www.irmbrjournal.com
International Review of Management and Business Research
September 2019
Vol. 8 Issue.3

Whither Goes the DJIA? The Problem of the Divisor Over Time and the Need to Change the Calculation of the Index.

RICHARD D. GRITTA
Professor of Finance, University of Portland, Oregon
Email: gritta@up.edu

BRIAN ADAMS
Associate Dean & Associate Professor of Finance, University of Portland, Oregon

Abstract

The Dow Jones Industrial Average (DJIA) is arguably the world's most widely watch stock market index. It is calculated as a simple unweighted arithmetic mean or average. Previous papers noted several flaws with the calculation which limits its usefulness as an overall or broad market gauge. Those flaws include its small sample size and it use of the summed market prices, not the summed market values of the component stocks. There is also the problem of the necessity to revise the divisor whenever stock dividends and splits occur. This brief paper will examine the "divisor problem" in far more detail than the earlier papers. The paper will first review the calculation of the average and briefly review prior discussed flaws. It will then explore the large number of divisor revisions during the period 1926, when the current calculation was constructed, through 2018. These changes have been the result of numerous stock splits and stock dividends over time. The direct result of all these divisor changes has been the steady and persistent decline in the meaning of a point change. It will be argued that, sooner or later, the calculation of the Dow may have to be changed.

Keywords: *Stock Market Averages, Dow Jones Industrial Average, Statistical Problems.*

Introduction

The Dow Jones Industrial Average (DJIA) is arguably the world's most widely watch stock market index. The DJIA was first published in a newsletter in 1884 by Charles Dow, who five years later founded the Wall Street Journal. Originally, the average only consisted of 11 equities. Stocks have been added or deleted many times over the past 100 plus years. Since 1926, the Dow has been composed of 30 industrial stocks. The average is computed as a simple unweighted arithmetic average or mean. Several criticisms have been leveled at the calculation. Investors should be aware of these problems and how they affect the meaning of U.S. equity market movements and the interpretation of those movements.

Prior research by two of the authors (Gritta & Adams, 2016; Gritta & Seal, 1999) have outlined several of these problems:

1. The DJIA is a narrow, "blue chip" index and thus doesn't necessarily represent the "market' in the broadest sense of the word.
2. Since the average is a simple unweighted mean, it is subject to statistical distortion stemming from its small sample size of only 30 stocks.
3. The Dow only measures appreciation over time, not dividend yields, and therefore does not measure total returns.

4. The divisor of the average must be recalculated over time because of numerous stock splits and stock dividends.
5. These divisor changes create problems in interpretation of the meaning of point movements in the average, especially in comparison with other equity market indices.

The interested reader is referred to the articles cited. This short paper will consider the last *two* problems, both of which center on the divisor and its effects on the meaning of point changes over time.

Calculation of the DJIA

Stock market indicators can be separated into several major types; weighted averages, geometric means, and arithmetic means. The latter can be weighted or unweighted. The DJIA falls into the latter group. It is a simple unweighted mean of the form:

$$X = \frac{\sum_{t=1}^{n=30} x_n}{n}$$

Each day when the market closes, the prices of each stock in the DJIA [p_t] are simply summed up and divided by the divisor. One might assume that that divisor was 30, since there are that is number of stocks in the average. As will be shown, that is a mistaken impression. The average, for example, on May 31, 2018 was:

$$DJIA = \frac{\sum_{t=1}^{n=30} p(t)}{0.14523}$$

Why the divisor on this day was 0.14523 and not 30, as one would logically expect, will be explained shortly. At the close of trading on May 31, 2018, the average stood at:

DJIA = \$3,546.14/0.14523 = 24, 415.84

Table 1: DJIA Closing Prices- May 31,2018

DJIA 30	PRICE	%	DJIA 30	PRICE	%
3M	197.25	5.6%	JPMorgan	107.02	3.0%
Amer Express	98.30	2.8%	McDonald	160.07	4.5%
Apple	186.87	5.3%	Merck	59.54	1.7%
Boeing	352.21	9.9%	Microsoft	98.84	2.8%
Catapillar	151.92	4.3%	Nike	71.81	2.0%
Chevron	124.28	3.5%	Pfizer	35.93	1.0%
Cisco	42.71	1.2%	Proctor & G	73.16	2.1%
Coca-Cola	43.00	1.2%	Travelers	128.56	3.6%
DuPont	64.12	1.8%	United Health	241.5	6.8%
Exxon	81.24	2.3%	United Tech	124.84	3.5%
GE	14.08	0.4%	Verizon	47.67	1.3%
Goldman	225.89	6.4%	Visa	130.73	3.7%
Home Depot	186.51	5.3%	WalMart	82.55	2.3%
Intel	55.20	1.6%	Disney	99.44	2.8%
IBM	141.30	4.0%	TOTAL	3,546.14	100.0%
John&Johnson	119.60	3.4%	*Source: Wall Street J, June 1, 2018*		

Table 1above lists all 30 stocks, their closing prices that day, and the summed prices and respective weights of each as a percent of the summed market prices.

The Divisor Problem

To explain why the divisor is 0.14523 and not 30, it is necessary and important to examine how stock splits and stock dividends affect the average. It helps to resort to a smaller example. Assume that there are only three stocks in the DJIA; Stock A, Stock B and Stock C. They closed on a Monday at $10, $6 and $5, respectively. That day the average would thus be:

$$DJIA = \frac{\$10+\$6+\$5}{3} = 7.00$$

After the close of trading, however, assume Company A announces a 2:1 stock split. Because the numerator of the equation is the summed market prices, the new average would, unadjusted for the split, would be:

$$DJIA = \frac{\$5+\$6+\$5}{3} = 5.33$$

The average thus indicates that the stock market declined. But that cannot be true even though the summed prices fell from $21 to $16. All that occurred was the stock split. The method of dealing with this problem historically, until 1928, was to change the divisor. Prior to that year, the split would have been handled by adjusting the divisor as follows: DJIA= [(2x6)+7+5]/3=8.00. After a period of time, this method got really cumbersome, and thus, a new method was introduced.

Starting in 1928, the method used by the Wall Street Journal was to construct a new divisor. The $\sum p(t)$ must produce the market average of 7.00:

$16/Divisor = 7.00
and

Divisor=$16/7.00 = 2.286

This new divisor will then apply to all further averages, until such time as there is another stock split. Apart from the problems of computing a new divisor each time a split in announced, a very real bias is introduced. To see why, assume that the next day Stock A advances to $6, Stock B advances to $7 and Stock C closes unchanged from the previous day. On Tuesday, the market is now at:

$$DJIA = \frac{\$6+\$7+\$5}{2.286} = 7.87$$

It does show that the average has increased, but it has biased the average downward. If no split was declared then the average would have been:

$$DJIA = \frac{\$12+\$7+\$5}{3} = 8.00$$

Since each post-split share advanced by $1, the pre-split equivalent would have risen by $2. Some would argue here that the split itself would cause a price increase in the post-split stock, and that, therefore, the pre-split stock would not have risen by $2. Carter and Cohen (1976), however, have argued that, except for a very real increase in the marketability of Stock A, there is no fundamental reason for the two post-split shares to sell at a premium (Shellback, 1976). The holder of shares now has two shares, each having one half the claim on income, earnings and dividends. Usually any increase in the post-split shares is an increase in dividends and the "news announcement" of the split along with other favorable news.

Ignoring the split, the average did go up from 7.00 to 8.00 or by one point. That point was equal to $1.00 since Stock A increased by $2 and Stock B rose by $1 [that is; (2+3+0)/3]. By revising the divisor for the split, it appears at the average price increase by $.87. Each subsequent adjustment (Carter & Cohen, 1967) will further systematically understate the index. Applied to the real DJIA, the bias is obviously not severe in the short-run, but it has been over a long-time horizon, since there have literally been hundreds of revisions since 1928 (Gritta & Seal, 1999).

The other event that has a significant impact on the DJIA's divisor is a stock dividend. Issuing a stock dividend is similar to declaring a stock split; with the major difference being how an accountant would record the two transactions. Otherwise, a 20% dividend will have the same impact on the DJIA as a 6:5 split; a 100% stock dividend is the equivalent of a 2:1 stock split.

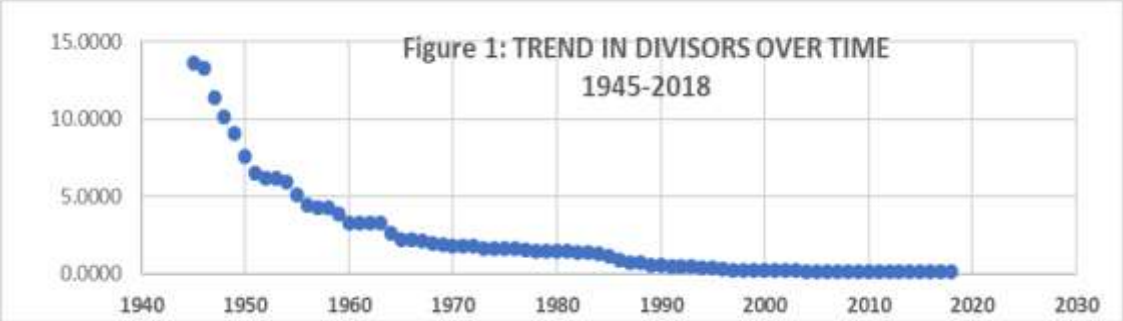
Table 2 summarizes many of the changes over the past nearly 90 years. The latest change was a reduction of the divisor to the current 0.14523.

Table 2: SAMPLE OF DIVISOR CHANGES OVER TIME: 1928-2015

DATE	NEW	OLD	REASON: SPLITS or SUBSTITUTIONS
2015	.1499	.1551	In: APPLE out: AT&T; VISA splits 4:1
2014	.1551	.1321	In: NIKE,VISA,GOLDMAN out: ALCOA, BofA, HP
2010	.1321	.1333	VERISON spinoff of SPINCO
2005	.1249	.1353	CAT(2:1), UNITED TECH(2:1)
2000	.1648	.2014	HP(2:1), CITICORP (4:3), INTEL(2:1),ALCOA(2:1),AMEXP(3:1),GE(3:1)
1995	.3460	.3715	INT.PAPER(2:1),ALCOA(2:1)
1990	.5051	.5860	BOEING(2:1),WOOLW(2:1),WESTERNELEC(2:1),COCACOLA(2:1) ,DUPONT(3:1)
1985	1.090	1.320	KODAK(3:2), IN: MCDONALDS and GENERAL FOOD Out: PHIL MORRIS, A
1980	1.431	1.465	ALCOA (2:1)
1975	1.588	1.598	ESMARK(5:4)
1970	1.826	1.894	PROCTOR & GAMBLE (2:1)
1965	2.245	2.615	UNAIRCRAFT(3:2),UNCARB(2:1),OWENSILL(2:1),KODAK(2:1).SEARS (2:1)
1960	3.280	3.824	INTPAPER(2:1),GENFOODS(2:1),AMTOB(2:1),WESTHOUSE(2:1),ALLC HEM(2:1)
1955	5.260	5.923	SEARS (2:1),GM(3:1),UAIRCRAFT(3:2),USSTEEL(2:1)GOODYEAR(2:1)
1950	7.540	8.920	P&G (1.5:1),NAT STEEL (3:1), ALLIEDCHEM (4:1). GM (2:1)
1945	13.60	15.10	LOEWS (3:1), WESTINGHOUSE (4:1), SEARS (4:1)
1930	10.38	9.850	In: BORDEN, KODAK, GOODYEAR out: AM SUGAR, AM TOBACCO, ATL.REFINING
1928	14.65	16.67	ATLANTIC REFINING (4:1), GM (2.5:1)

Source: For all divisor changes since 2000, see http://www.djaverages.com/docs-private/level2/djia-history-divisor.pdf For complete list of all changes from 1926 through 2000, see: Gritta & Seal (1999)

Figure 1 illustrates the history of all the divisor changes each year since 1940.



The non-linear relationship over time is very evident from this figure.

Interpretation of Market Movements

The adjustment or revision of the divisor has a corollary problem. It is twofold and it concerns; (a) the meaning of a point change on any specific day, and (b) the value of a one-point change over time. As noted above with the three-stock case, a one-point change signified a $1.00 change in the average stock price. Once Stock A split, however, the average stock appears to have only risen by $0.87. To convert a one-point change into the equivalent dollar value you must divide the divisor by 30, the number of stocks in the Dow.

The divisor on May 31, 2018, as noted above, was 0.14523. Thus, on that day, each one-point change was equal to:

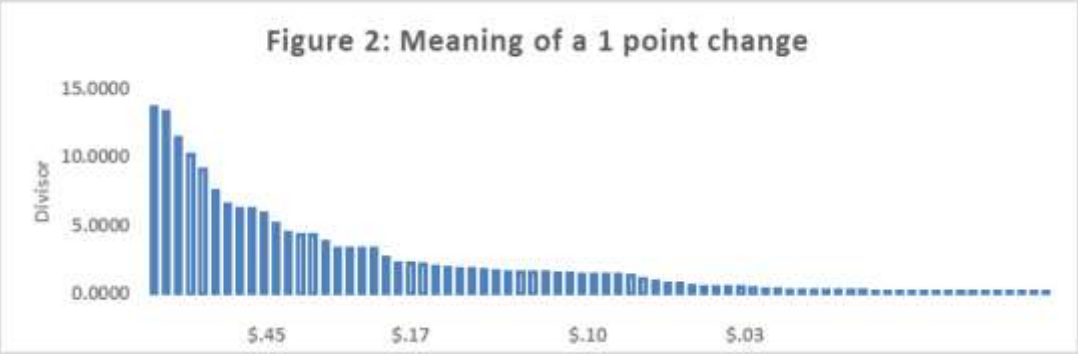
One-point change = Divisor/30 = 0.14523/30 = $0.00484

or less than half of a cent. If the market advanced 100 points on the following Monday, it would mean that the average stock only increased by only $0.48. There is a real disconnect between point changes and the meaning of those point changes. The second point is equally important. Stock dividends and splits occur frequently over time. The record is held by the year, 1999 (Gritta & Seal, 1999). There was a total of nine changes during that year. Table 3 shows the relationship of the divisor to a one-point change.

Table 3

If Divisor =	One Point =
16.28000	$.5426
10.00000	$.3333
2.00000	$.0670
1.00000	$.0330
0.14523	$.0048
0.10000	$.0033
0.01000	$.0003

Figure 2 plots all the changes in the value of each point since 1940 and Figure 3 isolates more recent changes. It is obvious that, as the divisor heads to zero [although it will never reach zero], the meaning of a one-point change will be virtually meaningless.



Conclusion

This short paper has discussed key flaws in the calculation of arguably the world's most widely watched index of stock market behavior. It was argued that the DJIA's method of dealing with stock dividends and stock splits presents two troublesome problems. The average may be biased downward over time, if either or both conditions are met according to Carter and Cohen (1976): (1) The stock rises more rapidly after the split/dividend than other stocks in the average, and/or (2) The stock, after the split/dividend falls more slowly than the other stocks in the average. Since it tends to be the growth type stocks which split or pay stock dividend, this further understates the true level of the average (Shellback, 1976).

It should be evident from this discussion that care should be used when interpreting movements in the average as revisions in that divisor become necessary, and the meaning of market movement changes with the recalculation of the divisor. It may be time to revise the calculation of the DJIA to a market cap-weighted average (similar to the Standard & Poor's 500), or a factor-weighted average based on dividend yield, Tobin's q, profitability, etc. More weight can be given to firms with stronger financial health (rather than stock price), or all stocks in the index can be equally-weighted, giving no preference to any firm in the index. Either way, the divisor issues will vanish when the DJIA moves off a price-weighted approach.

References

Carter, E.E. & K.J. Cohen. (1967). Bias in the DJIA caused by stock splits. *Financial Analyst Journal*, (Nov.-Dec.), 91.

Gritta, R. & seal, J. (1999). The Dow Jones Industrial Average: Statistical problems with an internationally watched index," *Journal of Foreign Exchange and International Finance*, XIII(4), 125-137.

Gritta, R., & Adams, B. (2016). Problems with the Dow Jones Industrial Average-A simple unweighted arithmetic mean: An issue re-revisited. *Global Review of Accounting & Finance*, VII (2), 20-35.

Schellback, L.L. (1967). When did the Dow top 1000? *Financial Analysts Journal*. (May-June), 72.