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Black swans, market timing and the Dow

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Do investors in the US stock market obtain their long-term returns smoothly and steadily over time or is their long-term performance largely determined by the return of just a few outliers? How likely are investors to successfully predict the best days to be in and out of the market? The evidence from the Dow Jones Industrial Average over the 1900–2006 period shows that a few outliers have a massive impact on long-term performance. Missing the best 10 days resulted in portfolios 65% less valuable than a passive investment and avoiding the worst 10 days resulted in portfolios 206% more valuable than a passive investment. Given that 10 days represent 0.03% of the days in the sample, the odds against successful market timing are staggering.

I. Introduction

Consider an investor who put $100 in the Dow Jones Industrial Average on the closing bell of 31 December 1986. Through 16 October 1987, when the Dow closed at 2246.7, this investor obtained an 18.5% return, turning his initial $100 into $118.5. Then, in a single day, the market tumbled 22.6%, and the investor's $118.5 was reduced to $91.7. The return of 201 trading days was more than wiped out in a single day.[1] It took the Dow 320 trading days to get past the level of 16 October 1987; on 24 January 1989 it closed at 2256.4.

Black Monday, as 19 October 1987 became known, was not just another day; it was the single worst day (in percentage terms) in the Dow's history and therefore unique. But what is neither unique nor unusual is that a few large daily swings can more than overturn the return of a portfolio obtained over a long period of time. Interestingly, under the widely used and abused assumption of normality, this should happen very infrequently, if at all. And yet the evidence shows that these events happen *far* more often than would be expected under this assumption.

This article, however, is not about assessing the normality of the distribution of the US daily stock returns. Rather, its ultimate goal is to quantify the impact of outliers on the long-term performance of the US stock market. Do investors obtain their long-term returns smoothly and steadily over time, or is their long-term performance largely determined by the return of just a few outliers? Are investors likely to predict the best days to be in and out of the market successfully? Those are the ultimate issues addressed here.

The evidence, based on data for the Dow Jones Industrial Average over the last 107 years, is unequivocal: outliers have a massive impact on long-term performance. Missing the best 10 days resulted in portfolios 65% less valuable than a passive investment, whereas avoiding the worst 10 days resulted in portfolios 206% more valuable than a passive investment. Given that 10 days represent 0.03% of the days

This article draws its central idea and methodology from Estrada (2008). Gabriela Giannattasio provided valuable research assistance. The views expressed here and any errors that may remain are entirely my own.

[1] These figures do not account for dividends, but doing so does not change the essence of the story. Accounting for dividends, the return between 31 December 1986 and 16 October 1987 was 21.3%, which turned the $100 investment into $121.3. The 22.6% fall on 19 October 1987 turned that stake into $93.9, still more than wiping out the return of the previous 201 days.

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in the sample, the odds against successful market timing are staggering. Hence, of the countless strategies that academics and practitioners have devised to generate alpha, market timing does not seem to be the one most likely to succeed.

II. The Issue

This section first introduces the concept of black swans (which, although informally defined, is at the heart of the issues discussed here) and then briefly discusses previous research on the impact of outliers on long-term performance.

What is a black swan?

Taleb (2007) defines a black swan as an event with three attributes: (1) it is an outlier, lying outside the realm of regular expectations because nothing in the past can convincingly point to its occurrence; (2) it carries an extreme impact; and (3) despite being an outlier, plausible explanations for its occurrence can be found after the fact, thus giving it the appearance that it can be explainable and predictable. In short, then, a black swan has three characteristics: rarity, extreme impact and retrospective predictability.

Now consider Black Monday. Between inception on 26 May 1896 and 16 October 1987, the Dow had only twice in its whole history fallen by more than 10% in 1 day. This happened on back-to-back days in the midst of the crash of 1929; on 28 and 29 October 1929, the Dow fell to 12.8 and 11.7%, respectively. But nothing in the 90+ years of history of the Dow pointed out to the possibility of a fall of the magnitude observed on 19 October 1987. And yet, the unexpected and inconceivable did happen. Black Monday was an extremely rare event; it did have a very significant impact on investors' portfolios, and many and varied stories were advanced to explain it *ex post*. In short, Black Monday was a black swan.

As discussed below, daily swings in the markets do not have to be so dramatic to have a substantial impact on long-term performance. For this reason, the focus of this article is on 'large' daily swings, as informally defined below. Although some attention is paid to daily returns more than 3 SDs away from the mean, as well as to the best and worst 10, 20 and 100 daily returns, no attempt is made here to formally define a black swan.

The impact of large swings on portfolio performance

The idea that outliers are far more often observed than what the normality assumption would predict is not new. Quantifying the impact of these outliers on long-term performance, however, is a more recent development. Mauboussin (2006) argues that over the 3 January 1978 to 31 October 2005 period the S&P-500 delivered a mean annual return of 9.6%; excluding the best 50 days (out of over 7000) lowers the mean return to 2.2%, and excluding the worst 50 days increases the mean return to 18.4%.[2]

Browne (2007) discusses a study by Sanford Bernstein showing that, during the period 1926 to 1993, the returns of the US stock market in the best 60 months (7% of the time) averaged 11%, whereas the returns of the rest of the months (93% of the time) averaged 0.01%. He concludes that finding the way to reliably predict the 7% of the time that stocks do well is a 'daunting task' and that the real danger is not to be in the market when big moves occur. He also discusses a study by American Century Investments showing that $10 000 invested in the US stock market in 1990 turned into $51 354 by 2005, but missing the best 10, 30 and 50 days would have reduced the terminal wealth to $31 994, $15 730 and $9030, respectively.

Finally, in a large sample of 15 international markets that spans over more than 600 years and 160 000 daily returns, Estrada (2008) finds that on average across all markets, missing (avoiding) the best (worst) 10 days resulted in a portfolio 50.8% less valuable (150.4% more valuable) than a passive investment. Importantly, 10 represent less than 0.1% of the days considered in the average market.

III. Evidence

This section looks at the evidence in two stages, first by focusing on the longer 1900–2006 period and then on the shorter and more recent 1990–2006 period.

The Dow, the Longer 1900–2006 Period

To assess the impact of outliers on long-term performance, we will focus on the behaviour of the Dow Jones Industrial Average Index. The results of the analysis of the Dow's daily returns between the beginning of 1900 and the end of 2006 are summarized in Exhibit 1.

As shown in panel A, over the 29 190 trading days (107 years) of the Dow's history considered in Exhibit 1, the daily (arithmetic and geometric) mean return and

[2] None of these figures accounts for dividends.

Exhibit 1. The Dow, the longer 1900–2006 period

Panel A: Summary statistics

Years	Days	Min	Max	AM	GM	SD	Skw	Krt	SSkw	SKrt
107	29 190	–22.61%	15.34%	0.02%	0.02%	1.07%	–0.2	19.2	–15.9	668.6

Panel B: Outliers

AM – 3 SD	Exp	Obs.	Ratio	AM + 3 SD	Exp	Obs.	Ratio	TE	TO	Ratio
–3.17%	39	253	6.4	3.22%	39	208	5.3	79	461	5.8

Panel C: Mean returns

	All	B10	B20	B100	W10	W20	W100
AM	0.02%	11.10%	9.37%	5.92%	–10.46%	–8.73%	–5.87%
SDs from AM		10.4	8.8	5.5	9.8	8.2	5.5

Panel D: Terminal values

	TV100	–B10	–B20	–B100	–W10	–W20	–W100
TV	$25 746	$9008	$4313	$83	$78 781	$162 588	$11 198 734
Change	N/A	–65.0%	–83.2%	–99.7%	206.0%	531.5%	43 396.8%
MACR	5.3%	4.3%	3.6%	–0.2%	6.4%	7.2%	11.5%

Notes: This exhibit shows information based on the series of daily returns of the Dow Jones Industrial Average Index. Panel A shows the minimum (Min) and maximum (Max) return, arithmetic (AM) and geometric (GM) mean return, SD, coefficients of skewness (Skw) and kurtosis (Krt), and coefficients of standardized skewness (SSkw) and standardized kurtosis (SKrt). Panel B shows the expected (Exp) and observed (Obs.) number of daily returns 3 SDs below and above AM, and the ratio of the number of these observed and expected returns to the total number of expected (TE) and observed (TO) returns more than 3 SDs away from the mean. Panel C shows the arithmetic mean return for the whole sample (All), the mean return of the best 10, 20 and 100 days (B10, B20 and B100), the mean return of the worst 10, 20 and 100 days (W10, W20 and W100) and the number of SDs away from AM these last six magnitudes are. Panel D shows the terminal value of $100 invested on 31 December 1899 and held passively through 31 December 2006 (TV100), not including dividends; such terminal value without being invested during the best 10, 20 and 100 days (–B10, –B20 and –B100); such terminal value without being invested during the worst 10, 20 and 100 days (–W10, –W20 and –W100); the percent changes of these last six terminal values with respect to TV100 and the MACR in all these scenarios. 'Exp' figures are rounded to the nearest integer. Returns account for capital gains but not for dividends. All magnitudes are calculated over the period 1 January 1900 to 31 December 2006.

SD were 0.02 and 1.07%, respectively. The maximum and minimum daily returns were 15.34 and –22.61%, the latter on Black Monday, respectively. The coefficients of standardized skewness and kurtosis indicate a significant degree of (negative) skewness and kurtosis, both of which suggest a very clear departure from a normal distribution.[3]

Panel B shows that –3.17 and 3.22% are the limits of the interval 3 SDs around the (arithmetic) mean return. As is well known, under a normal distribution, the area within this interval is 99.73% and the area outside it is 0.27%. Therefore, under the assumption of normality, given the 29 190 daily returns considered, 79 ($=0.0027 \times 29\,190$) would be expected to fall outside this interval, 39 below –3.17% and 39 above 3.22%.[4] However, as the exhibit shows, 253 daily returns were observed below –3.17% and 208 above 3.22% for a total of 461 – almost six times as many as would be expected under normality. Again, the data suggest that the daily returns of the Dow clearly depart from normality.

Panel C shows the daily (arithmetic) mean return over the whole sample period, as well as the mean return of the best and worst 10, 20 and 100 days. Relative to a sample-wide mean return of 0.02%, the mean return of the best 10, 20 and 100 days were 11.10%, 9.37% and 5.92%, thus being 10.4, 8.8 and 5.5 SDs above the mean, respectively. The mean

[3] Under normality, the coefficients of standardized skewness and kurtosis are asymptotically distributed as $N(0, 6/T)$ and $N(0, 24/T)$, where T is the number of observations in the sample. Hence, values of these coefficients outside the range (–1.96, 1.96) indicate, at the 5% level of significance, significant departures from normality.

[4] The number of returns expected outside the interval considered must be equally split between the upper and the lower tails of the distribution. For clarity, all numbers have been rounded to the nearest integer, and for this reason the 39 returns expected on each tail do not add up to 79.

return of the worst 10, 20 and 100 days, on the other hand, were –10.46%, –8.73% and –5.87%, thus being 9.8, 8.2 and 5.5 SDs below the mean, respectively.

For perspective on the significance of these departures from the mean, consider the following. The lowest of the best 100 daily returns (4.20%) is 3.9 SDs above the mean. This implies that we should observe one return of this magnitude or higher every 20 792 trading days, or one every 83 years, or less than two in the 107 years in the sample period considered,[5] and yet 100 such returns were observed. Similarly, the highest of the worst 100 daily returns (–4.28%) is 4 SDs below the mean. This implies that we should observe one return of this magnitude or lower every 31 574 trading days, or one every 126 years, or less than one in the 107 years in the sample considered, and yet 100 such returns were observed.

One more interesting perspective is that the lowest of the best 10 daily returns (9.19%) is 8.6 SDs above the mean. This implies that one return of this magnitude or larger should be observed every 250 890 349 457 896 000 trading days or one every 1 003 561 397 831 590 years. Assuming that the life of planet Earth is around 4.5 billion years, we should then observe one return of this magnitude or larger every 223 014 lives of our planet, and yet 10 such returns were observed in 107 years.[6]

Finally, consider panel D, which displays the most interesting figures for investors. A $100 investment at the beginning of 1900 turned into $25 746 by the end of 2006 and delivered a Mean Annual Compound Return (MACR) of 5.3%.[7] Note that in a sample of 29 190 days, 10 days account for only 0.03% of all the days considered. Yet missing the best 10 days reduced the terminal wealth by 65% to $9008 and the MACR 1 percentage point to 4.3%. Missing the best 20 days reduced the terminal wealth by 83.2% to $4313 and the MACR to 3.6%. Missing the best 100 days (0.34% of the days considered) reduced the terminal wealth by a staggering 99.7% to just $83 (less than the initial capital invested) and the MACR to –0.2%.

It may be worthwhile to briefly reflect about these figures. If, as argued by Browne (2007), finding the 7% of the time that stocks do well is a 'daunting task', consider the difficulty of finding the 0.03% of the time that determines nearly two-thirds of the terminal wealth, or the difficulty of finding the 0.34% of the time that determines whether or not any wealth is created at all! The odds against successful market timing are simply staggering.

Panel D also considers the impact on terminal wealth of being out of the market during the worst 10, 20 and 100 days. Avoiding the worst 10 days increased the terminal wealth (with respect to a passive investment) by 206% to $78 781 and the MACR by more than 1 percentage point to 6.4%. Avoiding the worst 20 days increased the terminal wealth by 531.5% to $162 588 and the MACR to 7.2%. Avoiding the worst 100 days (0.34% of the days considered) increased the terminal wealth by a staggering 43 396.8% to $11 198 734 and more than doubled the MACR to 11.5%.

As this evidence shows, the odds against successfully predicting the negligible number of days that generates the bulk of long-term returns are staggering. And as we will see immediately below, the evidence for the more recent 1990–2006 period points exactly in the same direction.

The Dow, the Shorter and More Recent 1990–2006 Period

The 1900–2006 period, although useful to assess the impact of outliers on the long-term performance of the Dow, is too long to be considered the relevant holding period of any investor. The 17-year period between 1990 and 2006, however, is long enough to assess long-term performance and also short enough so that it could have been the actual holding period of many investors. Exhibit 2 summarizes the analysis of the Dow's daily returns over this shorter and more recent period.

Panel A of Exhibit 2 shows that the minimum and maximum daily returns are both lower (in absolute value) than the respective figures for the 1900–2006 period. Similarly, although this distribution of daily returns displays less negative skewness and kurtosis than that for the longer period, it still displays significant departures from normality. Panel B shows that there are still many more outliers observed than expected; the former outnumber the latter by a factor larger than 5. Panel C shows that the mean returns of the best and worst 10 and 20 days are over 100 times larger than the sample-wide mean return.

Panel D shows that a passive investment of $100 at the beginning of the 1990 turned into $453 by the end of 2006 and delivered an MACR of 9.3%. Missing the best 10 days (0.23% of the holding period) would have reduced the terminal wealth by 38% to $281 and the

[5] This and all similar calculations assume 250 trading days a year.
[6] If these numbers are hard to assess, consider that given the Dow's distribution of daily returns between inception and 16 October 1987, Black Monday was an event 21.1 SDs above the mean. The probability of observing an event of this magnitude or larger is 3.98E–99. For perspective, note that the probability of observing an event 8.6 SDs above the mean is 'only' 3.99E–18.
[7] As indicated in the exhibit, all figures account for capital gains but not for dividends.

Exhibit 2. The Dow, the 1990–2006 shorter and more recent period

Panel A: Summary statistics

Years	Days	Min	Max	AM	GM	SD	Skw	Krt	SSkw	SKrt
17	4288	–7.18%	6.35%	0.04%	0.04%	0.98%	–0.1	4.5	–3.4	60.6

Panel B: Outliers

AM – 3·SD	Exp	Obs.	Ratio	AM + 3·SD	Exp	Obs.	Ratio	TE	TO	Ratio
–2.91%	6	29	5.0	2.99%	6	31	5.4	12	60	5.2

Panel C: Mean returns

	All	B10	B20	B100	W10	W20	W100
AM	0.04%	4.90%	4.29%	2.82%	–5.17%	–4.29%	–2.80%
SDs from AM		5.0	4.3	2.8	5.3	4.4	2.9

Panel D: Terminal values

	TV100	–B10	–B20	–B100	–W10	–W20	–W100
TV	$453	$281	$195	$28	$770	$1089	$7782
Change	N/A	–38.0%	–56.8%	–93.8%	70.1%	140.6%	1619.1%
MACR	9.3%	6.3%	4.0%	–7.2%	12.8%	15.1%	29.2%

Notes: This exhibit shows information based on the series of daily returns of the Dow Jones Industrial Average Index. For a definition of all the magnitudes in this exhibit, refer to Exhibit 1. Returns account for capital gains but not for dividends. All magnitudes are calculated over the period of 1 January 1990 to 31 December 2006.

MACR by 3 percentage points to 6.3%, whereas avoiding the worst 10 days, in turn, would have increased the terminal wealth by 70.1% to $770, and the MACR by over 3 percentage points to 12.8%. Interestingly, missing the best 100 days (2.33% of the holding period) would have resulted in a loss of 72% of the *initial* capital invested and, therefore, in a negative MACR.

The evidence from the more recent 1990–2006 period, then, confirms and reinforces the results for the 1990–2006 period: a very small number of outliers have a massive impact on the long-term returns delivered by the Dow, and for this reason, investors are very unlikely to successfully predict the best times to be in and out of the market.

IV. An Assessment

Large daily swings that have a significant impact on long-term performance, unexpected *ex ante* though seemingly predictable *ex post*, occur far more often than is usually believed. Black swans do exist. In fact, investors stumble on them far more often than they expect, and the impact on their portfolios is far larger than they usually think.

The evidence discussed in this article clearly shows that black swans have a massive impact on long-term performance. Given the 107 years of US stock market history considered in this article, the evidence shows that missing the best 10 days, out of the 29 190 in the sample, resulted in portfolios 65% less valuable than a passive investment, whereas avoiding the worst 10 days, in turn, resulted in portfolios 206% more valuable than a passive investment. These magnitudes are enormous given that 10 days account for only 0.03% of the days considered.

The figures speak for themselves and should help investors assess the odds they are against when attempting to time the market. A negligible proportion of days determines an enormous creation or destruction of wealth, and therefore, the odds against successful market timing are simply staggering. Of the countless strategies that academics and practitioners have devised to generate alpha, market timing seems to be one very unlikely to succeed. Much like going to Vegas, market timing may be an entertaining pastime, but not a good way to make money.

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