This paper quantifies the intangible benefits using subjective well-being data. To our knowledge, we are the first to provide evidence of a causal and positive subjective well-being impact of the Olympics on local residents.

We assess empirically whether the subjective well-being of host city residents increases during the event. To do so, we employ a novel and newly constructed panel that measures the different dimensions of subjective well-being, eliciting reports from more than 26,000 individuals in London, Paris, and Berlin during the summer months of 2011, 2012, and 2013. Methodologically, we exploit a quasi-natural experiment and a difference-in-differences approach to identify the causal effects of the 2012 Olympic Summer Games in London on people's subjective well-being in the host city.

Our findings show that the Olympics increased the life satisfaction and happiness of Londoners in the short-run; that is, during the Olympics period, and particularly around the times of the opening and closing ceremonies. Clearly, these are only average effects: it may well be that, for some population sub-groups, hosting the event did actually reduce subjective well-being, for example due to congestion. On average, however, our findings point towards positive impacts of hosting and we find little evidence for heterogeneous effects: the impact seems independent of age or gender but tends to be higher among higher-income households.

In terms of magnitude, the increase in life satisfaction—ranging between six and eleven percent of a standard deviation—is quite large compared to standard estimates in the subjective well-being literature. It appears even larger when considering its prevalence, that is, when considering that the event affects millions of residents in the host city. Our estimates offer an implicit individual willingness-to-pay for the immediate rise in subjective well-being of about £270 ($440) or a total of £2.2 billion ($3.6 billion) for London. When considering the plausible range of break-even multipliers for the *national* subjective well-being effect required to make hosting the Olympics worthwhile, a case can be made that hosting was actually worth the costs.

This study is unable to claim any strong evidence of legacy effects on the hosting city, one year after the event. Likewise, it cannot entirely reject the possibility of such persistent effects, possibly channelled through other intangible benefits such as national pride or social capital. Adopting a broader view, in our opinion, the Olympics should be regarded as a global public good, the cost of which are endorsed by the host city and country. Although we find clear evidence that the subjective well-being effects are larger in the host city, there is also evidence for positive spillover effects to other countries, which may speak for a joint funding mechanism. Appropriately accounting for these spillover effects in cost-benefit analyses is, however, a considerable challenge.

Notwithstanding these challenges, this paper provides evidence that the 2012 Olympic Summer Games in London generated significant but likely short-term benefits to residents of the host city. This "happiness dividend" appears to be a function of hosting *per se* and not a function of sporting success measured by (gold) medals won. More generally, we have shown how subjective well-being data can be feasibly gathered and robustly analyzed to evaluate mega events.

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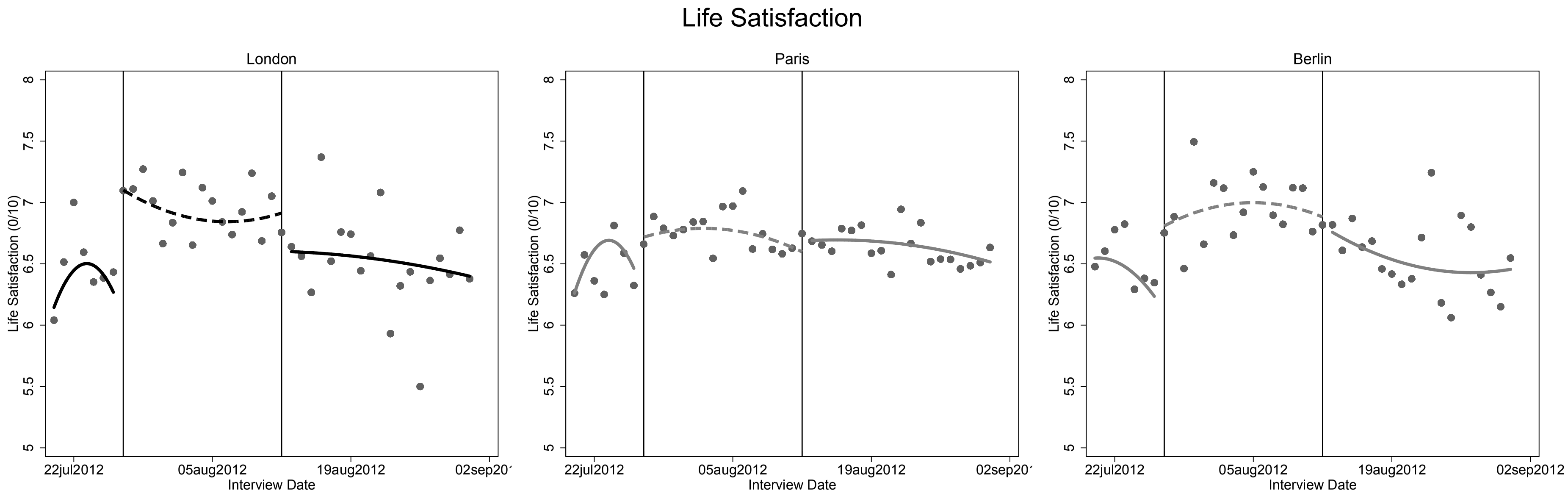
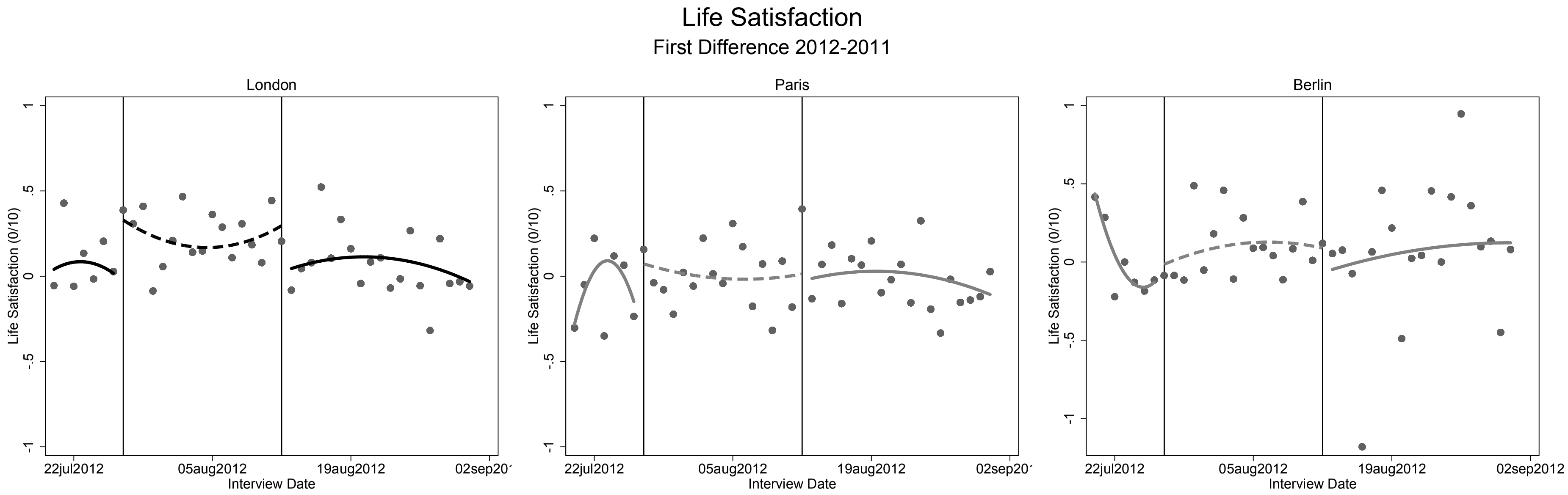
Figures and tables

Figure 1: Subjective well-being in London, Paris, and Berlin in 2012



Source: Own data collection, own illustration. Scatter dots show raw responses for life satisfaction (on a 0-10 Likert scale) in 2012, averaged by date of interview, separately for London, Paris, and Berlin (without further manipulation). The vertical lines illustrate the beginning (July 27) and the end (August 12) of the Games. In addition, in each of the three time periods in each graph, we apply a kernel-weighted local polynomial smoothing, with an Epanechnikov kernel, a degree of polynomial smooth of two, and a rule-of-thumb bandwidth estimator.

Figure 2: Subjective well-being in London, Paris, and Berlin: Individual-level change from 2011 to 2012



Source: Own data collection, own illustration. Scatter dots show changes in individual-level life satisfaction (on a 0-10 Likert scale) between 2011 and 2012, displayed and averaged by the interview date in 2012, separately for London, Paris, and Berlin(without further manipulation). The vertical lines illustrate the beginning (July 27) and the end (August 12) of the Games. In addition, in each of the three time periods in each graph, we apply a kernel-weighted local polynomial smoothing, with an Epanechnikov kernel, a degree of polynomial smooth of two, and a rule-of-thumb optimized default bandwidth estimator.

Table 1: Descriptive statistics

	London			Paris			Berlin		
	2011	2012	2013	2011	2012	2013	2011	2012	2013
Life satisfaction	6.515	6.690	6.756	6.668	6.675	6.724	6.681	6.733	6.846
	(2.000)	(1.951)	(1.951)	(1.794)	(1.748)	(1.753)	(1.993)	(1.977)	(1.939)
Happiness	6.448	6.683	6.791	6.724	6.710	6.803	6.497	6.632	6.771
	(2.150)	(2.070)	(2.100)	(1.873)	(1.812)	(1.812)	(2.236)	(2.166)	(2.165)
Anxiety	4.252	4.296	4.064	4.324	4.436	4.464	4.197	4.328	4.402
	(2.722)	(2.667)	(2.686)	(2.564)	(2.512)	(2.531)	(2.685)	(2.583)	(2.582)
Worthwhileness	6.865	6.716	6.822	6.699	6.594	6.611	7.226	7.181	7.273
	(2.048)	(2.087)	(2.081)	(1.752)	(1.704)	(1.754)	(1.930)	(1.892)	(1.861)
Age	28.925	32.515	35.124	28.140	30.390	32.240	26.532	29.482	31.876
	(14.929)	(14.379)	(14.259)	(15.200)	(14.981)	(14.984)	(14.688)	(14.613)	(14.452)
Male	0.407	0.413	0.431	0.472	0.476	0.465	0.429	0.436	0.450
	(0.491)	(0.493)	(0.495)	(0.499)	(0.499)	(0.499)	(0.495)	(0.496)	(0.498)
Log HH income	10.386	10.434	10.446	10.310	10.396	10.398	10.006	10.076	10.163
	(0.786)	(0.755)	(0.748)	(0.694)	(0.661)	(0.643)	(0.830)	(0.832)	(0.812)
Married	0.418	0.451	0.483	0.356	0.371	0.375	0.332	0.367	0.396
	(0.493)	(0.498)	(0.500)	(0.479)	(0.483)	(0.484)	(0.471)	(0.482)	(0.489)
With partner	0.146	0.135	0.115	0.213	0.202	0.190	0.167	0.169	0.159
	(0.353)	(0.342)	(0.319)	(0.409)	(0.402)	(0.392)	(0.373)	(0.374)	(0.365)
Separated	0.023	0.020	0.014	0.022	0.019	0.020	0.029	0.024	0.023
	(0.150)	(0.141)	(0.119)	(0.146)	(0.135)	(0.139)	(0.167)	(0.152)	(0.149)
Divorced	0.071	0.082	0.084	0.083	0.089	0.098	0.100	0.112	0.115
	(0.256)	(0.274)	(0.277)	(0.276)	(0.285)	(0.297)	(0.299)	(0.316)	(0.320)
Widowed	0.029	0.035	0.039	0.026	0.030	0.034	0.022	0.027	0.031
	(0.168)	(0.185)	(0.192)	(0.160)	(0.170)	(0.182)	(0.146)	(0.162)	(0.174)
In school	0.053	0.021	0.012	0.084	0.060	0.042	0.126	0.089	0.069
	(0.224)	(0.142)	(0.107)	(0.278)	(0.237)	(0.201)	(0.332)	(0.285)	(0.253)
Prof. degree	0.148	0.141	0.174	0.153	0.033	0.185	0.052	0.319	0.316
	(0.355)	(0.348)	(0.379)	(0.36)	(0.177)	(0.388)	(0.223)	(0.466)	(0.465)
Univ. degree	0.429	0.442	0.416	0.102	0.522	0.000	0.436	0.400	0.429
	(0.495)	(0.497)	(0.493)	(0.303)	(0.500)	(0.000)	(0.496)	(0.490)	(0.495)
Other higher	0.200	0.181	0.178	0.515	0.242	0.631	0.234	0.212	0.188
education degree	(0.400)	(0.385)	(0.383)	(0.500)	(0.428)	(0.483)	(0.423)	(0.409)	(0.391)
Retired	0.134	0.170	0.205	0.172	0.200	0.244	0.123	0.161	0.187
	(0.341)	(0.376)	(0.404)	(0.377)	(0.400)	(0.429)	(0.328)	(0.367)	(0.390)
Lives: Flat share	0.346	0.301	0.261	0.422	0.389	0.375	0.719	0.702	0.680
	(0.476)	(0.459)	(0.439)	(0.494)	(0.488)	(0.484)	(0.449)	(0.458)	(0.467)
Lives: Relatives	0.077	0.048	0.039	0.058	0.053	0.041	0.034	0.027	0.022
	(0.266)	(0.214)	(0.194)	(0.233)	(0.225)	(0.198)	(0.180)	(0.161)	(0.147)
Lives: Other	0.013	0.012	0.014	0.025	0.002	0.013	0.038	0.034	0.043
	(0.115)	(0.108)	(0.119)	(0.157)	(0.045)	(0.115)	(0.191)	(0.181)	(0.203)
Phone	0.207	0.220	0.275	0.207	0.177	0.213	0.286	0.252	0.265
	(0.405)	(0.414)	(0.447)	(0.405)	(0.382)	(0.409)	(0.452)	(0.434)	(0.442)
N	9,402	4,663	2,857	9,629	5,945	3,672	6,927	3,892	2,541

Notes: Own data collection, own illustration. Means (proportions in case of binary variables). Standard deviations in parentheses.

Table 2: The impact of the Olympics on subjective well-being

	Model 1, Equation 1, 2012		Model 2, Equation 2, 2011-2012		Model 3, Equation 3, 2011-2012		Model 4, Legacy, 2011-2013	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
London×Olympics	0.121***	0.107**			0.110***	0.108***		
	(0.046)	(0.048)			(0.017)	(0.017)		
London×PostOlympics	0.034	0.070			0.044***	0.047***		
	(0.045)	(0.045)			(0.014)	(0.014)		
Olympics	0.175***	0.150***			0.002	0.017		
	(0.040)	(0.036)			(0.014)	(0.017)		
PostOlympics	0.072	0.020			-0.014	-0.001		
	(0.050)	(0.047)			(0.009)	(0.013)		
London	-0.031	0.075						
	(0.061)	(0.063)						
London×2012			0.072***	0.072***			0.070***	0.069***
			(0.010)	(0.011)			(0.011)	(0.011)
2012			-0.010	0.006			-0.012	-0.009
			(0.008)	(0.013)			(0.008)	(0.010)
London×2013							-0.023	-0.014
							(0.020)	(0.022)
2013							-0.005	-0.002
							(0.014)	(0.015)
N	14,500	14,500	40,458	40,458	40,458	40,458	49,528	49,528
F	8.6	64.4	14.1	9.2	16.0	11.8	12.2	10.3
Unique individuals	14,500	14,500	26,030	26,030	26,030	26,030	26,036	26,030
Day-of-week FE	yes	yes	yes	yes	yes	yes	yes	yes
Calendar-month FE	yes	yes	yes	yes	yes	yes	yes	yes
Individual FE	no	no	yes	yes	yes	yes	yes	yes
Individual-level controls	no	yes	no	yes	no	yes	no	yes

Notes: Own data collection, own illustration. All models follow Models 1 to 4 in Equations 1, 2, or 3, respectively (see Section 3.1 for details). Regressions with individual-level controls include: age, age^2, gender, marital status, education level, home ownership, change in quarterly real GDP since first quarter of 2008, and a time-invariant dummy for survey mode; all time-invariant controls drop out in the models with individual fixed effects. Model 3 also includes London×PreOlympics and PreOlympics (not shown). Robust standard errors are clustered at the date level and in parentheses. *** $p < 0.01$, ** $p < 0.05$

Table 3: Placebo and confirmation tests

	Life satisfaction	Happiness	Anxiety	Worthwhileness	Thoughts about finances
Panel A: Alternative outcomes					
	(1)	(2)	(3)	(4)	(5)
London×Olympics	0.108***	0.111***	0.028	-0.018	0.028
	(0.017)	(0.022)	(0.028)	(0.021)	(0.028)
London×PostOlympics	0.047***	0.052***	0.041**	-0.079***	-0.010
	(0.014)	(0.018)	(0.020)	(0.021)	(0.022)
Olympics	0.017	0.005	-0.034	-0.028	-0.060
	(0.017)	(0.019)	(0.018)	(0.017)	(0.035)
PostOlympics	-0.001	-0.023	0.054***	-0.035**	-0.019
	(0.013)	(0.018)	(0.017)	(0.014)	(0.033)
N	40,458	40,458	40,458	40,458	37,400
F	11.81	14.4	6.7	7.6	7.6
Unique individuals	26,030	26,030	26,030	26,030	25,988
Controls	yes	yes	yes	yes	yes
Panel B: Placebo tests 2011					
	Life satisfaction	Happiness	Anxiety	Worthwhileness	Thoughts about finances
	(1)	(2)	(3)	(4)	(5)
London×PlaceboOlympics	-0.038	-0.166	0.178	-0.121	0.087
	(0.142)	(0.114)	(0.119)	(0.131)	(0.107)
London×PlaceboPostOlympics	0.054	0.098	-0.085	-0.030	0.114
	(0.092)	(0.079)	(0.101)	(0.072)	(0.081)
PlaceboOlympics	0.216***	0.191***	-0.165***	0.198***	0.062
	(0.035)	(0.039)	(0.036)	(0.033)	(0.056)
N	25,958	25,958	25,958	25,958	25,958
F	45.8	54.3	59.7	93.7	16.1
Unique individuals	25,958	25,958	25,958	25,958	25,958
Controls	yes	yes	yes	yes	yes

Notes: Panel A follows Model 3 in Equation 3 with individual fixed effects and exact Olympics cut-off dates. Panel A, Column (1) is our baseline specification using life satisfaction as dependent variable. Columns (2) and (3) use responses to the following question on a 0-10 Likert scale as dependent variables: "Overall, how happy/anxious did you feel yesterday?". Column (4) uses responses to the following question on a 0-10 Likert scale as dependent variable: "Overall, how worthwhile are the things that you do in your life?" Column (5) estimates a linear probability model using a binary indicator equal to one if the respondent has thought about her finances the day before the interview, and zero otherwise, as dependent variable. Models in Panel A also include the remaining controls (London, London×PreOlympics) in Equation 3 (not shown). Panel B only uses the non-contaminated pre-treatment year 2011 and estimates Equation 1 as placebo test pretending that the Olympics took place in 2011 instead of 2012. All regressions include all controls reported in Table 1, that is, day-of-week fixed effects, calendar-month fixed effects, and individual fixed effects for Model 3. Robust standard errors are clustered at the interview date and in parentheses. *** $p < 0.01$, ** $p < 0.05$

Table 4: Robustness checks: selective attrition, control group and counterfactual, and extended controls (Panel, Individual FE: 2011, 2012)

	Panel A: Selective attrition			
	Propensity-score matching		Inverse-probability weighting	
	(1)	(2)	(3)	(4)
London×2012	0.062***	0.059***	0.075***	0.074***
	(0.014)	(0.014)	(0.011)	(0.012)
2012	0.004	0.002	-0.009	0.011
	(0.012)	(0.014)	(0.009)	(0.013)
N	29,226	29,226	40,458	40,458
F	13.4	9.3	12.9	9.6
Unique individuals	20,860	20,860	26,030	26,030
Individual-level controls	no	yes	no	yes

	Panel B: Varying control group and extended controls			
	London and Paris		Extended controls	
	(1)	(2)	(3)	(4)
London×2012	0.041***	0.044***	0.066**	0.066**
	(0.014)	(0.015)	(0.029)	(0.029)
Paris×2012	-0.040***	-0.036**	0.046	0.031
	(0.014)	(0.016)	(0.156)	(0.156)
2012	0.032***	0.043***	-0.098	-0.074
	(0.012)	(0.015)	(0.110)	(0.112)
N	40,458	40,458	40,458	40,458
F	14.1	9.2	12.4	10.2
Unique individuals	26,030	26,030	26,030	26,030
Individual-level controls	no	yes	no	yes

	Panel C: Choice of counterfactual			
	London vs. Berlin		London vs. Paris	
	(1)	(2)	(3)	(4)
London×2012	0.040***	0.040***	0.084***	0.089***
	(0.014)	(0.015)	(0.011)	(0.012)
2012	0.036***	0.055***	-0.012	-0.011
	(0.012)	(0.016)	(0.008)	(0.012)
N	24,884	24,884	29,639	29,639
F	14.5	8.7	12.0	8.8
Unique individuals	16,379	16,379	19,079	19,079
Individual-level controls	no	yes	no	yes

Notes: All models follow Model 2 in Equation 2, with and without individual-level controls, respectively. Panel A, Columns (1) and (2) use nearest-neighbor matching on observables and match respondents in the three cities one-to-one based on their propensity to participate in wave two of the panel (i.e. 2012); Columns (3) and (4) weigh responses with the inverse probability of participating in wave two of the panel. Panel B, Columns (3) and (4) additionally control for the daily stock market index closing value in each country, the number of unemployed, the daily amount of rain, and the daily maximum temperature in each city. Panel C, Columns (1) and (2) compare London solely to Berlin and Columns (3) and (4) compare London solely to Paris. All regressions include all controls in Equation 2 as reported in Table 1, that is, day-of-week fixed effects, calendar-month fixed effects, and individual fixed effects. Robust standard errors clustered at the interview date level reported in parentheses. *** $p < 0.01$, ** $p < 0.05$

Appendix A

Table A1: Potentially Confounding Events in 2012

Date	Potentially Confounding Event
UK, 2012, July to September	
Jul 6	Andy Murray first Briton in 74 years to qualify to the 2012 Wimbledon Championships Men's singles final. He got defeated two days later by Roger Federer.
Jul 7	Britain's Jonathan Marray and Denmark's Frederik Nielsen win Wimbledon's men's doubles final. Marray becomes the first Briton to win such a match since 1936.
Jul 22	Bradley Wiggins wins the 2012 Tour de France bicycle race, the first British rider ever to do so.
Aug 12	Golfer Rory McIlroy wins the 2012 US PGA Championship at Kiawah Island.
Sep 10	Andy Murray wins the US Open Tennis Championship, the first British man to win a Grand Slam tournament since 1936.
France, 2012, July to September	
Jul 16	The commission on renewal and ethics in public life is formed by François Hollande.
Aug	France posts zero growth in the 2^{nd} quarter of 2012, as in the previous two.
Germany, 2012, July to September	
Jul 3	Success for German players in the Wimbledon tennis singles: in the Men's section, Florian Mayer and Philipp Kohlschreiber reach the quarter finals; in the Women's section, Sabine Lisicki reaches the quarter finals, and Angelique Kerber reaches the semi finals.
Aug 9–12	Hanse Sail in Rostock
Sep 15–19	gamescom in Cologne
Sep 18–23	photokina in Cologne
Sep 20–27	Frankfurt Motor Show in Frankfurt
Sep 22–Oct 7	Oktoberfest in Munich
Sources:	BBC 2017, Various sources.

Table A2: Model 3 with Full Set of Controls

London×PreOlympics	0.0490	0.050
	(0.033)	(0.035)
London×Olympics	0.110***	0.108***
	(0.017)	(0.017)
London×PostOlympics	0.044***	0.047***
	(0.014)	(0.014)
PreOlympics	-0.011	-0.001
	(0.028)	(0.032)
Olympics	0.002	0.017
	(0.014)	(0.017)
PostOlympics	-0.014	-0.001
	(0.009)	(0.013)
Age		-0.025
		(0.014)
Age^2		0.001
		(0.001)
Married		0.127***
		(0.039)
Partnered		0.072***
		(0.026)
Separated		0.124***
		(0.042)
Divorced		0.156***
		(0.050)
Widowed		-0.034
		(0.086)
Studying		0.0412
		(0.032)
Professional Qualification		0.0220
		(0.019)
Higher Vocational Degree		0.009
		(0.019)
University Degree		0.0167
		(0.021)
Renting		-0.006
		(0.025)
Living with Relatives		-0.089**
		(0.039)
Other Living Arrangement		0.004
		(0.038)
N	40,458	40,458
F	16.0	11.8
Unique individuals	26,030	26,030
Controls	no	yes

Notes: All models are equivalent to Model 3 in Equation 3. All regressions also control for individual and day-of-week fixed effects. Robust standard errors clustered at the interview date level reported in parentheses. *** $p < 0.01$, ** $p < 0.05$

Table A3: Heterogeneity—Demographic Characteristics

	Life Satisfaction	Happiness	Anxiety	Worthwhile
	Panel A: Gender			
London×2012×Men	0.026	0.020	-0.001	-0.037
	(0.022)	(0.025)	(0.031)	(0.023)
London×2012	0.060***	0.072***	0.025	-0.025
	(0.014)	(0.020)	(0.025)	(0.019)
N	40,458	40,458	40,458	40,458
F	8.7	14.2	4.8	8.1
Unique individuals	26,030	26,030	26,030	26,030
Controls	Yes	Yes	Yes	Yes
	Panel B: Age			
London×2012×Age	-0.001	-0.000	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
London×2012	0.095***	0.096**	0.080**	-0.064
	(0.028)	(0.042)	(0.038)	(0.032)
N	40,458	40,458	40,458	40,458
F	9.1	12.4	5.5	8.0
Unique individuals	26,030	26,030	26,030	26,030
Controls	Yes	Yes	Yes	Yes
	Panel C: Income			
London×2012×Income	0.019	-0.002	0.031	0.013
	(0.013)	(0.018)	(0.018)	(0.017)
London×2012	-0.133	0.100	-0.295	-0.178
	(0.141)	(0.193)	(0.193)	(0.179)
N	40,458	40,458	40,458	40,458
F	11.1	13.8	5.0	7.9
Unique individuals	26,030	26,030	26,030	26,030
Controls	Yes	Yes	Yes	Yes

Notes: All models follow Model 2 in Equation 2; they estimate effect heterogeneity with respect to gender, age and income adding triple interaction terms as shown; two-way interactions are also included but partly suppressed. Controls include: gender, age, age^2, employment status, education level, marital status, log income, home ownership, change in quarterly GDP since 2008Q1, individual, day-of-the-week and calendar-month fixed effects. Robust standard errors clustered at the date level and are in parentheses.
*** $p < 0.01$, ** $p < 0.05$

Table A4: The Impact of Medals on Subjective Well-Being

	Life Satisfaction			
	(1)	(2)	(3)	(4)
London×2012×Medals	-0.005	-0.006		
	(0.003)	(0.003)		
London×2012×Gold			-0.009	-0.010
			(0.010)	(0.010)
Medals	0.002	0.002		
	(0.003)	(0.003)		
Gold Medals			0.007	0.007
			(0.009)	(0.009)
London×2012	0.086***	0.086***	0.077***	0.078***
	(0.013)	(0.013)	(0.012)	(0.012)
2012	-0.012	0.003	-0.012	0.003
	(0.010)	(0.014)	(0.009)	(0.013)
N	40,458	40,458	40,458	40,458
F	12.7	10.0	12.5	8.7
Unique individuals	26,030	26,030	26,030	26,030
Individual-level controls	no	yes	no	yes

Notes: All models follow Model 2 in Equation 2 with individual fixed effects. They estimate effect heterogeneity with respect to medals won by the respondents' national team on the day before the interview as triple interaction terms; two-way interactions are also included but suppressed. Panel A considers lagged daily overall medals won, Panel B considers lagged daily gold medals won only. Columns (1) and (2) use life satisfaction as dependent variable and Columns (3) and (4) happiness. Controls include: gender, age, age^2, employment status, education level, marital status, log income, home ownership, change in quarterly GDP since 2008Q1, individual, day-of-the-week and calendar-month fixed effects. Robust standard errors clustered at the interview date level reported in parentheses.*** $p < 0.01$, ** $p < 0.05$

Appendix B: Robustness Checks

Table B1: Number of Individuals Interviewed

	Wave 1	Wave 2	Wave 3
	Sample Attrition: Entire Sample		
Only Wave 1	11,165		
Only Waves 1 & 2	5,695	5,695	
Only Waves 1 & 3	139		139
All Waves	9,143	9,143	9,143
Total	26,142	14,838	9,282
% of Initial	100	56.76	35.51
	Sample Attrition: London		
Only Wave 1	4,679		
Only Waves 1 & 2	1,879	1,879	
Only Waves 1 & 3	42		42
All Waves	2,883	2,883	2,883
Total	9,483	4,762	2,925
% of Initial	100	50.22	30.84
	Sample Attrition: Paris		
Only Wave 1	3,541		
Only Waves 1 & 2	2,402	2,402	
Only Waves 1 & 3	62		62
All Waves	3,656	3,656	3,656
Total	9,661	6,058	3,718
% of Initial	100	62.71	38.48
	Sample Attrition: Berlin		
Only Wave 1	2,945		
Only Waves 1 & 2	1,414	1,414	
Only Waves 1 & 3	35		35
All Waves	2,604	2,604	2,604
Total	6,998	4,018	2,639
% of Initial	100	57.42	37.71

Notes: In Wave 1 (2011), interviews were conducted from August 8 to September 30. In Wave 2 (2012), interviews were conducted from July 20 to October 2. In Wave 3 (2013), interviews were conducted from July 23 to September 12.

Table B2: Testing for Differences in Attrition

	Life Satisfaction	Happiness	Anxiety	Worthwhile
Present (in all 3 Waves)	0.031	0.060**	-0.062**	0.030
	(0.026)	(0.027)	(0.025)	(0.025)
London	-0.106***	-0.027	0.031	-0.195***
	(0.021)	(0.021)	(0.020)	(0.020)
Paris	-0.013	0.123***	0.034	-0.263***
	(0.020)	(0.021)	(0.020)	(0.019)
Present×London	0.066	0.018	-0.047	0.032
	(0.035)	(0.036)	(0.034)	(0.034)
Present×Paris	0.012	-0.034	0.040	-0.033
	(0.032)	(0.033)	(0.033)	(0.031)
Constant	-0.007	-0.093***	-0.014	0.176***
	(0.016)	(0.017)	(0.015)	(0.015)
N	26,135	26,115	26,113	26,094
Controls	Yes	Yes	Yes	Yes

Notes: "Present" is equal to one if an individual is present in all waves, and zero otherwise. Controls include: gender, age, age^2, employment status, education level, marital status, log income, home ownership, change in quarterly GDP since 2008Q1, individual, day-of-the-week and calendar-month fixed effects. Robust standard errors clustered at the interview date level reported in parentheses.
*** $p < 0.01$, ** $p < 0.05$

Table B3: Robustness Check: Testing for Attrition – Out-of-Sample Selection

	Interviewed in 2012		Interviewed in 2012 During Olympics Period		Interviewed in 2012	
	(1)	(2)	(3)	(4)	(5)	(6)
London	0.024	0.038	-0.027	-0.041	0.028	0.042
	(0.028)	(0.026)	(0.028)	(0.026)	(0.028)	(0.027)
London × Life Satisfaction (2011)					0.007	0.005
					(0.005)	(0.004)
Life Satisfaction (2011)					-0.003	-0.004
					(0.003)	(0.003)
N	40,458	40,458	40,458	40,458	40,458	40,458
F	30.0	37.0	30.0	37.9	28.0	37.2
Unique individuals	26,030	26,030	26,030	26,030	26,030	26,030
Day-of-week FE	yes	yes	yes	yes	yes	yes
Calendar-month FE	yes	yes	yes	yes	yes	yes
Individual-level controls	no	yes	no	yes	no	yes

Notes: Own data collection, own illustration. Columns (1) and (3) replicate Table 2 Column (3), Columns (2) and (4) replicate Table 2 Column (4). Columns (5) and (6) are built on Table 2 Columns (3) and (4), and extend it by interacting the London dummy with pre-treatment values of life satisfaction, our primary outcome. Regressions with individual-level controls include: age, age^2, gender, marital status, education level, employment status, log annual gross household income, and home ownership. Both regressions include change in quarterly real GDP since first quarter of 2008. Robust standard errors are clustered at the date level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$

Table B4: Balancing Properties of Observables after Propensity-Score Matching

	Mean London	Mean Paris & Berlin Pooled	Normalised Difference
Age	31.65	30.492	0.056
Married	0.446	0.378	0.097
Partnered	0.140	0.185	0.087
Separated	0.019	0.021	0.010
Divorced	0.076	0.100	0.060
Widowed	0.033	0.031	0.008
Studying	0.026	0.070	0.146
Professional Qualification	0.149	0.142	0.014
Higher Vocational Degree	0.514	0.432	0.116
University Degree	0.142	0.255	0.202
Renting	0.308	0.524	0.318
Living with Relatives	0.053	0.039	0.047
Other Living Arrangement	0.010	0.014	0.026
N	10,438	18,624	–

Notes: The last column shows the normalized difference, calculated as $\Delta x = (\bar{x}_t - \bar{x}_c) \div \sqrt{\sigma_t^2 + \sigma_c^2}$, where $\bar{x}_t$ and $\bar{x}_c$ denote the sample mean of the covariate of the treatment and control group, respectively, and σ^2 denotes the variance. As a rule of thumb, a normalised difference greater than 0.25 indicates a non-balanced covariate, which might lead to sensitive results (Imbens and Wooldridge, 2009).

Table B5: Robustness Check: Selective Attrition in Legacy Effect (Model 4, 2011-2013)

	Life Satisfaction			
	Propensity-Score Matching		Inverse-Probability Weighting	
	(1)	(2)	(3)	(4)
London×2012	0.092***	0.082***	0.067***	0.065***
	(0.024)	(0.023)	(0.012)	(0.013)
London×2013	0.0541	0.055	-0.011	0.001
	(0.047)	(0.047)	(0.022)	(0.023)
2012	0.020	0.028	-0.005	-0.004
	(0.021)	(0.020)	(0.009)	(0.010)
2013	0.0360	0.044	0.004	0.005
	(0.027)	(0.026)	(0.015)	(0.016)
N	18,139	18,139	49,528	49,528
F	5.4	8.6	9.4	8.3
Unique individuals	13,138	13,138	26,036	26036
Controls	no	yes	no	yes

Notes: All models follow Model 4 as in Equation 2 but using years 2011-2013. Columns (1) and (2) use nearest-neighbor matching on observables and match respondents in the three cities one-to-one based on their propensity to participate in wave three of the panel (i.e. 2013); Columns (3) and (4) weigh responses with the inverse probability of participating in wave three of the panel.Controls include: gender, age, age^2, employment status, education level, marital status, log income, home ownership, change in quarterly GDP since 2008Q1, individual, day-of-the-week and calendar-month fixed effects. Robust standard errors clustered at the interview date level reported in parentheses. *** $p < 0.01$, ** $p < 0.05$

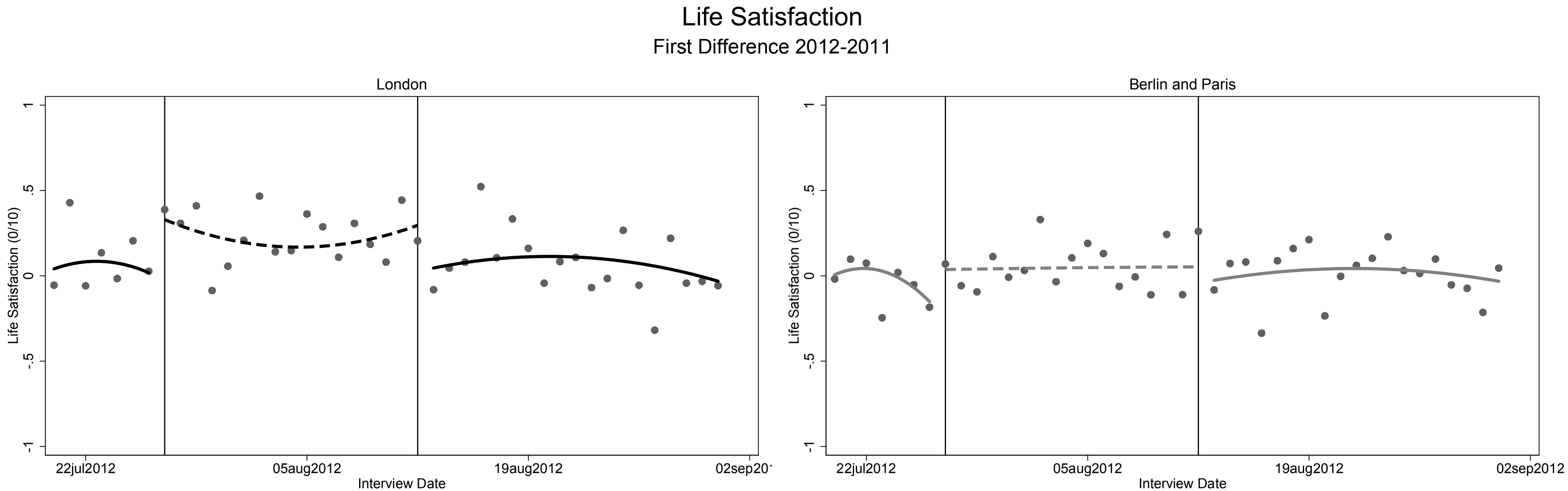
Table B6: Alternative Outcomes—Economic Indicators (Model 2, Equation 2)

	Full-Time Employed		Part-Time Employed		Self-Employed		Unemployed, Looking		Unemployed, Permanent		Ln(Income)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
London×2012	-0.004	-0.001	0.006	0.007**	-0.001	0.001	-0.006	-0.006	0.001	0.001	-0.006	0.007
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.006)	(0.006)
2012	0.008**	-0.007	-0.001	-0.002	-0.003	-0.005	-0.001	0.001	0.002	0.001	0.041***	0.015
	(0.003)	(0.004)	(0.002)	(0.005)	(0.002)	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)	(0.006)	(0.009)
N	40,458	40,458	40,458	40,458	40,458	40,458	40,458	40,458	40,458	40,458	40,458	40,458
F	3.8	34.0	2.6	11.0	4.9	6.3	3.8	12.9	3.4	6.0	11.1	23.5
Unique individuals	26,030	26,030	26,030	26,030	26,030	26,030	26,030	26,030	26,030	26,030	26,030	26,030
Controls	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes

Notes: All models follow Model 2 in Equation 2. Controls include: gender, age, age^2, employment status, education level, marital status, log income, home ownership, change in quarterly GDP since 2008Q1, individual, day-of-the-week and calendar-month fixed effects. Robust standard errors clustered at the interview date level reported in parentheses. *** $p < 0.01$, ** $p < 0.05$

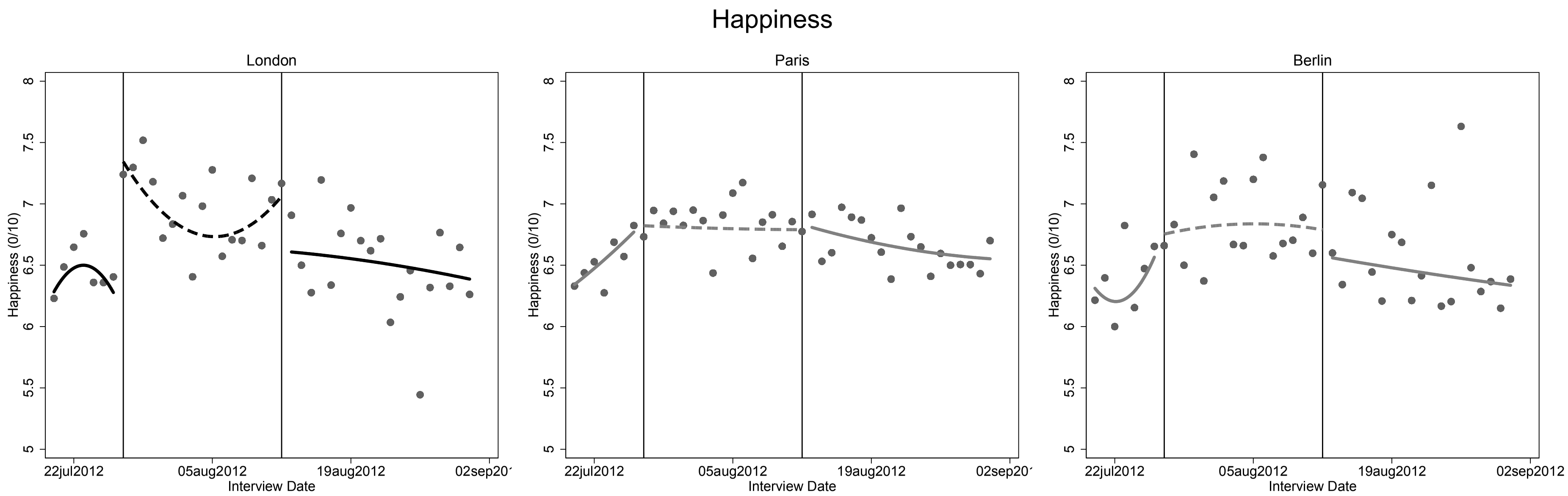
Appendix C: Additional Figures

Figure C1: Subjective Well-Being in London vs. Paris and Berlin jointly: Individual-Level Changes from 2011 to 2012



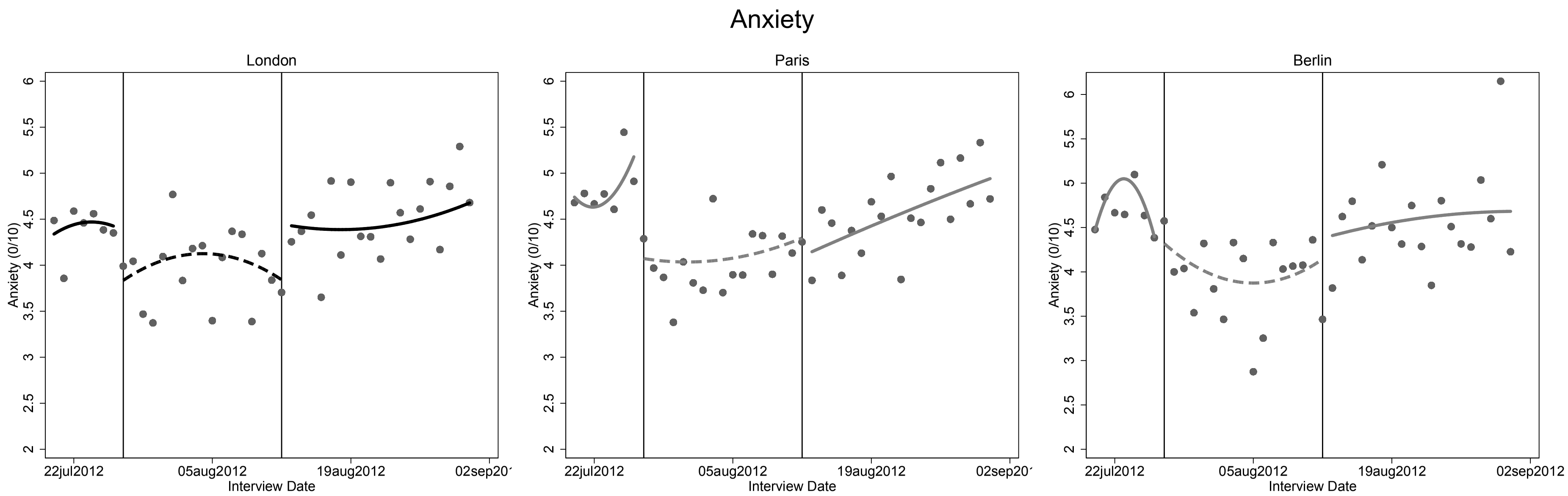
Source: Own data collection, own illustration. Scatter dots show changes in individual-level life satisfaction (on a 0-10 Likert scale) between 2011 and 2012, displayed and averaged by date of interview in 2012, separately for London as well as Paris and Berlin jointly (without further manipulation). The vertical lines illustrate the beginning (July 27) and the end (August 12) of the Games. In addition, in each of the three time periods in each graph, we apply a kernel-weighted local polynomial smoothing, with an Epanechnikov kernel, a degree of polynomial smooth of two, and a rule-of-thumb optimized default bandwidth estimator.

Figure C2: Happiness in London, Paris and Berlin in 2012



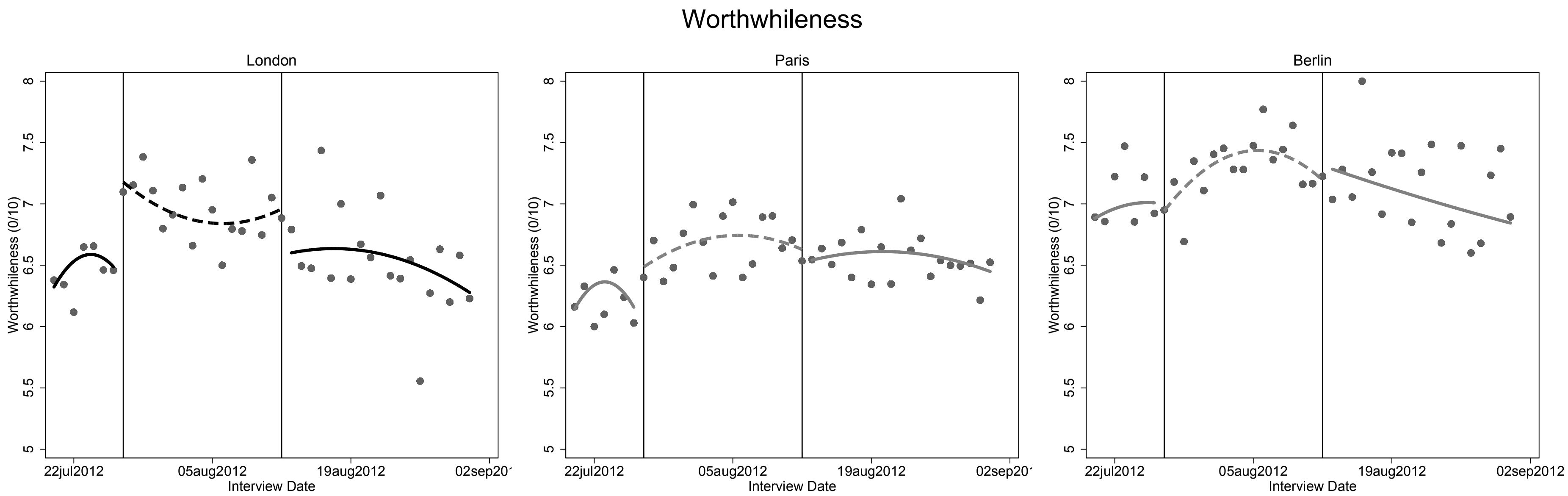
Source: Own data collection, own illustration. Scatter dots show raw responses for happiness (on a 0-10 Likert scale) in 2012, averaged by date of interview, separately for London, Paris and Berlin (without further manipulation). The vertical lines illustrate the beginning (July 27) and the end (August 12) of the Games. In addition, in each of the three time periods in each graph, we apply a kernel-weighted local polynomial smoothing, with an Epanechnikov kernel, a degree of polynomial smooth of two, and a rule-of-thumb optimized default bandwidth estimator.

Figure C3: Anxiety in London, Paris and Berlin in 2012



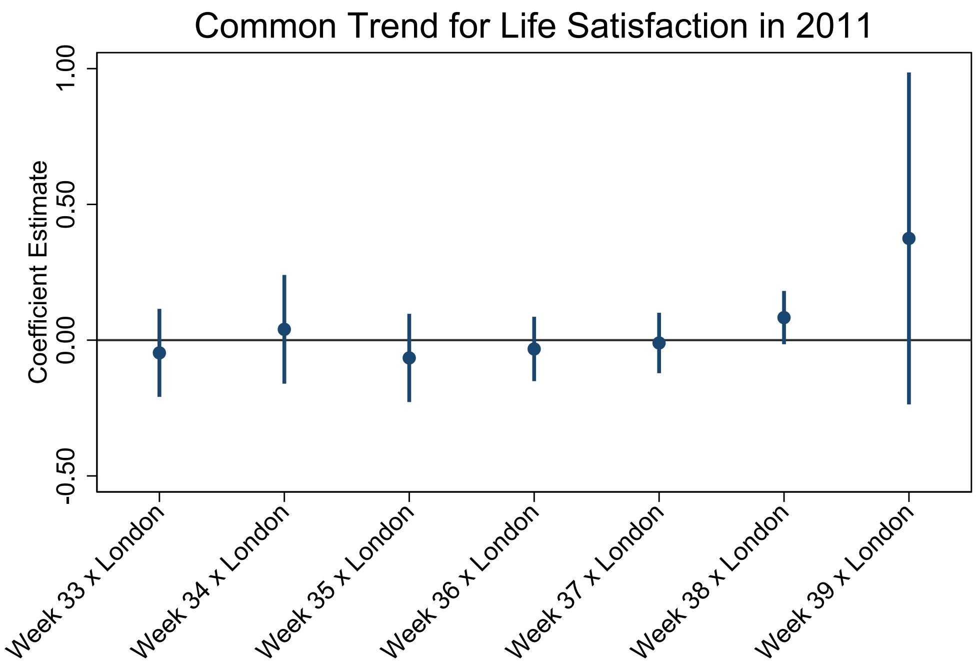
Source: Own data collection, own illustration. Scatter dots show raw responses for anxiety (on a 0-10 Likert scale) in 2012, averaged by date of interview, separately for London, Paris and Berlin (without further manipulation). The vertical lines illustrate the beginning (July 27) and the end (August 12) of the Games. In addition, in each of the three time periods in each graph, we apply a kernel-weighted local polynomial smoothing, with an Epanechnikov kernel, a degree of polynomial smooth of two, and a rule-of-thumb optimized default bandwidth estimator.

Figure C4: Worthwhileness in London, Paris and Berlin in 2012



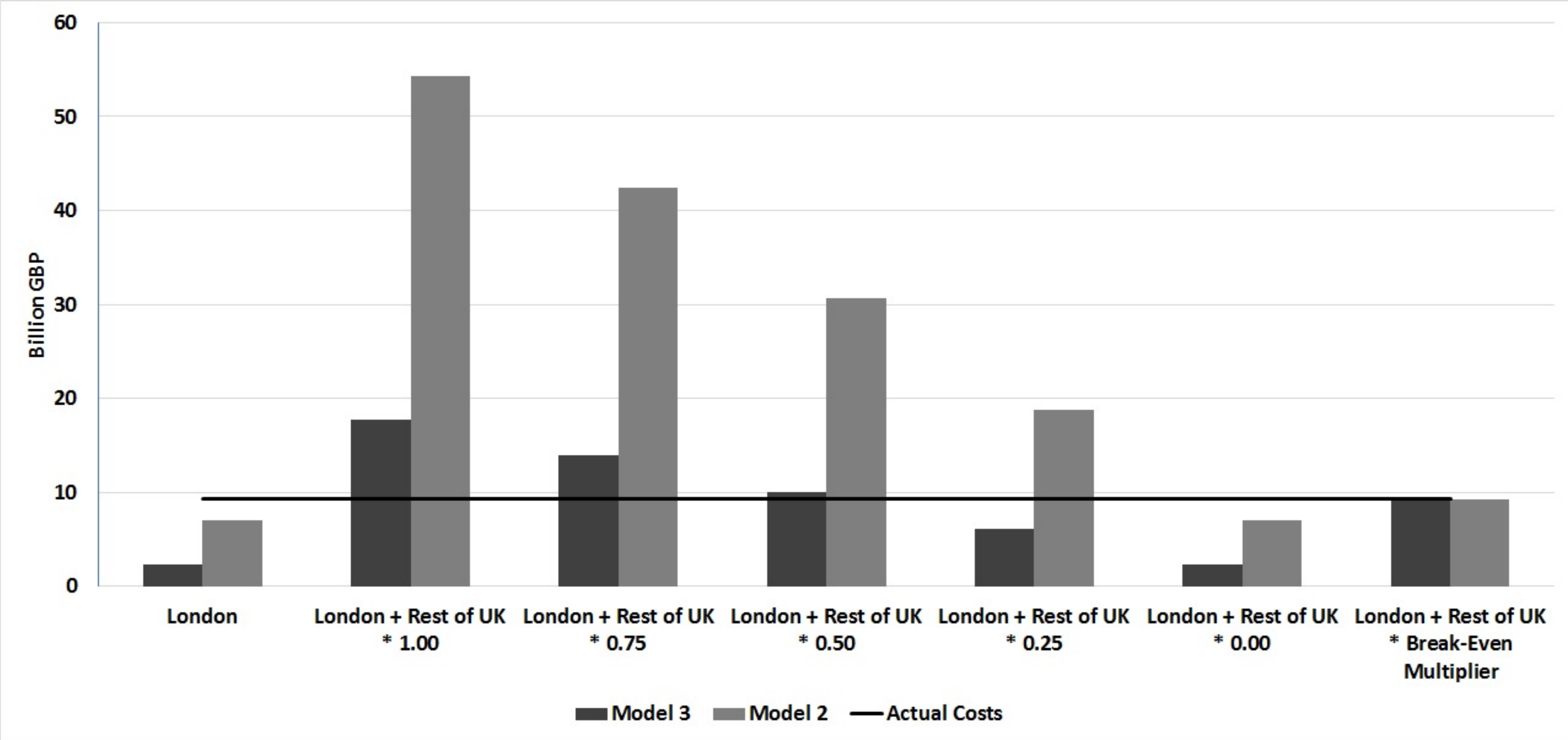
Source: Own data collection, own illustration. Scatter dots show raw responses for worthwhileness (on a 0-10 Likert scale) in 2012, averaged by date of interview, separately for London, Paris and Berlin (without further manipulation). The vertical lines illustrate the beginning (July 27) and the end (August 12) of the Games. In addition, in each of the three time periods in each graph, we apply a kernel-weighted local polynomial smoothing, with an Epanechnikov kernel, a degree of polynomial smooth of two, and a rule-of-thumb optimized default bandwidth estimator.

Figure C5: Testing the Common Trend Assumption



Source: Own data collection, own illustration. Figure plots coefficient estimates with corresponding 95% confidence bands from a regression that regresses life satisfaction in the pre-treatment period (i.e. the summer weeks of 2011 around which, in 2012, the Olympics were held) on week dummies, a London dummy, and an interaction between week dummies and the London dummy (plotted). The base category is calendar week 32 in Paris and Berlin (pooled together). Confidence bands including zero imply that there are no significant differences in life satisfaction on a weekly basis between London and Paris and Berlin (pooled together) in the pre-treatment period.

Figure C6: Scenarios with Impacts on Rest of UK



Notes: The figure illustrates, for our main models in our baseline specification, under which multipliers from the London population to the rest of the UK the monetized well-being impacts of hosting the Olympics would have been worth the costs of hosting.

Appendix D: Cost-Effectiveness Analysis

Unlike cost-benefit analysis, cost-effectiveness analysis does not convert the impacts on subjective well-being into a monetary value to compare them with the costs. Thus it does not rely on the correct estimation of the marginal utility of income. The basic idea behind cost-effectiveness analysis is to sum up the well-being benefits accruing to all individuals affected, divide the sum of well-being benefits by the costs of generating them, and then compare the ratio of benefits to costs with a pre-specific threshold. If the ratio exceeds the threshold, the project is cost-effective, and *vice versa*. Ideally, the social planner then ranks projects according to their ratios from highest to lowest and implements them until the budget runs out.

Using Model 3, which employs the exact cut-off dates of the Olympics, we obtain a ratio of benefits to costs in £ of $(0.21 \times 8{,}300{,}000)/9{,}300{,}000{,}000 = 0.00019$. Using Model 2, which employs the entire summer period of 2012 as the relevant treatment period, we obtain a smaller ratio of $(0.14 \times 8{,}300{,}000)\ /\ 9{,}300{,}000{,}000 = 0.00012$.

What threshold shall we compare this ratio to? Unfortunately, we still know little about "how much well-being" particular interventions can buy per £ invested (partly because costs of interventions are often not reported), so that direct comparisons with alternative interventions are difficult to make. Clark et al. (2018), in line with HM Treasury (2011) and the UK Government's Green Book on how to appraise policy proposals before committing funds, suggest comparing the ratio of benefits to costs in £ to a fixed threshold of $1/2{,}500 = 0.0004$. This threshold is derived from guidelines on National Health Service (NHS) expenditure in Britain: for all possible treatments, these guidelines evaluate the gain in Quality-Adjusted-Life Years (QALYs), measured on a zero-to-one scale; treatment is approved if the cost in £ per QALY is below 25,000, or put differently, if the costs in £ are below a QALY per £ ratio of $1/25{,}000 = 0.00004$. For life satisfaction, which is measured on a 0-10 scale, the critical value thus becomes $25{,}000/10 = 0.0004$.

It turns out that both ratios of benefits to costs in £ (0.00019 in Model 3 and 0.00012 in Model 2) are below the critical value (0.0004), so that hosting the Olympics cannot be considered cost-effective.

Our analysis so far, however, has looked at the well-being impact on Londoners only. Similar to our cost-benefit analysis, we can calculate the break-even multipliers for the national well-being effect required to make hosting the Olympics worthwhile. They can be obtained as $(0.0004 \times 9{,}300{,}000{,}000 - 0.21 \times 8{,}300{,}000)/(0.21 \times 55{,}530{,}000) = 0.17$ (about 17% of the well-being impact on Londoners) for Model 3 and $(0.0004 \times 9{,}300{,}000{,}000 - 0.14 \times 8{,}300{,}000)/(0.14 \text{ x } 55{,}530{,}000) = 0.33$ (about 33% of the well-being impact on Londoners) for

Model 2. The range of break-even multipliers under cost-effectiveness analysis [0.17; 0.33] lies within that under cost-benefit analysis [0.04; 0.47]. The implication, as we observed before, is that a case can be made that the Olympics were worth the costs.

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