

December 27, 2007

Weather & Film Box Office Revenue:

The impact of precipitation and temperature on UK film box office revenue

By WeatherBill

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EXECUTIVE SUMMARY

WeatherBill analyzed nearly 10 years of box office data from the United Kingdom to identify the effect of weather on revenue from each weekend's 10 top-grossing films. It was found that both temperature and precipitation have had an impact on box office totals. Movies in the box office top 10 earned significantly less than expected on particularly warm or unusually dry weekends. Time of year also played a role in how temperature and precipitation affected box office revenue – revenue during summer months turned out to be particularly susceptible to the effects of weather.

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INTRODUCTION

Movie theater admissions in the United Kingdom reached a 40-year high of 50.8 million viewers in the summer of 2007. Film industry experts speculate that audiences were motivated to seek indoor entertainment because of the summer's record-setting inclement weather. 2007 was the wettest summer in the UK since records began in 1914 and August 2007 was the coldest in more than a decade. The idea of weather motivating or discouraging filmgoers and thus impacting box office revenue has historically been speculative. Little evidence, and less analysis, has been compiled on the impact of weather on box office revenue.

In this study, WeatherBill formally assessed the effect of weather on box office receipts, identifying specific weather triggers, and quantifying the impact.

WeatherBill assembled data on top-grossing films in the United Kingdom from the Internet Movie Database's UK box office archive.¹ The United Kingdom was specifically selected as the subject of this study due to the combination of the relative uniformity of regional climate conditions through the UK and the availability of detailed box office data. The lack of detailed and accessible regional box office data in the United States makes a rigorous analysis more difficult. For each weekend between January 1998 and July 2007, the database provided the following five statistics for each of the 10 top-grossing films at the UK box office:

- the film's total weekend revenue in the UK (the sum of revenues from Friday, Saturday, and Sunday of the given week),
- the film's rank (based on revenue) within the 10 top-grossing films,
- the number of weeks the film had been out in movie theaters in the UK,
- the number of screens in the UK on which the film was playing, and
- the film's cumulative UK box office revenue (which included the current weekend).

Daily mean temperature readings from the Met Office Hadley Centre Central England Temperature (CET) series were then assembled for use as one pertinent weather variable in the analysis.² The figures reported in this series are by no means representative of the entire United Kingdom, but they do closely approximate the conditions in the triangular area enclosed by London, Bristol, and Lancashire. According to the UK Film Council's 2006-2007 Statistical Yearbook³, the regions of London, the Midlands, and Lancashire together accounted for over half of all UK movie theater admissions in 2006. So as these regions account for the majority of UK movie theater admissions, the CET was utilized as the temperature measure, keeping in mind that more granular data on temperature variation and the distribution of box office revenue would likely only strengthen the general results. By the same reasoning, the amount of rain reported daily at London Heathrow airport was used as the measure of precipitation, as the London region alone accounted for over one quarter of all UK movie theater admissions in 2006, again according to the UK Film Council.

Before embarking on any such analysis, it is important first to understand the underlying climate norms in this Central England region in order to put into perspective what would be regarded as “warm weather” or a “rainy day.” Table 1 below gives the monthly average Central England Temperature, an average of the daily mean temperature within each month over the past 30 years. Table 2 gives the average daily rainfall for each month over the past 30 years as well as the average frequency of rainy days in each month (where “rainy” here is taken to mean there was any precipitation at all.)

1 <http://imdb.com/boxoffice/calendar?region=uk>

2 <http://www.metoffice.gov.uk/research/hadleycentre/obsdata/cet.html>

3 <http://www.ukfilmcouncil.org.uk/information/statistics/yearbook/?y=2006>

TABLE 1: Central England Temperature 30 year averages

	average daily mean temperature (Celsius)	average daily mean temperature (Fahrenheit)
January	4.3	39.7
February	4.3	39.8
March	6.4	43.6
April	8.4	47.0
May	11.5	52.8
June	14.4	57.9
July	16.6	61.9
August	16.3	61.4
September	14.0	57.2
October	10.7	51.3
November	7.1	44.8
December	4.9	40.8

TABLE 2: Average monthly rain at London Heathrow airport

	average daily rainfall (cm)	average daily rainfall (inches)	percent of days that are rainy
January	0.17	0.07	76%
February	0.14	0.05	72%
March	0.14	0.06	68%
April	0.14	0.06	62%
May	0.16	0.06	61%
June	0.16	0.06	58%
July	0.14	0.05	53%
August	0.16	0.06	52%
September	0.16	0.06	58%
October	0.22	0.09	68%
November	0.18	0.07	75%
December	0.19	0.07	76%

England has a generally mild maritime climate. In order to quantify how unusual weather impacts box office revenue, it was important to consider what conditions would qualify as anomalous weather—namely, particularly warm or dry weekends.

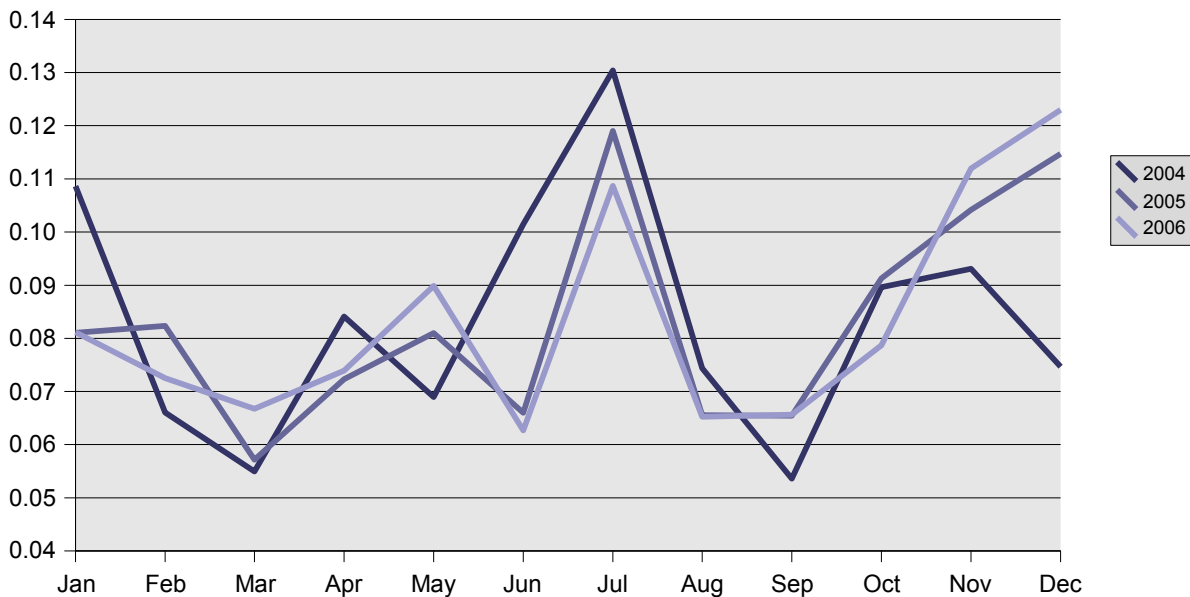
ASSUMPTIONS

The linear regression framework allows for comparisons across very different films, provided the model incorporating all of the determinants of box office revenue is included. Thus, these other effects can be held constant and their impact on revenue can be disentangled from the effects of temperature and precipitation. While no single objective measure can perfectly predict how well a given film will do at the box office, including measures of “popularity” and “seasonality” should do a reasonable job of capturing these other effects, and the regression output should yield the isolated effects of temperature and precipitation on box office revenue, assuming all else to be equal.

To control for a film's popularity, the regression a variable for the number of weeks the film had been playing was included, because a film's weekend revenue is expected to fall the longer it has been in release. Also included were measures of the number of screens on which the film was playing that weekend and the cumulative revenue the film had made. Taken together, these descriptive statistics act as a proxy for the film's popularity. Even very popular films that slip down in rankings over time will have cumulative revenues that are higher than expected for a given number of weeks out in theaters, so in this sense, such a film will still be easily identifiable as an exceedingly popular film and can be controlled for as such.

It is also important to account for seasonality within the calendar year. Figure 1 illustrates this by plotting, for each year from 1998 to 2006, the fraction of the year's total revenue that was earned in each month (where total revenue and the revenue in each month are the sums of earnings from the top 10 films from each weekend). There are noticeable seasonal trends, with the month of July and the November through January holiday season consistently garnering large portions of the yearly revenue relative to other months.

FIGURE 1: Monthly revenue from top films as fractions of total yearly revenue



To capture this seasonality, 12 binary variables were included in the regression to denote the month in which a given weekend fell. For example, for a film from the box office top 10 from the weekend of January 2, 1998, the “January” variable would be set to one and those for each of the other months would be set to zero.

In addition to monthly indicators, a binary variable was included to indicate whether a given weekend coincided

with a major bank holiday in the UK. This “holiday” variable was set equal to one if any of the following holidays fell on the given weekend (plus or minus one day):

- New Year's Day (January 1)
- May Day (first Monday in May)
- Spring Bank Holiday (last Monday of May)
- Summer Bank Holiday (last Monday of August)
- Christmas Day (December 25)
- Boxing Day (December 26)

The weekend box office revenue figures as reported on the Internet Movie Database website include only the revenue earned between Friday and Sunday, so if a bank holiday falls on a Monday the revenue on that day will not be included in the weekend total. This is still considered a “holiday weekend” for the purposes of this study. If such a holiday falls on a Monday, the longer weekend would presumably influence the habits of moviegoers during the Friday through Sunday period and it is important to control for this effect.

By regressing a film's weekend box office revenue on proxies for the film's popularity, variables to capture the seasons and holidays, and measurements of that weekend's weather, it is possible to isolate the effect of weather on a given film's revenue while essentially holding other factors constant.

METHODOLOGY

The relevant weather variables were taken to be temperature and precipitation—more specifically, “warm” weather and “dry” weather as these events are relatively rare in England's maritime climate.

Weekend temperature was defined as the average of the Friday, Saturday, and Sunday mean CET values in degrees Celsius for a given weekend, where the mean temperature for each day was simply taken to be the midpoint between the maximum and minimum observed temperatures for that day. In regressions that included box office information across all months of the year, a “warm weekend” was defined to be any weekend for which the average weekend temperature was above 12°C (54°F), the temperature of a warm weekend in the spring.

Weekend precipitation was defined as the total rainfall for the weekend (the sum of the Friday, Saturday, and Sunday values) as measured in centimeters at London Heathrow airport. A “dry weekend” was then defined to be any weekend for which there was no rain at all (0cm) between Friday and Sunday.

To isolate the effect of weather on the box office revenue for a given film, all of the top 10 films from all of the weekends in our data set were compiled and the logarithm of each individual film's weekend box office revenue was regressed on the following explanatory variables:

- the film's rank (based on revenue) within the 10 top-grossing films of that weekend,
- the number of weeks the film had been out in movie theaters,
- the number of screens on which the film was playing that weekend,
- the logarithm of the film's cumulative revenue including that weekend,
- “warm weekend” indicator variable,
- “dry weekend” indicator variable,
- “holiday weekend” indicator variable, and
- indicator variables to capture the month of the year in which the weekend fell.

Use the logarithm of each film's weekend revenue, rather than the original amount (recorded in Pounds Sterling) allows an interpretation of each regression coefficient as the percentage change in revenue associated with a one-unit change in the explanatory variable. (In the case of the binary weather variables, this interpretation allows consideration of the difference in expected revenue for a warm weekend to one that was not warm, for example) This tractable interpretation is also useful in allowing for comparisons between hugely popular movies and moderately successful films by eliminating the issue of generating “fair” comparisons across revenues of such different magnitudes.

ANALYSIS BY BOX OFFICE RANK

The table below gives an interpretation of the regression coefficients for the effect of weather on top-grossing films at the box office, and looks specifically at the effect of weather on the movies in each of the top 10 spots for a given weekend. When the cumulative revenue of the 10 top-grossing films are considered, the regression shows that the revenue for a given film in the top 10 on a warm weekend will be expected to be more than 10 percent lower than what a similar film would have made on a cooler weekend, all else equal. A given film in the top 10 would be expected to earn nearly 9 percent less on a dry weekend than it would be expected to earn on a weekend with any measurable rainfall, again assuming all else to be equal.

TABLE 3: Effect of weather on revenue from top-grossing films, by box office rank

	warm weekend	dry weekend
all 10 top-grossing films	-10.3%	-8.8%
1	-9.1%	-8.9%
2	-10.4%	-14.7%
3	-14.9%	-9.6%
4	-19.3%	-11.6%
5	-21.6%	-13.7%
6	-23.2%	-15.4%
7	-27.9%	-14.1%
8	-31.2%	-9.1%
9	-32.6%	-9.7%
10	-31.3%	-9.8%

**highlighted coefficients are statistically different from zero at the 10% significance level

When split into separate regressions based on rank within the top 10, the regressions of lower-ranked films result in “wet weekend” coefficients that are much larger in magnitude than those for the top-grossing films. While the number one film for a given weekend is seen to earn, all else equal, 9.1 percent less on a warm weekend than on a cooler weekend, the films ranked eighth through tenth at the box office are expected to earn more than 30 percent less than they would have been expected to earn had the weather not been so warm. The revenue from lower-grossing films in the top 10 is seen to be far more sensitive to temperature than that of the highest-grossing films.

The “dry weekend” coefficients tell a slightly different story. While all of the coefficients are negative—implying that revenue from each film in the top 10 will be lower over a dry weekend than over a rainy weekend, all else equal—the coefficient for the top-ranked film is not statistically significant. This may imply that the presence or lack of rain on a given weekend does not have a significant effect on the revenue from the weekend's number one film. It could also be a result of the relatively high standard errors from such variable data. Relative to revenue from lower-ranked films, revenue from number one films sees huge variation between “average” weekends and weekends during which a highly anticipated film like “Harry Potter” or “Pirates of the Caribbean” is released, and this variation makes it harder to identify with certainty the effect of weather on revenue.

Dry weekends were much rarer, comprising only 77 of the 500 weekends under consideration. As these weekends were also more likely to occur during the drier summer months in which the biggest films are often released, it is likely that the “dry weekend” group ended up with a particularly widespread distribution of

revenues. This would result in a high standard error for the “dry weekend” coefficient in the regression, and could mean that the effect appears as insignificant when in reality the lack of rain really does impact the revenue of number one films.

ANALYSIS BY MONTH

The following table gives an interpretation of the regression coefficients for the seasonal effect of weather on top-grossing films at the box office, and isolates how warm weather and dry weather affect box office revenue differently at different times of the year.

When analyzing the effect of weather during each individual month, the temperature threshold for a “warm weekend” had to be adjusted, as different months have varying average temperatures. So, in such regressions, a “warm weekend” was defined as one for which the weekend temperature was above the average mean CET for that month—an average of the daily mean temperature values for that month over the last thirty years. Similarly, the definition of “dry weekend” had to be changed since some months saw very few completely dry weekends between 1998 and 2007. Thus, a “dry weekend” is taken here to mean that the total rainfall for the weekend was less than three times the average daily rainfall for that month. (See Table 1 for these monthly averages.)

TABLE 4: Effect of weather on revenue from top-grossing films, by month

	warm weekend	dry weekend
Jan	9.8%	2.1%
Feb	-9.7%	0.2%
Mar	-0.6%	-3.1%
Apr	-2.7%	-8.6%
May	-19.0%	-1.2%
June	-10.3%	-12.3%
July	-9.2%	-11.4%
Aug	-9.1%	1.2%
Sept	-4.3%	1.0%
Oct	-2.6%	-5.7%
Nov	3.2%	-1.4%
Dec	-4.6%	-7.3%

**highlighted coefficients are statistically different from zero at the 10% significance level

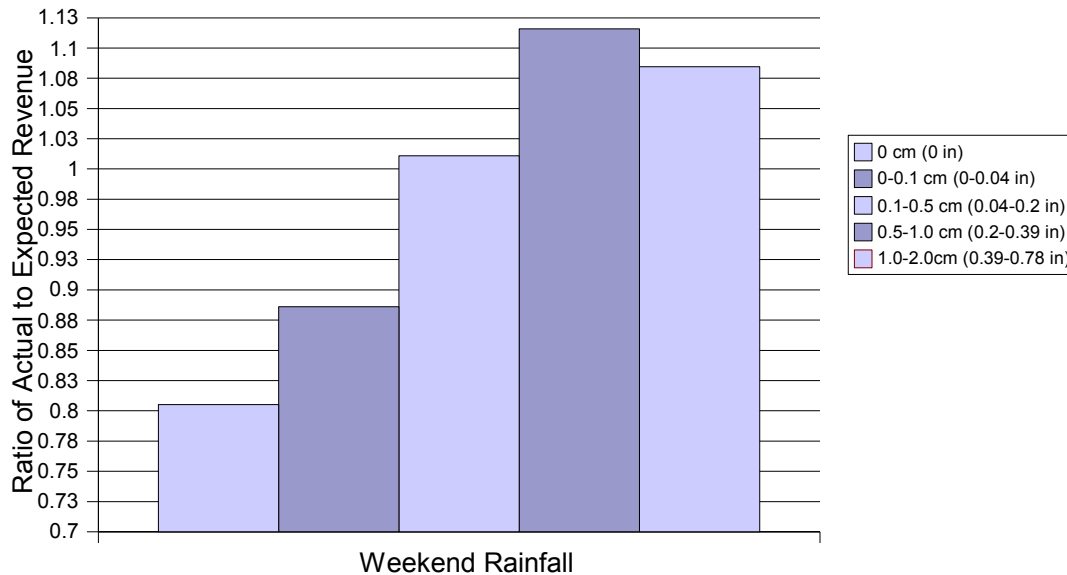
“Warmer than usual” weekend weather has the greatest effect on the box office between May and August, resulting in revenues that are significantly lower than what would have been expected had the weather been cooler. During these warmer months, it is possible that particularly warm weather over a certain weekend could instigate more outdoor activities, whereas “warm weekends” during colder months might still be too cold for outdoor activities.

April, June, and July may be similarly affected by weekends that are less rainy than usual. Dry weather in a warmer month may be better outdoor weather than a dry spell during a colder month. Thus, when the rain eases up in the summertime, people may be more likely to reduce their time spent indoors. August, however, marks the earliest days of the rainy season, with the number of wet days typically starting to increase after a relatively dry summer. Being “drier than usual” in August is often still wet, so movie theater attendance does not drop over such weekends as it does earlier in the summer season. In October, the month with the highest average daily rainfall, box office revenue falls on weekends that are drier than usual. Dry weekends in October may have particularly large impact, because the average temperature drops precipitously in November, making October the last typically outdoor month before winter weather officially sets in.

Graphically, these trends can be illustrated by plotting revenue against the relevant weather variables. The

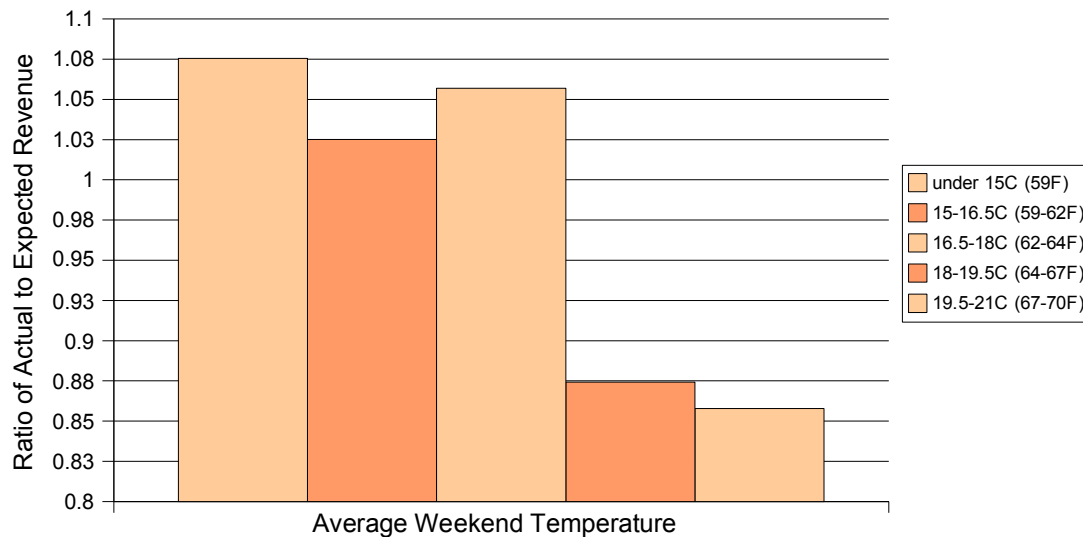
following charts use the sum of revenue from the top 10 films at the box office as the weekend's “actual revenue” and take the average total revenue for each separate weekend and holiday weekend of the year to be the “expected revenue” for that weekend or holiday weekend. The weekends were then divided into groups based on ranges of the weather variables, and the average of the “actual to expected revenue” ratios within each group was plotted against the range of weather values within which these weekends fell.

FIGURE 2: April Box Office Revenue vs. Precipitation



April’s box office revenue shows distinct trends based on weekend rainfall (Figure 2). The higher the rainfall, the higher the ratio of actual to expected revenue increases.

FIGURE 3: July Box Office Revenue vs. Temperature



July’s box office revenue reflects the impact of weekend temperature on the ratio of actual to expected revenue (Figure 3). During July, as the average temperature decreases, so does box office revenue. This may indicate that filmgoers are motivated to seek indoor entertainment when lower temperatures occur during months when higher temperatures are expected.