The Undergraduate Statistics Project that Consistently Outperforms 82% of Actively Managed Mutual Funds (and all of the DJIA Index Funds)

By: Spencer Sargent

The Complaint

"At T. Rowe Price, our collaborative global research process helps us better understand the connections of a complex, global economy, so we can make the best decisions about where to invest your money. It's just one of the reasons why over 70% of our funds beat their 10-year Lipper average as of 3/31/13."

One of the most frustrating aspects of the investment industry is the reliance on relative performance as opposed to absolute performance. For example, a mutual fund will be considered "high performing" if they only lose 10% when the market loses 20%, yet it will be considered "low performing" or "underperforming" when it increases 10% while the rest of the market increases 20%. My frustration stems from the core purpose of investing – capital appreciation. A portfolio that increases 5% will earn you a 5% return on your invested capital, regardless of whether the market decreases 500% or increases 1000%.

Furthermore, with the high reliance on "beating the market", most mutual funds and money managers are scared to deviate from the benchmark they are expected to beat. Because of this, mutual funds have an average 3-year R^2 value of 90.82.[1] This means that roughly 91% of the average mutual fund's performance can be explained by the benchmark index. That is what I call 9% creativity on the fund manager's part!

Over the last 3 years, the S&P 500 (benchmark index) has had an average (annualized) return of 12.29%. To show that the "high performing" mutual funds are not all that "special" (based on correlation to the market), I narrowed down the list of equity mutual funds to contain only those that had an average (annualized) return of 12% or greater over the past 3-years.[2] The R^2 figure for this calculation was fractionally *higher* at 90.89!

This is exactly why mutual fund managers prefer a nearly complete mirror of the benchmark index – they have the highest chance of beating the market, but *more importantly, this gives them the lowest chance of underperforming the market*. This goes back to my original complaint: mutual fund managers are more concerned with "beating the market" than they are appreciating capital – the main purpose of investing.

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[1] Source: Scottrade–Figure derived from a sample of 9,213 equity-only mutual funds

[2] Perhaps most telling is that only 29.39% (2,708 out of 9,213) of mutual funds beat the S&P 500 benchmark over a 3-year period

The Question

Can a relatively basic quantitative model be built to consistently outperform the market, and as a result, consistently outperform over 70% of mutual funds?

Relevancy

This question is very relevant to asset managers today as people are constantly looking for new ways to outperform the market. There are essentially two mutual fund types on the market today – index-based and actively managed.

Index mutual funds and exchange-traded funds (ETFs) are intended to mirror the performance of a financial index (before expenses), such as the Dow Jones Industrial Average (DJIA), S&P 500, or Wilshire 5000. Index funds are generally hailed for their low costs, simplicity, low turnover rates (beneficial for tax purposes), and do not drift in investment style. The main disadvantage of index funds is their inability to outperform the index – the main reason many people turn to actively managed funds.

This leads us to the second type of mutual fund – those that are actively managed. Unlike index funds, managed funds have an investment manager, called the portfolio manager, who trades based on a specific investment style. Their focus may be towards a specific sector (healthcare, industrials), a specific market capitalization (companies with a market-cap $2B), or a specific investment style (value or growth). The latter two options are oftentimes morphed together to form a conglomeration of the two (such as a Mid-Cap Value Fund). The main advantage of actively managed funds is their potential to outperform the market. However, going back to my original point, over 82% of actively managed portfolios underperformed their benchmark.[3] The disadvantages of a managed fund, aside from their historical record, is their high fees (to pay the manager and employees), lack of consistency, and portfolio turnover rates that are generally higher than that of index funds (tax inefficient).

But what if there was a third option – one that had low costs, a fixed investment style, *and* a historical record that consistently outperforms the index? The type of mutual fund I am referring to is one that has not yet been invented – one that trades solely on quantitative data. As long as it can consistently outperform the market based on historical data, a fund of this type has the potential to revolutionize the industry. Let's get started.

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[3] Source: Morningstar Principia through June 30, 2010

Data Collection/Discussion

While "quantitative analysis" certainly has an academic ring to it, I intend to consistently "beat the market" using only one financial metric: price-to-earnings ratio. More specifically, I will be utilizing the TTM P/E ratio. This ratio uses the net income for the most recent 12-month period, divided by the weighted average number of common shares in issue during the period. The TTM P/E ratio (henceforth referred to as "P/E") is computed the following way:

P/E = (Price per share / Earnings per share)

I chose P/E ratio because it is relatively easy to calculate, and it is one of the best indicators of *shareholder value* when purchasing a stock. This is because it normalizes the historical value of a company by dividing its share price by its earnings per share. Everything else equal, a stock with a lower P/E ratio is more attractive than a stock with a higher P/E ratio.

Some may argue that I should have chosen a slightly more advanced ratio, such as the price-to-earnings-to-growth (PEG) ratio. This ratio takes into account not only the P/E ratio, but further normalizes that ratio by dividing the P/E ratio by the annual EPS growth. I chose not to use the PEG ratio because the annual EPS growth changes at a much faster rate than the annual EPS alone due to the fact that annual EPS growth is the derivative of annual EPS. This means that even slight changes in the annual EPS are magnified, and thus give an inaccurate measurement of value at any given period of time. Put simply, EPS does not fluctuate very much while the % change of the EPS does.

Most importantly, however, is that the TTM P/E ratio is one that is based on historical earnings and current price. This means that the P/E ratio for 12/31/2003 was readily available on that date and does not rely on any forward-looking data.

To test "the question", I will gather the current price of the DJI components as of April 15, 2013, as well as the P/E ratio and price of each DJI component on:

– December 31, 2003
– December 31, 2008
– December 31, 2010

From this, I will be able to derive:

–10-year performance (from 2003 to 2013)
– 7-year performance (from 2003-2010)
– 5-year performance (from 2003-2008)
– 5-year performance (from 2008-2013)
– 3-year performance (from 2010-2013)
– 2-year performance (from 2008-2010)

Analysis

To analyze this data, I will be comparing the results of a quantitatively based portfolio to that of the Dow Jones Industrial Average (DJIA). While in reality, the DJIA is a price-weighted index (each component makes up a fraction of the index that is proportional to its price); I will be using an *evenly distributed* variation of the DJIA. This means that each component will make up $1/30^{th}$ of the portfolio, regardless of price or market capitalization. While this weighting method makes less sense than a capitalization-weighted indexing method, it is arguably more sensible to use an evenly distributed index-weighting method than the price-weighted method of the DJIA (but that can be an argument for a different day).

Throughout the rest of the project, I will refer to 2 different portfolios. The first is the evenly distributed DJIA, which will represent the index, or "benchmark". This benchmark is what I aim to outperform using the second portfolio. The second portfolio will be referred to as the "P/E adjusted portfolio". The composition method of this portfolio will be discussed in the following section.

Descriptive Statistics

The process for computing the make-up of the P/E adjusted portfolio is as follows:

1. Create list of all 30 DJIA components
2. List P/E ratios of all components for historical test start date
3. Compute average P/E ratio of all 30 DJIA components using Step 2
4. Omit all components with a negative P/E ratio
5. Omit all components with a P/E ratio greater than or equal to the average
   The remaining components make up the P/E adjusted portfolio

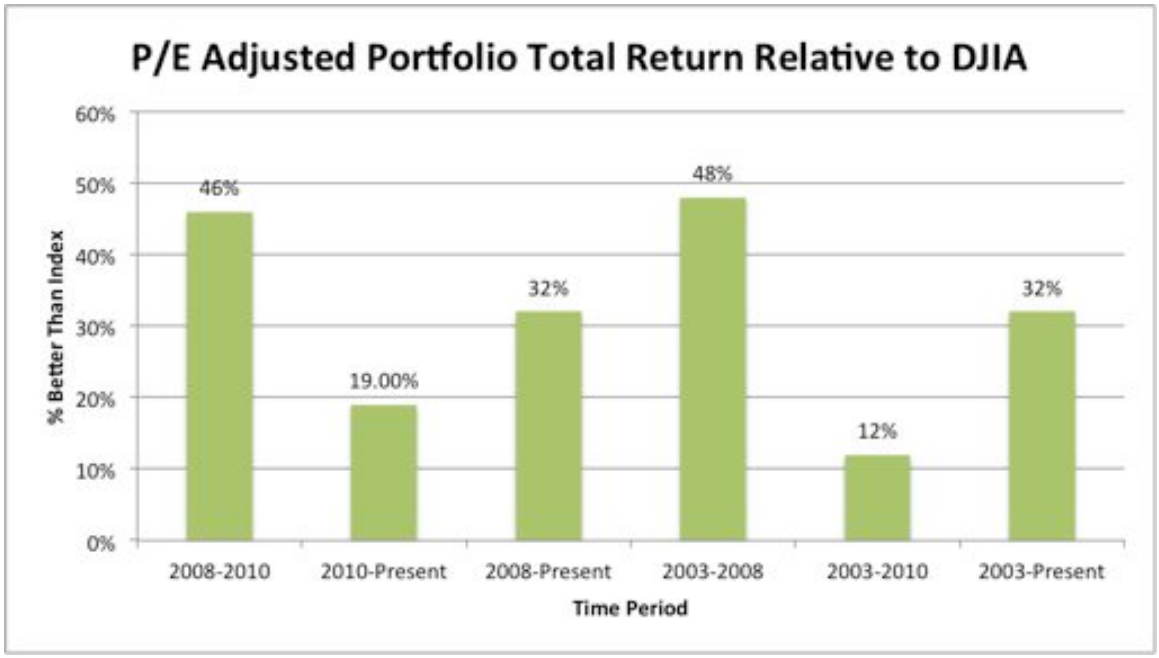
The process for computing the performance of the two portfolios is as follows:

6. List prices of all components for historical test end date
7. List prices of all components for historical test start date
8. Compute the Gain/Loss using Steps 6 and 7 above
9. Compute DJIA portfolio return using the average of all 30 values from Step 8
10. Compute P/E adjusted portfolio return using the average of remaining components after Step 5 above

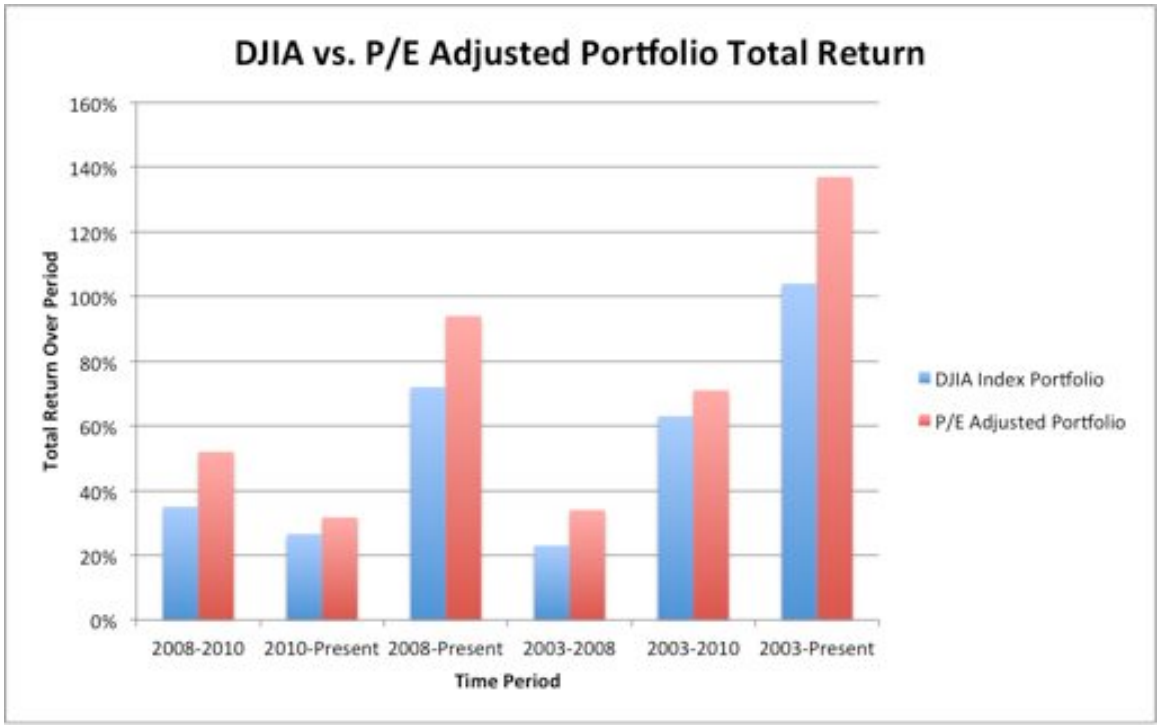
The results of this 10-step process are compared in 3 ways:

1. Percentage *points* better/worse than index
   a. Ex: 4% return and 8% return = 4 percentage points better
2. Percent better/worse than index
   a. Ex: 4% return and 8% return = 100% better)
3. Annualized performance of DJIA
   a. Ex. 5-year total return of 34% = average (annualized) return of ~6%

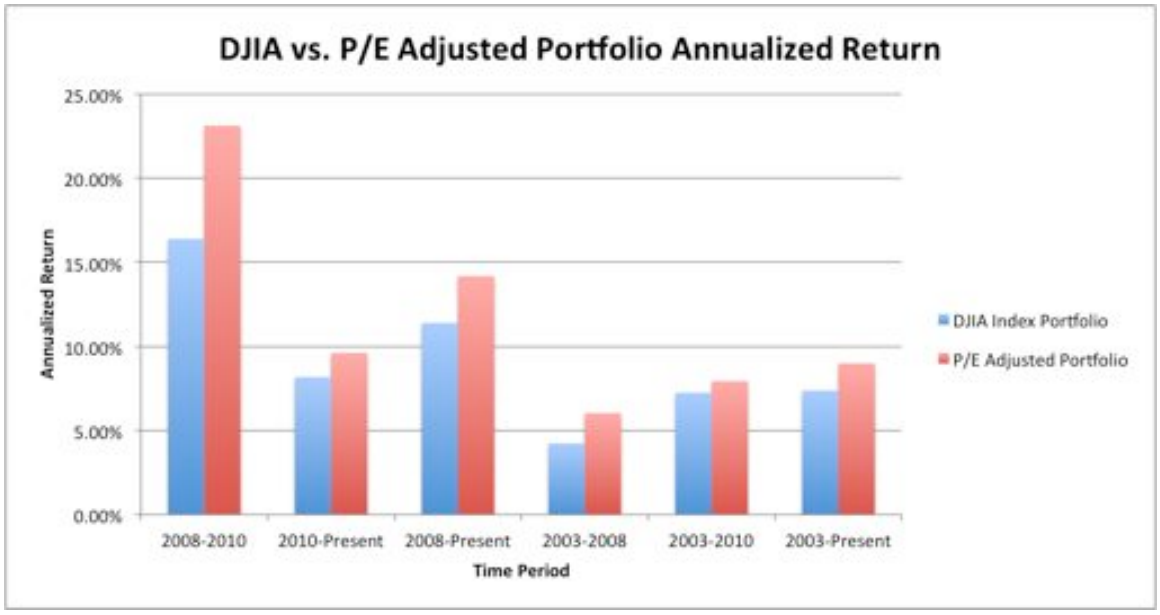
The following charts represent the results of Steps 1 to 10 above. They are compared in the 3 ways listed above:



Not only does the P/E adjusted portfolio consistently outperform the DJIA benchmark it *nearly doubles* it over two of the six selected time periods.



The P/E adjusted portfolio outperforms the total return of the DJIA benchmark by as much as 33 percentage points (between 2003 and 2013)



This chart is possibly the best indicator of P/E adjusted portfolio performance versus DJIA benchmark performance because it take the total return over varying time periods and normalizes it to 1-year using the geometric mean

	P/E Adjusted Annualized Return over Benchmark
2008-2010	41%
2010-Present	18%
2008-Present	24%
2003-2008	43%
2003-2010	9%
2003-Present	22%
Average	**26%**
Standard Deviation	**13%**

This chart presents the annualized performance of the P/E adjusted portfolio relative to the DJIA benchmark. The average return of this elementary P/E portfolio adjustment method yields additional annualized gains of 26% on average across the 6 sample periods

This chart shows the actual comparison of $10,000 invested in the P/E adjusted portfolio versus the DJIA benchmark. In this period, the P/E adjusted portfolio will have a net surplus of $396.50 (assuming $10,000 invested) over the DJIA benchmark. For this example, the price increase/decrease was tracked on a monthly basis

Portfolio Alpha

Alpha is a component of the capital asset pricing model (CAPM) that measures the risk-adjusted returns of a portfolio relative to the benchmark. The excess return of the fund relative to the return of the benchmark is the fund's alpha. For example, if a CAPM analysis estimates that a portfolio should earn 10% based on the risk of the portfolio but the portfolio actually earns 15%, the portfolio's alpha would be 5%. This 5% is the excess return over what was predicted in the CAPM. Alpha is computed using the following equation:

$$\text{Alpha} = r_s - r_f + \beta\,(r_b - r_f)$$
$$\text{Where } \beta = [\text{Covariance}\,(r_s, r_b)] \,/\, [\text{Variance}\,(r_b)]$$

Variables:
r_s = expected portfolio return
r_f = the risk-free rate (monthly)
β = portfolio beta (volatility of the portfolio vs. benchmark)
r_b = market return

For this example, I will compute the monthly alpha of the portfolio based on the adjusted closing price of all DJIA components as well as the adjusted closing price of the P/E adjusted portfolio. The adjusted closing price (adjusted for dividends and splits) is recorded on the first trading day of each month from January 2011 to April 2013.

To see the actual calculation, refer to Excel spreadsheet "DJIA Component Prices" sheet "ALPHA". The results are presented below:

Monthly Alpha of P/E Adjusted Portfolio vs. DJIA Benchmark Over 3-year Period	
Covariance	0.134%
Variance	0.141%
Monthly Risk-Free Rate (arbitrary)	0.001%
Beta	0.951
Monthly Alpha	0.2%
Annualized Alpha*	2%
3-Year Alpha*	6%

* It is generally unwise to extrapolate monthly Alpha to longer periods because the standard deviation (risk) changes over time. It is included for comparison purposes.

This chart shows that, not only does the P/E adjusted portfolio outperform the DJIA benchmark portfolio over this period; the risk-adjusted returns of the P/E adjusted portfolio are superior to that of the DJIA benchmark portfolio.

Inferential Statistics

The essential question stemming from my complaint is the following: is this P/E adjusted portfolio strategy replicable? While it is impossible to predict the future, we can estimate the lowest (LCL) and highest (UCL) value for the population mean based on the annualized returns of our P/E adjusted portfolio relative to the DJIA benchmark. For this example, the population mean is defined as the long-term percent gain/loss of the P/E adjusted portfolio relative to the DJIA benchmark. Therefore, our hypothesis is as follows:

$$H_0: \mu = 0\%$$
$$H_1: \mu > 0\%$$

To see this calculation, refer to Excel spreadsheet "DJIA" sheet "interval estimator" and sheet "hypothesis testing".

With a 5% significance level (alpha = 0.05), we can estimate that the population mean falls between 14.39% and 34.73%. These two figures represent the lower confidence level (LCL) and upper confidence level (UCL). The value of the one-sided t-test statistic is 2.83. Based on the p-value (0.018), we can reject the null in favor of

the alternative hypothesis at the alpha = .05 level. In layman's terms, this analysis infers that the performance of the P/E adjusted portfolio consistently outperforms its benchmark (the DJIA index).

Conclusion

Based on our data and analysis, we can infer that a P/E adjusted portfolio that includes all the components of an index, less:

– Those with a P/E ratio less than or equal to zero AND
– Those with a P/E ratio greater than or equal to the average P/E ratio of the index

…will consistently beat its benchmark index. Furthermore, this elementary value-based portfolio composition will effectively outperform over

Final Thoughts

There are 3 known flaws of this analysis. Starting with the flaw of most significance:

1. The *historical* components of the DJIA for this test were based on the *current* components of the index. A total of 6 of the DJIA components have changed since 2003, 3 components have changed since 2008, and 1 component has changed since 2010. However, this analysis is based off of the fact that an adjusted P/E portfolio will outperform its benchmark, regardless of whether the chosen components are part of an index or not.
2. Only the DJIA components were tested. There may be a significantly different result with a larger sample size such as the S&P 500. However, for purposes of simplicity, the DJIA was used. As much as I like data analysis, there is nothing fun about importing 10 years of stock data into Excel from 500 different companies.
3. As has been mentioned throughout this report, the indexing method I used is evenly distributed (each component has an equal weighting) while the actual DJIA is price-weighted. In the long-term, however, this has little effect on the results. This is because I compared the returns of the P/E adjusted portfolio (evenly distributed) to that of an evenly distributed variation of the DJIA.

I am interested in continuing this analysis, especially with other variables (such as P/S ratio, PEG ratio, etc.) to see the historical performance of a ratio-adjusted portfolio compared to its benchmark. I would also like to explore the historical portfolio turnover rate that maximizes relative performance (eg. How often should the ratio-adjusted portfolio be readjusted based on new information).

In conclusion, I strongly believe that a quantitative-based fund trading on metrics as elementary as TTM P/E ratios can create a new class of funds between actively-managed funds and index funds; all while reaping the benefits of both.