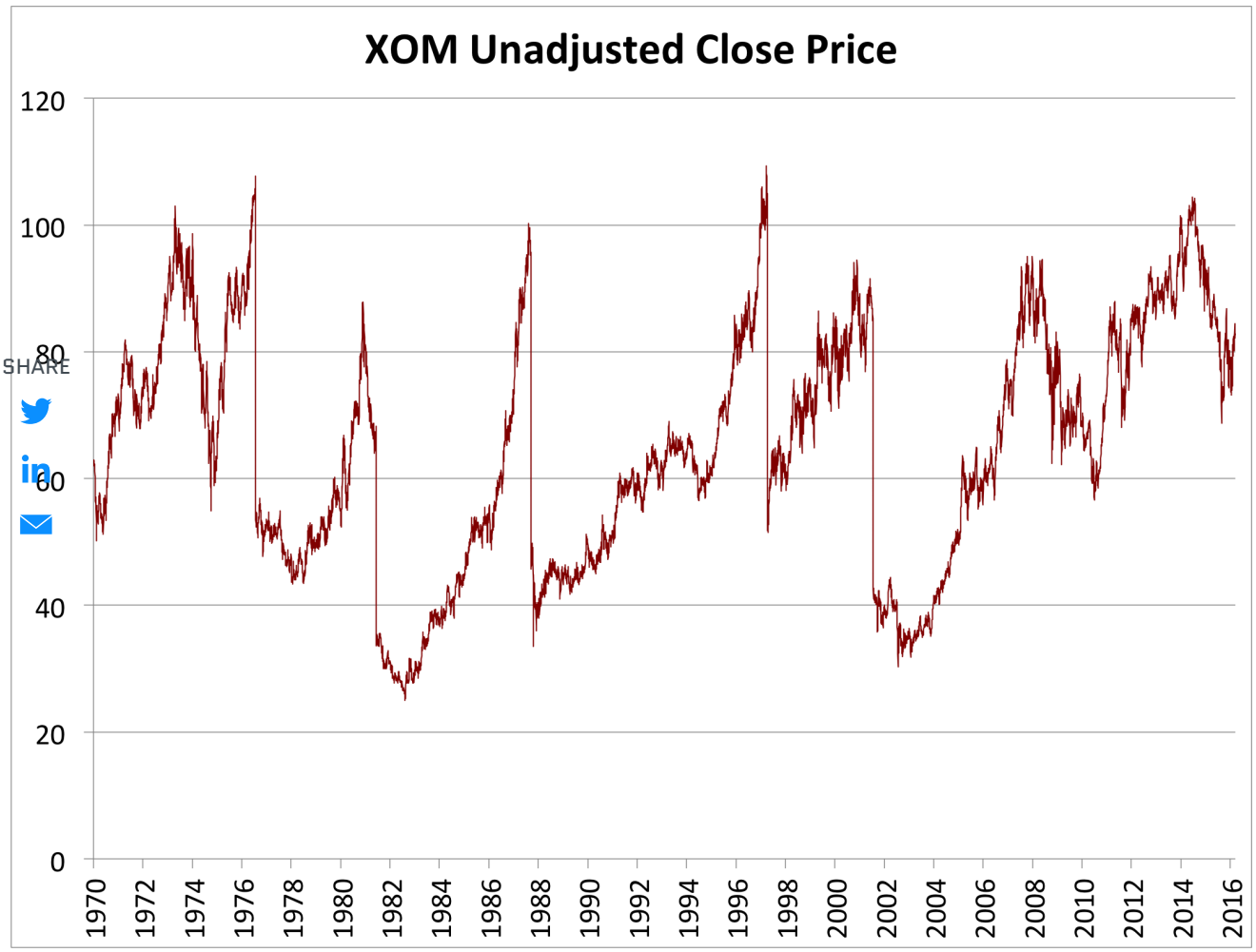
Below is a graph showing the unadjusted or nominal closing price of Exxon (XOM) stock every day since 1970.



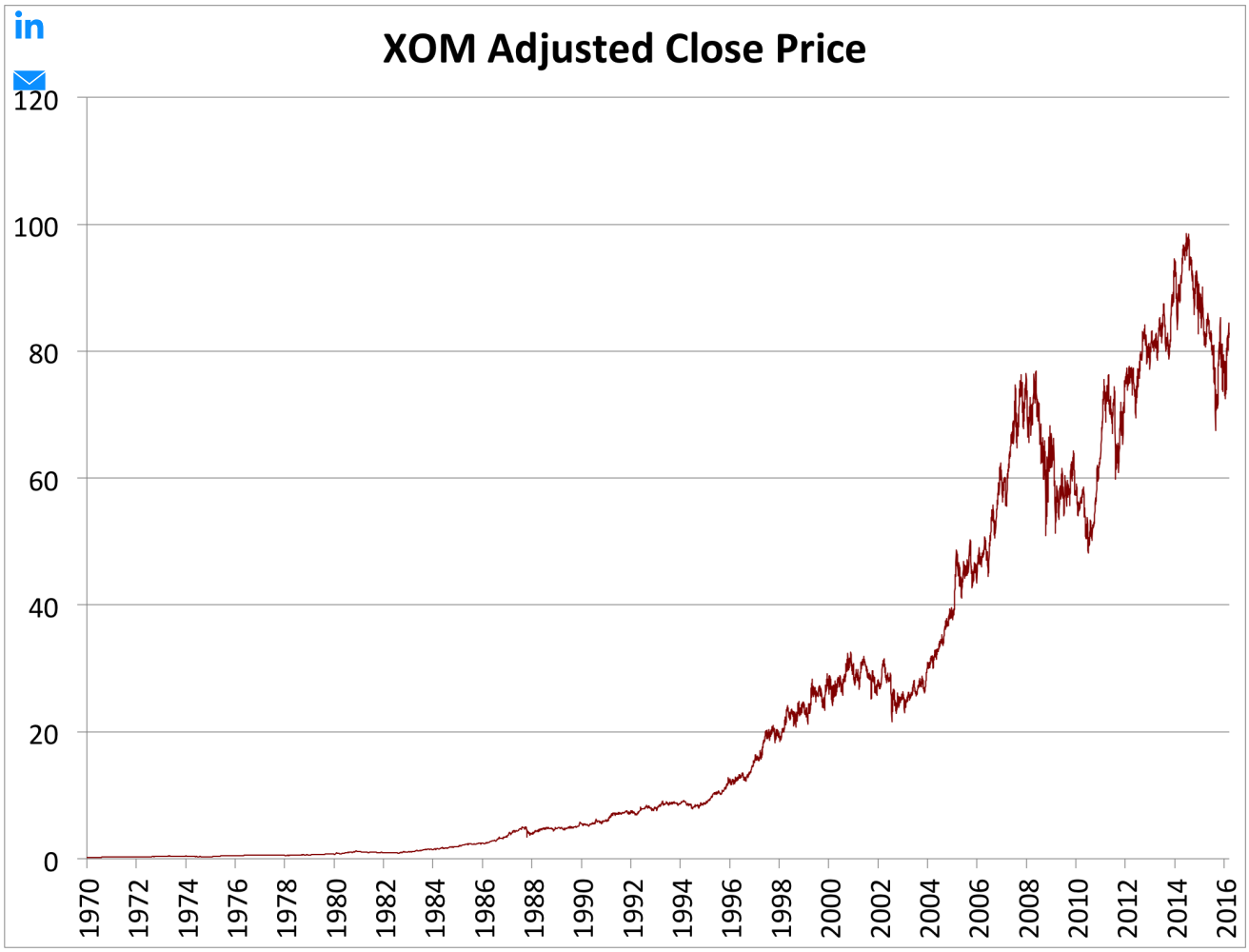
Of course, this graph says nothing about the returns an investor in Exxon would have achieved over this period, because the change in nominal stock price is only one part of the investment outcome. Over this span, Exxon paid hundreds of dividends, causing the stock price to go down on each occasion. Exxon split its shares five times, each time causing the share price to plummet. There were also several acquisitions and a merger with Mobil Oil in 1999 that impacted the stock price. Yet none of these events had any economic impact on shareholders; they were nominal in effect.

Time-series analysis of stocks demands that such purely nominal changes be adjusted for or eliminated. Historical stock prices must be transformed so that the data is indicative of the total return that would have been achieved from holding a particular stock over a particular period of time. The transformation must create a

series that reflects the dividends, mergers, spinoffs, splits and various other events that impact the stock's total return.

Every such event or change in a company's structure causes the nominal stock price to change discontinuously. And this stock price change is not due to buyers and sellers re-evaluating the worth of the underlying business; it is due to corporate action, not market action. These are what stock price adjustments are designed to eliminate.

Here is a graph showing the adjusted stock price of Exxon since 1970. It's very different! But it's much closer to "economic reality."



Any decent analyst knows that their analysis must always be conducted on adjusted stock prices. But there are few analysts who truly understand the financial mathematics required to actually do these adjustments. And while you can choose to rely on third-party providers to provide you adjusted stock prices, a proper understanding of how these adjustments are made is the hallmark of a great analyst.

Adjustment Principles

Stock prices are almost always backward-adjusted. This convention means that in any time series, the stock price for "today" matches the current exchange- traded price. All adjustments are applied to historical data and historical data alone.

Historical stock price adjustments are usually multiplicative. This ensures that the returns from holding a stock on non-adjusted days are unchanged by any stock price adjustment. This also ensures that historically-adjusted stock prices are never negative. Some providers do, however, use additive adjustments, resulting in negative stock prices.

The following sections describe the most popular corporate actions and how to adjust stock prices for each of them.

See related databases: the EOD stock price database and the ZEP back-testing price database.

1. Cash Dividends

When a company pays a cash dividend, its total value goes down by the amount of cash paid out. (This makes intuitive sense: the cash has been transferred from the company's coffers to the pockets of its shareholders, hence the company is worth that much less). The nominal share price then goes down by the dividend per share, on the ex-dividend date.

$$\text{Share Price before Dividend} = \frac{\text{Company Value}}{\text{Shares Outstanding}}$$

$$\text{Share Price after Dividend} = \frac{\text{Company Value} - \text{Total Cash Paid Out}}{\text{Shares Outstanding}}$$

$$= \frac{\text{Company Value}}{\text{Shares}} - \frac{\text{Cash Paid Out}}{\text{Shares}}$$

$$= \text{Share Price before Dividend} - \text{Dividend per Share}$$

To create a consistent time series of adjusted stock prices, we calculate an "adjustment factor" that encapsulates the drop in the share price, and then divide all pre-dividend prices by that adjustment factor.

$$\text{Adjustment Factor} = \frac{\text{Close Price on Dividend Date} + \text{Dividend per Share}}{\text{Close Price on Dividend Date}}$$

Since the adjustment factor is a constant multiplicative change, it does not affect the stock's return profile over history. At the same time, this factor ensures that the measured return on the dividend date is due to actual market action, and not only due to the dividend.

Here is an example of the dividend adjustment factor at work:

Apple (AAPL) had a dividend of $0.47 that went ex-dividend 2014-08-07. Its close price that day was $94.48.

The adjustment factor is calculated as:

$$\text{F} = \frac{94.48 + 0.47}{94.48} = 1.00497$$

The unadjusted close price for the previous day was $94.96.

The adjusted closing price for the previous date is then:

$$\text{P}_{adj} = \frac{\text{P}_{unadj}}{\text{F}} = \frac{94.96}{1.00497} = 94.49$$

The same multiplicative adjustment is used for all days prior to the dividend date. Hence the entire history of the stock "changes" due to the dividend issuance.

"Capital Repayments" and "Special Dividends" are both special cases of cash dividends, and are treated in exactly the same way when it comes to price adjustments.

2. Stock Dividends

Sometime companies pay out dividends in the form of stocks. Each shareholder receives new shares in proportion to the shares they already own.

The effect of this action is to decrease the value of each share, by exactly the ratio at which new shares are issued. The company's total value is unchanged, but the number of shares outstanding has increased so the per-share price decreases. At the same time, note that the ownership percentage and hence the dollar value of each shareholder's holding remains unchanged.

$$\text{Share Price before Dividend} = \frac{\text{Company Value}}{\text{Shares Previous}}$$

$$\text{Share Price after Dividend} = \frac{\text{Company Value}}{\text{Shares Previous} + \text{Shares Issued}}$$

$$= \frac{\text{Company Value}}{\text{Shares Previous}} \times \frac{\text{Shares Previous}}{(\text{Shares Previous} + \text{Shares Issued})}$$

To create a consistent time series, as before, we calculate an "adjustment factor" that encapsulates the drop in the share price, and then divide all pre-dividend prices by that adjustment factor. The adjustment factor in this case is simply the second term in the equation above, viz, the dilution suffered by all shareholders.

$$\text{Adjustment Factor} = \frac{\text{New Float}}{\text{Old Float}}$$

$$= \frac{\text{Shares Previous} + \text{Shares Issued}}{\text{Shares Previous}}$$

As before, since the adjustment factor is multiplicative and not additive, it has no effect on returns; it simply acts as a "scale change."

Here is an example of the stock dividend adjustment factor at work:

BIOL had a 0.5% stock dividend effective 2014-03-12. A stock dividend of 0.5% means that for every share an investor held prior to the dividend, they would receive 0.005 (=0.5%) new shares. More correctly, for every 200 shares owned pre-dividend, the investor would get 1 new share.

Then, by construction:

$$\text{New Float} = 1.005 \times \text{Old Float}$$

Hence:

$$\text{Adjustment Factor} = \frac{\text{New Float}}{\text{Old Float}} = 1.005$$

The unadjusted share price on the day before the dividend was 2.83.

The adjusted close price for the previous date is then:

$$\text{P}_{adj} = \frac{\text{P}_{unadj}}{\text{F}} = \frac{2.83}{1.005} = 2.8159$$

Note that the close price on the dividend date does not feature in this calculation.

Stock Dividends are also sometimes referred to as “Bonus Issues.”

3. Stock Splits

Stock splits are similar to stock dividends. In a stock split, each existing stock is converted to multiple stocks, at a fixed ratio. This is exactly equivalent to every shareholder getting new shares in proportion to the shares they already own, which is the scenario for stock dividends.

The adjustment factor for stock splits takes the same form as for stock dividends:

$$\text{Adjustment Factor} = \frac{\text{New Float}}{\text{Old Float}}$$

Here is an example of a stock split:

Chesapeake Utilities Corp. (CPK) had a 3-for-2 split on 2014-09-09. This means that for every 2 shares owned before the split, shareholders owned 3 shares after the split.

Thus they were granted an incremental 1 share for every 2 shares owned pre-split; this is exactly equivalent to a 50% stock dividend.

In this case,

$$\text{New Float} = \frac{3}{2} \times \text{Old Float}$$

Hence:

$$\text{Adjustment Factor} = \frac{\text{New Float}}{\text{Old Float}} = 1.5$$

The unadjusted share price on the day before the split was 69.41.

The adjusted share price for the previous date is then:

$$\text{P}_{adj} = \frac{\text{P}_{unadj}}{\text{F}} = \frac{69.41}{1.5} = 46.273$$

Stock Splits are also sometimes referred to as “Bonus Issues.”

4. Reverse Stock Splits

A reverse split is exactly the same as a split, except that shareholders are left holding fewer shares than before. Instead of shareholders being granted new shares in proportion to their ownership, a reverse split sees shareholders give up a part of their existing shares, in proportion to their ownership.

Since the total number of shares outstanding after a reverse split decreases, the share price increases. The company’s value does not change in this corporate action.

As before:

$$\text{Adjustment Factor} = \frac{\text{New Float}}{\text{Old Float}}$$

Therefore, a reverse split has an adjustment factor less than 1.

Here is an example of a reverse split:

PostRock Energy Corp. (PSTR) underwent a 1-for-10 reverse split on 2015-01-05.

$$\text{New Float} = \frac{1}{10} \times \text{Old Float}$$

Hence:

$$\text{Adjustment Factor} = \frac{\text{New Float}}{\text{Old Float}} = 0.1$$

The unadjusted share price on the day before the reverse split was 0.4442.

The adjusted share price for the previous date is then:

$$\mathrm{P}_{adj} = \frac{\mathrm{P}_{unadj}}{\mathrm{F}} = \frac{0.4442}{0.1} = 4.442$$

Reverse Stock Splits are also known as “Consolidations.”

See related databases: the EOD stock price database and the ZEP back-testing price database.

5. Spinoffs

In a spinoff, a company splits itself into two pieces: the original or parent company, and a smaller spinoff or child company. Shareholders of the parent company get shares in the child company in proportion to their parent-company ownership.

A spinoff is economically equivalent to a dividend payout, with one exception. Instead of being paid in cash or parent- company stock, shareholders are given child-company stock.

The share price of the parent company during a spinoff acts in exactly the same manner as the share price of a company issuing a dividend. The value of the parent [issuing] company falls by the value of the child company [dividend paid].

$$\text{Share Price before Spinoff} = \frac{\text{Parent Company Value}}{\text{Shares Outstanding}}$$

$$\text{Share Price after Spinoff} = \frac{\text{Parent Company Value} - \text{Child Company Value}}{\text{Shares Outstanding}}$$

The value of the child company is easy to compute: it is the stock price of the child company on the spinoff date, multiplied by the number of child company shares outstanding.

To create a consistent time series, we must therefore add back the value of the child company, on a per-share basis.

$$\text{Adjustment Factor} = 1 + \frac{\text{Child Price} \times \text{Child Shares}}{\text{Parent Price} \times \text{Parent Shares}}$$

Economically, this is as if the shareholders sold their child company holdings immediately after the spinoff, and invested the proceeds back in the parent company.

It is important to synchronize the sale and investment actions, to avoid distortions caused by changes in the overall level of the market. Most stock data providers use open-versus-open buy/sell; some use close-versus-close.

Note that price discovery can occur between the opening quotes on a spinoff date, and the closing prices. This is a second-order effect that stock price adjustments do not capture.

Here is an example of the price adjustment for a spinoff:

Automatic Data Processing Inc. (ADP) spun off CDK Global Inc. (CDK) on 2014-10-01. ADP shareholders were given 1 share of CDK for every 3 shares of ADP they held.

Hence:

$$\frac{\text{Child Shares}}{\text{Parent Shares}} = \frac{1}{3}$$

ADP's open price on the spinoff date was 73.03 and CDK's open price on the same date was 30.13.

Hence:

$$\text{Adjustment Factor} = 1 + \frac{\text{Child Price} \times \text{Child Shares}}{\text{Parent Price} \times \text{Parent Shares}}$$

$$= 1 + \frac{30.13 \times 1}{73.03 \times 3}$$

$$= 1 + 0.13752$$

$$= 1.13752$$

ADP's unadjusted close the day before the spinoff was 83.08.

Hence the adjusted close pre-spinoff is:

$$\mathrm{P}_{adj} = \frac{\mathrm{P}_{unadj}}{\mathrm{F}} = \frac{83.08}{1.13752} = 73.036$$

Spinoffs are sometimes referred to as "Reverse Mergers."

6. Mergers and Acquisitions

Mergers see two companies join to form a single larger company.

The vast majority of mergers are actually acquisitions, in which one company acquires the other. Typically, the acquirer pays for the acquisition using cash, stock or a mixture of the two.

If the acquisition is done solely with cash, the acquirer's share price requires no adjustment. The acquirer has merely replaced one asset on its balance sheet (cash) with another, equal-valued asset (the acquired company). There is no change to either the value of the company or the shares outstanding so no event-driven adjustment needs to be made to its stock price.

More often, and especially for larger acquisitions, there is some stock component to the deal. In these cases, what typically happens is that the acquirer offers to exchange its shares for the acquiree's shares, at a given conversion rate (defined by the terms of the acquisition).

This causes a dilution of the acquirer's share table. Since this dilution is exactly counter-balanced by the addition of new assets (the acquired company) to the acquirer's balance sheet, no adjustment is required for historical stock prices.

Note that the above dilution only occurs in cases where the acquirer issues new shares in order to finance the acquisition. In some cases, the acquirer uses existing shares from the company treasury. These cases are similar to cash-financed acquisitions: the acquirer is merely replacing one asset (owned shares) with another (acquiree company). Again, no adjustment factor is required is here.

In all the above cases, the returns accruing to a shareholder in the acquiring company are fully captured by changes in its nominal share price. As a result, mergers and acquisitions do not require any adjustments to the acquiring company's stock price history.

7. Buybacks

During a buyback, a company offers cash to its existing shareholders in exchange for the stock they own. The company then retires the shares bought.

The retired shares cause a reduction in the company's float. However, this reduction is exactly counter-balanced by a decrease in the company's assets (viz. the cash paid out to buy the repurchased shares). Hence there is no change implied and no adjustment to be made to the share price.

Buybacks are also often referred to as "Share Repurchases."

Implementation Challenges

Even a brief overview of stock price adjustments suggests the scale of work required to maintain a bias-free collection of correctly-adjusted historical stock price data. While not conceptually complex, there is a large amount of tedious, meticulous, painstaking effort that goes in to any properly constituted stock price data base.

Dividends alone accounted for over 20,000 corporate actions in 2015. And they are just one class of corporate action. There are many more: splits, mergers, rights issues, buybacks, reverse splits, consolidations, acquisitions, treasury repurchases