Sunny Upside? The Relationship Between Sunshine and Stock Market Returns

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Abstract

Weather can have profound effects on economic activity, most obviously agriculture, construction, and transportation. It has also been argued that the daily weather in New York City affects daily U.S. stock returns, a clear challenge to the efficient market presumption that rational investors will not let their assessment of a stock's value be swayed by whether the sun happens to be shining. Studies claiming to have found a sunshine effect are clouded by differing methodologies which may have been chosen to buttress their results. We examine a fresh set of data and confirm the existence of a New York City sunshine effect which has weakened over time as trading has become more geographically dispersed.

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Several studies have found that people tend to be happier on sunny days and sadder on cloudy days. Lack of sunshine has been linked to increased depression (Eagles 1994), as well as increased risk of suicide (Tietjen and Kripke 1994). It has also been found that people suffering from bipolar depression have significantly shorter hospital stays when they are exposed to morning sunlight through an eastern facing window (Benedetti, *et al* 2001).

Seasonal Affective Disorder (SAD) was first described by Norman E. Rosenthal (Rosenthal 1984), and has gained widespread acceptance after encountering early skepticism. SAD involves depression that sets in during the fall and winter months and subsides in the spring and summer, and is thought to be caused by reduced sunlight exposure which can disrupt circadian rhythms as well as serotonin and melatonin levels (www.mayoclinic.org). It is more prevalent farther from the equator, and is seldom found in countries within 30 degrees of the equator (www.webmd.com). Recent research has shown that light therapy is just as effective as antidepressants for the treatment of SAD (Westrin and Lam 2007).

Studies have also found that decisions are often affected by visceral factors like anger and pain (Loewenstein 1996 and 2000), and that judgments about risk rarely occur in an emotionally neutral setting (Johnson and Tversky 1983). If so, perhaps investment decisions are influenced by sunlight.

Edward Saunders (1993) investigated whether daily sunshine in New York City has had a measurable effect on daily stock market returns, as gauged by percentage changes in the Dow

Jones Industrial Average and value-weighted and equal-weighted indexes compiled by the Center for Research in Security Prices (CSRP). Looking at New York City data from 1927 through 1989, with daily cloudiness at Central Park (1927–1960) and La Guardia Airport (1961–1989) recorded in whole numbers on a scale of 0 (completely cloudless all day) to 10 (completely cloudy all day), he found that the stock market did better on relatively sunny days than on completely cloudy days. He also observed a significant decrease in the strength of the correlation during the years 1983–1989, suggesting that the sunshine effect may have weakened over time.

Mark Trombley (1997) argued that Saunders' conclusion depended on a peculiar comparison of days that were 0 percent to 20 percent cloudy with days that were 100 percent cloudy. Even more oddly, the reported relationship was due entirely to unusually high returns on days that were 10 percent cloudy. Average daily stock returns on days with 0 percent clouds were the second lowest among the eleven cloud categories for the Dow and CRSP value-weighted portfolios and in the middle of the pack for the CRSP equal-weighted portfolio.

Trombley also concluded that Saunders' sunshine effect only appeared in some subsets of the time period Saunders studied and, in particular, that there is no evidence of a sunshine effect before 1962, which does not support Saunders' theory that the effect has weakened over time.

These peculiarities suggest that the reported results may have been a small subset of many statistical tests that were conducted but not reported—which undermines the statistical significance of the results that were reported. As Nobel Laureate Ronald Coase (1988) wryly observed, "If you torture the data enough, nature will always confess." Kramer and Runde (1997) and Jacobsen and Marquering (2008) conclude that reported statistical relationships between the weather and stock returns may be a spurious correlations unearthed by eta mining.

Hirshleifer and Shumway (2003) looked at twenty-six international stock exchanges using 1982–1997 International Surface Weather Conditions (ISWO) data that are hourly observations of the total sky cover on a scale from 0 (clear) to 8 (overcast). They calculated the average sky cover each day during the hours 6 a.m. through 4 p.m. at locations near the 26 stock exchanges. They used these daily data to calculate the average sky cover during each week of the year at each location. Finally, they calculated the daily seasonally adjusted cloud cover SKC* by subtracting the historical weekly means from the daily observations.

They reported least squares estimates of the equation:

$$r = \alpha + \beta SKC^{*} + \varepsilon \qquad (1)$$

where *r* is the daily return and SKC* is their seasonally adjusted measure of sky cover. Overall, they found cloudiness generally to be negatively correlated with daily stock returns, though the the results were often not statistically significant at the 5 percent level. They also reported that their results were little affected by using sky cover data that were not seasonally adjusted.

Stephen Keef and Melvin Roush (2007) produced a meta-analysis of Hirshleifer and Shumway's results and added two new variables, latitude and per-capita GDP. They confirmed Hirshleifer and Shumway's overall findings, and also discovered that the strength of the sunshine effect grows with distance from the equator, with little or no effect at or near the equator. This similarity to SAD research strengthens the argument that mood changes are responsible for the relationship between sunshine and stock returns.

The primary inadequacy of the Hirshleifer/Shumway study is that they only considered a brief 16-year period, 1982–1997. We apply their approach to comparable New York City data for a longer time period, from 1948 through 2013, that incorporates 34 years before and 16 years after the period they studied. Our expectation was that their reported results may have been tainted by multiple tests and would not hold up when their procedure was applied to data that have not been contaminated by data dredging.

Data

The National Oceanic and Atmospheric Administration's National Climate Data Center (2014) has hourly LaGuardia sky-cover data for the years 1948 through 2013 using the same 0-to-8 scale as the Hirshleifer/Shumway data. Following Hirshleifer and Shumway, we calculated the average cloudiness each day between the hours of 6 a.m. and 4 p.m. and adjusted these daily averages by subtracting each week's mean cloudiness (averaged over the whole period) from each daily average.

Hirshleifer and Shumway obtained daily stock returns from Datastream Global Index, but these data are only available back to 1973. So, we followed Saunders in using the Dow Jones Industrial Average and the CRSP value-weighted and equal-weighted indexes. Saunders used the daily percentage changes in each of these indexes, but we used CRSP returns that include dividends as well as price changes. We use daily percentage changes in the Dow because we do not have comparable daily returns including dividends.

Results

Table 1 shows the average stock returns on days that were perfectly sunny and days that were completely cloudy every hour from 6 a.m. to 4 p.m. The complete data set 1948–2013 was also broken into three subsets: the days before, during, and after the 1982–1997 years studied by Hirshleifer and Shumway. In every case, the average daily return was higher on cloudless days, with the magnitude of the difference and the statistical significance highest in the early years and diminishing over time.

Notice that the return difference and the statistical significance generally increase as we move from the Dow Jones Industrial Average to the CRSP value-weighted index to the CRSP equal-weighted index, indicating that the sunshine effect is strongest for lightly capitalized stocks.

Table 2 is a similar analysis, this time comparing the ten percent of the days with the lowest seasonally adjusted cloud cover and the ten percent with the highest seasonally adjusted cloud cover. The differences between the average returns on the top-ten and bottom-ten cloudiness days are comparable to those for perfectly sunny versus completely cloudy days.

The differences in the average daily stock returns are substantial and statistically significant for the years 1948 through 1981, but diminish over time. Again the size of the differences and the statistical significance are more pronounced for relatively small stocks.

Table 3 shows the estimates of Equation 1 using seasonally adjusted cloud cover data for the years 1948–2013 as a whole and broken into the years before, during, and after the Hirshleifer and Shumway study. We also estimated Equation 1 using unadjusted data and found, as did Hirshleifer and Shumway, that the results were little affected.

As was true of a simple comparison of the mean returns, the sunshine effect is most apparent for relatively small stocks. For all three measures of stock returns, there is a strong, statistically significant, inverse relationship between cloudiness and market returns for the period as a whole and for the early subperiod 1948-1981. The relationship is weaker for the years 1982–1997 studied by Hirshleifer and Shumway and has essentially vanished since then.

The values of R-squared are consistently small because most of the variation in daily stock returns is due to factors and that are unrelated to the weather.

Hirshleifer and Shumway investigate a trading strategy based on the seasonally adjusted cloud cover each day between the hours of 5 a.m. and 8 a.m., before markets open. A morning was considered to have above-average cloudiness if the seasonally adjusted cloud cover was positive, and below-average cloudiness if the seasonally adjusted cloud cover was negative. It would be difficult to implement this strategy in practice because the weekly averages used to make the seasonal adjustments are not known until the end of the historical period being studied.

Instead, we investigated a trading strategy based on whether the sky was perfectly sunny or completely cloudy every hour between 5 a.m. and 8 a.m. The average returns were then compared for the days where the mornings were cloudless or entirely cloudy. (We didn't use the Dow data in these calculations because these only reflect price changes, not total returns including dividends.)

Table 4 shows that the average returns were consistently higher on days that began perfectly sunny compared to days that began completely cloudy. The differences are most pronounced for the equal-weighted index and are larger and more statistically significant for the years 1948-1981 than for later years. However, even though the market does better when the morning is perfectly sunny, the average return is still positive when the morning is completely cloudy. So, getting out (or staying out) of the market on cloudy mornings is not a profitable strategy. In addition, the profits from any trading strategy based on morning cloudiness would be further eroded by the transaction costs (including bid-ask spreads and taxes on realized short-term capital gains) that would be incurred with the frequent jumping in and out of the market.

Conclusions

To our surprise, our study confirms that the U.S. stock market has done better on sunny days than on cloudy days even though fluctuations in New York's daily cloudiness do not affect the fundamental value of the stocks being traded. We also find that the sunshine effect is strongest for lightly capitalized stocks.

While this is evidence that investors are influenced by otherwise meaningless mood swings, the effects are not large enough to be exploited. The weather does not leave $100 bills on the sidewalk.

Robert Shiller (1984), among others, has made the point that the empirical observation that it is difficult to beat the stock market does not prove that stock prices are "correct" in the sense that they are equal to an objective present value calculation of the best estimates of future cash flows. It is also difficult to predict stock prices that are buffeted by fads, fancies, greed, and gloom—what Keynes called animal spirits. Our findings are consistent with the view that stock prices can be swayed by something as meaningless as whether the sun is shining.

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Table 1 Perfectly Sunny (C = 0) Versus Completely Cloudy (C = 8)

	1948 - 2013		1948 - 1981		1982 - 1997		1998 - 2013	
	C = 0	C = 8	C = 0	C = 8	C = 0	C = 8	C = 0	C = 8
Observations	714	2,645	391	1,393	262	669	61	583
Dow								
Mean Return	0.0547	-0.0121	0.0476	-0.0360	0.0760	-0.0194	0.0068	0.0533
Two-Sided P-value	0.0868		0.0328		0.2141		0.8133	
CRSP value-weighted								
Mean Return	0.0733	0.0082	0.0718	-0.0147	0.0906	-0.006	0.0088	0.0791
Two-Sided P-value	0.0767		0.0175		0.1545		0.7384	
CRSP equal-weighted								
Mean Return	0.1018	0.0379	0.1135	-0.0056	0.1136	0.0661	-0.0247	0.1095
Two-Sided P-value	0.0428		0.0005		0.3699		0.4614	

Table 2 Ten Percent Most Sunny (Low C) Versus Ten Percent Most Cloudy (High C) Days

	1948 - 2013		1948 - 1981		1982 - 1997		1998 - 2013	
	Low C	High C	Low C	High C	Low C	High C	Low C	High C
Observations	1,662	1,690	854	874	404	404	403	404
Dow								
Mean Return	0.0575	-0.0313	0.0405	-0.0647	0.1449	–0.0262	–0.0551	0.0565
Two-Sided P-value	0.0068		0.0035		0.1610		0.9883	
CRSP value-weighted								
Mean Return	0.0743	–0.0080	0.0630	–0.0249	0.1513	–0.0173	0.0850	0.0600
Two-Sided P-value	0.0085		0.0107		0.0070		0.7991	
CRSP equal-weighted								
Mean Return	0.1054	0.0024	0.1048	–0.0267	0.1621	0.0175	0.1263	0.0655
Two-Sided P-value	0.0001		0.0001		0.0033		0.4701	

Table 3 Regression Estimates of the Relationship Between Cloud Cover and Daily Stock Returns

	1948-2013	1948-1981	1982-1997	1998-2013
Observations	16,605	8,539	4,042	4,024
Dow				
Mean Return	0.0315	0.0208	0.0597	0.0259
Beta	-0.0075	-0.0086	-0.0085	-0.0030
Two-side P-value	0.0054	0.0038	0.1318	0.6924
R-squared	0.0005	0.0010	0.0006	0.0000
CRSP value-weighted				
Mean Return	0.0457	0.0426	0.0643	0.0337
Beta	-0.0074	-0.0083	-0.0077	-0.0039
Two-sided P-value	0.0044	0.0030	0.0984	0.6330
R-squared	0.0005	0.0010	0.0007	0.0001
CRSP equal-weighted				
Mean Return	0.0742	0.0636	0.0989	0.0720
Beta	-0.0081	-0.0105	-0.0051	-0.0055
Two-sided P-value	0.0004	0.0000	0.1314	0.4360
R-squared	0.0008	0.0018	0.0006	0.0002

Table 4 Average Daily Returns, Perfectly Sunny (C = 0) Versus Completely Cloudy (C = 8)

	1948 - 2013		1948 - 1981		1982 - 1997		1998 - 2013	
	C = 0	C = 8	C = 0	C = 8	C = 0	C = 8	C = 0	C = 8
Observations	3,686	4,691	2,030	2,480	913	1,095	743	1,116
CRSP value-weighted								
Mean Return	0.0602	0.0228	0.0505	0.0233	0.0748	0.0355	0.0684	0.0091
Two-Sided P-value	0.0671		0.2084		0.3555		0.3262	
CRSP equal-weighted								
Mean Return	0.0896	0.0505	0.0809	0.0363	0.0914	0.0845	0.1111	0.0489
Two-Sided P-value	0.0266		0.0339		0.8217		0.2272	