The Dividend Puzzle Decompose: Influence of Taxes and Application in Short-term Trading Signal

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Abstract

In this paper, we revisit the classic behavioral finance topic known as the "dividend puzzle". Our analysis starts with examining the different dividend preferences before and after the 2003 Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) in the United States. The results confirm the expectation that the dividend puzzle is less significant after the reform. To explain this shift, tax-based theories argue that the tax benefit is no longer significant for a long-term capital gain compared with a cash dividend. Although less significant, the dividend puzzle still exists based on analysis of different markets. To understand other factors driving this observation, we investigate the impact of various company structures, long-term dividend yield trend, and market conditions on ex-post dividend price changes. Based on the conclusions, a discretionary strategy is constructed to build a dividend robust portfolio.

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Chapter 1

Introduction

In a frictionless market, a stock price should fall by the same amount as the dividend on an ex-dividend day. However, empirical results show that on average the price declines less than the dividend, potentially producing a positive ex-day return.

In this thesis, this classic behavioral finance topic known as the "dividend puzzle" is revisited. Our analysis is targeted at comparing the dividend puzzle before and after the 2003 US tax reform and exploring the driving factors which could benefit discretionary trading. In chapter 2, we review the existing papers about this topic and how institutional investors exploit opportunities of positive ex-dividend-day returns. In chapter 3, we introduce our data sources and provide the descriptive statistics of the data. In chapter 4, we explain our methodology and selection of explanatory factors related to the dividend puzzle. In chapter 5, we argue that although a large part of abnormal returns on the ex-dividend day can be explained by the taxation hypothesis, the dividend puzzle is still significant after mitigating the tax differentials between dividend and capital gains. To demonstrate our argument, we attach back-testing results on a paper portfolio. Finally, we conclude and propose the future work in chapter 6.

Chapter 2

Literature Review

Without considering trading costs and taxes, stock prices are supposed to drop by the same amount as the dividend paid on an ex-dividend day. However, decades of empirical research have concluded that the stock price drop differs from the dividend payout on the ex-dividend day. Among all previous studies that have tried to explain the dividend puzzle, we selected the most popular theories that are relevant to our research.

2.1 Taxation (Elton and Gruber 1970)

Elton and Gruber (1970) [1] studied the New York Exchange market index and observed that the average drop of stock prices relative to dividend amount on the ex-dividend day is 0.7767, smaller than the theoretical value of 1. They explained that the due to the higher taxation of dividend income than capital gains, stock prices fall less than the dividend payout on the ex-dividend day.

Elton and Gruber also studied stock price behavior on the ex-dividend day and derived the marginal stockholder's tax brackets. Based on that, they further illustrated one rationality that compared to those in lower tax brackets, investors who are in higher tax brackets have a preference of capital gains over dividend income.

2.2 Cost of Trading and Associated Risk

Subsequently, several studies challenged the taxation hypothesis as a cause of the differentiation between the stock price drop and the dividend payout on

the ex-dividend day. Partially after the 2003 tax reform which reduced taxation of dividend income so that the tax advantage of capital gains became negligible, the taxation hypothesis was less tenable to explain the extent dividend puzzle.

2.2.1 Short-Term Trading and Transaction Costs (Kalay 1982)

Kalay (1982) [2] re-examined stock price behavior by adjusting the closing prices on the ex-dividend day and challenged Elton and Gruber's taxation hypothesis by arguing that the marginal tax rates of stockholders cannot be inferred; therefore, the ex-dividend day behavior of stock price is not necessarily evidence of a tax effect. On the other hand, he supported the hypothesis that short-term trading along with transaction costs eliminates profit potential for short-term traders.

2.2.2 Tick Size (Bali and Hite 1998)

Bali and Hite (1998) [3] introduced the discreteness hypothesis that accounts for the price drop to dividend ratios declining between ticks (minimum price change allowed by the exchange) and concluded that the stock price drop would be less than the dividend but not less than the dividend minus one tick on the ex-dividend day. They also showed that it is hard to generate arbitrage profits on the ex-dividend day since short-term trading is confined to tick multiples.

2.2.3 Risk Premium on Ex-Dividend-Day Returns (Heath and Jarrow 1988)

In contrast to the short-term trading hypothesis, Heath and Jarrow (1988) [4] provided an alternative argument that even in a frictionless market where trading costs are negligible, the stock price can still fall as a different amount as the dividend on the ex-dividend day. This argument is constructed on the premise that short-term traders know for sure about the trading signals around the ex-dividend day. They showed this premise was not satisfied based on the empirical evidence, which indicated that it is challenging to exploit arbitrage opportunities even though the stock price drop differs from the dividend. Heath and Jarrow also claimed that the difference between the stock price drop and the dividend could be explained by taking into account of taxes and risk aversion of the long-term and short-term traders. A required risk premium should be incorporated into stock prices to compensate investors with different risk tolerance.

2.3 Implications on Trading Strategies (Shantanu 2004)

Shantanu (2004) [5] studied the stock price ex-dividend day behavior in the Canadian stock market and presented empirical evidence that taxation and short-term trading can jointly affect the differential between stock price drop and dividend payout. By comparing periods between 1996-1999 when dividend income was tax-favorable and 2000-2003 when the capital gain was tax-favorable, Shantanu demonstrated that the ratios of a stock price drop to dividend were consistently less than one during those periods and the price drop was more pronounced for stocks with high dividend yields.

This paper further examined the short-term returns and trading volumes around the ex-dividend day and concluded that there were significant abnormal returns and active short-term trading activities around ex-dividend day. Their results motivate us to find potential implications for trading strategies, for example, incorporating ex-dividend day as an essential input in the trading strategies for market makers.

2.4 Ex-dividend Profitability and Institutional Trading Skill (Henry and Koski 2017)

Recently, Henry and Koski (2017) [6] used a proprietary data set to measure the execution cost more accurately. They conclude that dividend capture strategies are not profitable on average, though skilled investors do profitably pursue dividend capture strategies on targeted ex-day.

Given the phenomena observed by the economist, the enormous paper has been published related to capturing this abnormal return. The strategy so-called dividend capture can generate positive performances; however, they become negative once adding the transaction cost into the paper portfolio.

Chapter 3

Data and Pre-processing

3.1 US Dividend and Stock Data

Dividend and individual equity-level data are collected from the Center for Research in Security Prices (CRSP) database which reports all dividend events (declaration date, ex-dividend date, record date, dividends per share). The daily prices series we used in our research start from 1977 and all those companies are listed on the major U.S. exchanges: NYSE, AMEX and NASDAQ.

In particular, we consider ordinary cash dividends paid in U.S. dollars (CRSP distribution codes starting with 12) on common shares (CRSP share codes 10, 11, and 12) trading on one of the NYSE, AMEX or NASDAQ exchanges (CRSP exchange codes 1, 2, and 3). Our study exclusively focuses on taxable dividend events (CRSP distribution codes ending with 2). After data cleaning, the database we obtained includes 313,294 dividend events and 21,986,243 daily stock prices.

	price change	dividend	ex-day return	dividend yield	price ratio
count	313294	313294	313294	313294	313294
mean	-0.194069	0.220509	0.000744	0.009240	1.071795
std	0.851095	0.482430	0.023675	0.015470	24.487923
min	-91.110010	0.000010	-0.780650	0.000002	-3000
25%	-0.375000	0.069000	-0.007097	0.004654	0
50%	-0.125000	0.122500	0.000818	0.006510	0.892857
75%	0	0.290000	0.008462	0.010764	1.941898
max	35.849970	85	4.077551	3.435779	10097

Table 3.1: CRSP Dividend Event Data Summary after Data Clean

Dividend event data is obtained with "Distribution" query under "Stock/Events". Items selected include:

- Dividend

Data layout is presented in below table.

	PERMNO	DISTCD	DIVAMT	EXDT
1	10001	1232	0.095000	19860310
2	10001	1232	0.105000	19860609
3	10001	1232	0.105000	19860908
4	10001	1232	0.105000	19861208
5	10001	1232	0.105000	19870309

Table 3.2: Dividend Events

Daily stock price and volume data is downloaded with "Daily Stock File" query under "Stock/Security Files". Items selected include:

- Company Name
- Ticker
- Exchange Code
- North American Industry Class System
- Price
- Share Volume

Data layout is presented in below table.

	PERMNO	date	EXCHCD	TICKER	NAICS	PRC	VOL
18922	10006	19770103	1	ACF	nan	34.7500	2000
18923	10006	19770104	1	ACF	nan	34.8750	3300
18924	10006	19770105	1	ACF	nan	34.7500	10200
18925	10006	19770106	1	ACF	nan	34.6250	3100
18926	10006	19770107	1	ACF	nan	34.6250	5800

Table 3.3: Daily Prices

Listing exchange for the stocks are NYSE and NASDAQ. The EXCHCD (Exchange Code) attribute identifies the exchange of each stock entry.

PERMNO is the CRSP Permanent Security Identifier which can be used as key to merge data frames from various queries.

SICCD represents the Standard Industrial Classification code which is used to group companies with similar products or services.

NAICS represents the North American Industry Classification System which is used to group establishments with similar products or services. However, this field is only adopted in 1997 and implemented in 1999, thus any data before this data will record NaN in their field.

PRC contains the field of close price.

VOL is the daily trading volume. Date is represent in the format "YYYYMMDD".

Daily stock file entry with negative price represents the date with no trading activity. Such negative quote is neither tradable nor reflects reasonable market movement thus is removed from dataset.

3.2 Monthly Summary and Dividend Month Premium

In S.M. Hartzmark, D.H. Solomon's paper "The dividend month premium" [7], they discovered that companies tend to make positive abnormal returns in months when they are about to pay the dividend. The majority of the transaction happens right before the ex-dividend day are mainly motivated by the dividend events. Anyone wish to acquire that dividend has to buy the stock while the others who want to avoid any cash income will have to sell those stocks. Once dividend-avoiding investors are fewer than dividend-seeking investors, the excess demand will put pressure on the stock price.

From the table 3.4, we found the evidence of dividend month premium that companies tend to have higher return in months when they are expected to issue a dividend.

To compare, we first built three paper portfolios. For all return portfolio, we equal weight all the equities without considering dividend or not. For Only Dividend portfolio, we only select all the equities expect to pay dividend this month and re-balance monthly. Base on our previous analysis, the gap between dividend

Months since dividend payment	Mean return (%)	Standard deviation (%)
1	-0.914989	12.548774
2	0.265448	11.631816
3	0.561208	11.522136
4	-0.581539	12.093022
5	0.173269	12.024882
6	0.505056	11.733694
7	-0.580008	12.355670
8	0.129005	12.314868
9	0.441144	11.990348
10	-0.582832	12.629135
11	0.131716	12.579967
12	0.418107	12.240090

Table 3.4: Raw return with respect to dividend month

	count	mean	std	min	25%	50%	75%	max
all returns	491	-0.002967	0.059527	-0.358317	-0.033725	0.004270	0.033418	0.177569
Only Dividend	491	0.009218	0.045000	-0.275801	-0.011384	0.012454	0.037066	0.148675
No dividend	491	-0.005013	0.061938	-0.367135	-0.037323	0.002398	0.033032	0.186722

Table 3.5: Return based on predicted dividends

declare day and ex-dividend day are roughly four weeks, this means at the end of this month, we will have a general idea of which equity will issue dividend next month. For No dividend portfolio, we do the opposite way.

From the histogram, all three series of returns are close and hard to identify. However, it changed when we plot the cumulative returns. A positive mean return of dividend-paying stock will overall yield more than 5000% within 40 years while other two portfolios decreased to zero. In table 3.5, we aggregated monthly returns of dividend-paying stocks and all the stocks, and results illustrated a clear difference between them.

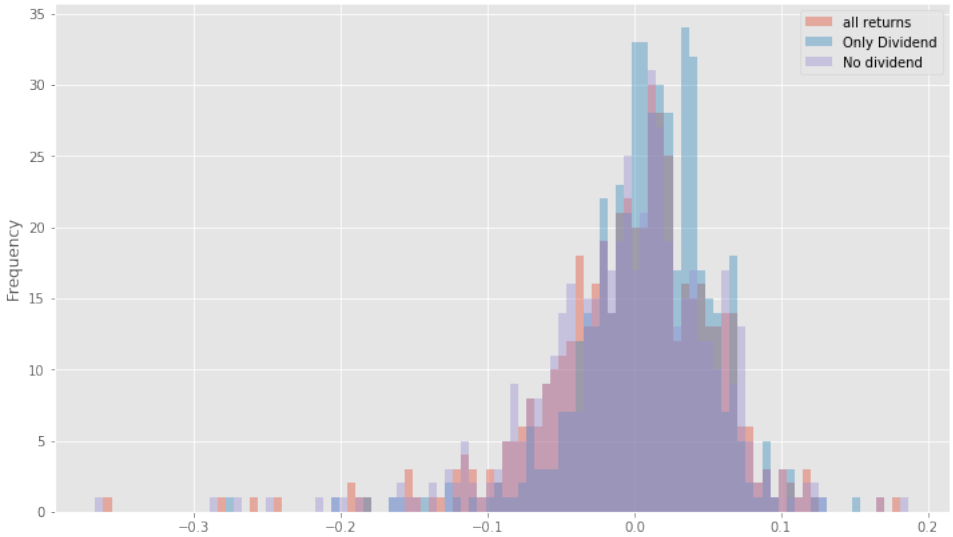

Figure 3.1: Histogram of Three paper portfolios

This significant positive return can be explained from a behavioral finance perspective. As proposed by Hartzmark and Solomon, the investors' preference of dividend and a positive discount rate both cause the purchase of stock before its dividend payment rather than afterward.

In L.E. Harris, S.M. Hartzmark and D. H. Solomon's further paper "Juicing the dividend yield" [8], they discussed this favor of dividend further. They suggested that for some funds, juicing dividend is a way for fund managers to maximize their compensation through increasing the Asset Under Management. They argued that one of the critical features that investors desire is the payment of dividends.

According to US tax law, dividend payment from a mutual fund must base on the "Pass-through" principal. The fund must distribute all their PL to its shareholders to avoid paying corporate income taxes. Thus all the dividend are from the dividend payment of the equities the fund holds. Then, it is easy for the fund

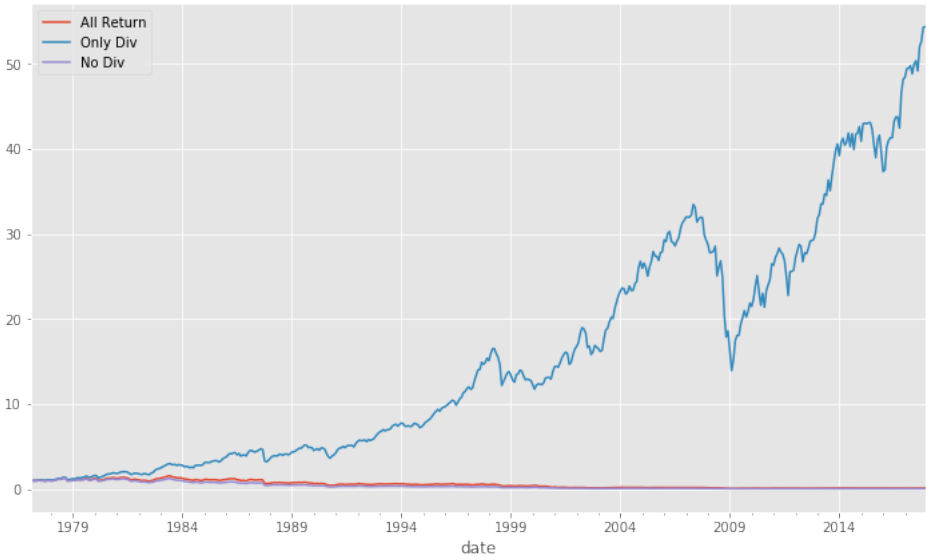

Figure 3.2: Cumulative Return of three paper portfolios

manager to manipulate that dividend by taking costly transaction to purchase that dividend. For example, buy a stock before ex-day and sell those stock after record day to get those dividend.

From their paper [8], several examples are given to illustrate the popularity of all the mutual funds. Some fund, for example, the Huntington Dividend Capture Fund using the core strategy as its name. That might be caused by the different treatment towards capital gain and the dividend of the retail investors. They categorize the dividend as income of their principal while any capital gain as principal itself. This different treatment allows them to bear more tax burdens.

Chapter 4

Methodology

4.1 Tax Effect on Dividend Puzzle

In Elton and Gruber's paper (1970) [1], they propose that buyers and sellers are indifferent between trading cum-dividend and ex-dividend if the following formula is satisfied:

$$\frac{P_{cum} - P_{ex}}{D} = \frac{1 - t_d}{1 - t_g}$$

where P_{cum} is the stock price cum-dividend, P_{ex} is the expected price on the ex-dividend day, D is the amount of the dividend per share, t_g is the capital gains tax rate and t_d is the tax rate on dividends. The left-hand-side part is called ex-day premium. Therefore, the difference between the capital gains tax rate and the tax rate on dividends could be a factor to explain dividend puzzle. Starting from this idea, we would like to further research on the influence of taxes, by comparing among countries whose tax policies are different. In the US, the capital gains tax rate was lower than the tax rate on dividends before the 2003 tax reform, and they became equal since then. A comparison between the period before and after the tax reform would be done at first. We expect to observe if price ratio[1] changed between these two periods.

In Bauer, Beveridge and Jha's paper (2006) [9], they applied the following formula to research on dividend puzzle for stocks listed on the Toronto Stock Exchange:

$$R_i = \alpha_0 + \alpha_1 Yield_i + \alpha_2 Dummy + \alpha_3 Dummy * Yield_i$$

where R is the ex-day return given by $\frac{P_{ex} - P_{cum} + D}{P_{cum}}$, Yield is the dividend yield given by $\frac{D}{P_{cum}}$ and Dummy is equal to one for the dividend preferred regime ($t_d < t_g$) and zero otherwise. Using the data between 1977 and 2000, they found that, in capital

[1] Price ratio is defined as $\frac{P_{cum} - P_{ex}}{D}$

gain preferred regime, the coefficient (α_1) is significantly positive, which means that the dividend puzzle exists in this regime, since in a world without dividend puzzle, the coefficient should be statistically equal to one. In addition, they found that, in dividend preferred regime, the coefficient ($\alpha_1 + \alpha_3$) is significantly positive and less than the previous coefficient, which means that the dividend puzzle becomes less significant when the tax rate on dividends is less.

Inspired by Bauer, Beveridge and Jha's work (2006), our first step would be to study the dividend puzzle in the US equity market by splitting the data into two periods: capital gain preferred period (before the 2003 reform) and the period when investors are indifferent between capital gain and dividend (after the 2003 reform). More precisely, we would slightly modify the above regression and respectively run this regression on the data before and after the 2003 reform. The modified regression formula is given as following:

$$\text{Price change ratio}_i = \beta \text{Dividend yield}_i \tag{4.1}$$

where Price change ratio is given by $\frac{P_0 - P_1}{P_0}$, and Dividend yield is given by $\frac{D}{P_0}$. We selected P_0 as stock price on the day before the ex-dividend day and P_1 as stock price on the day after the record day for a given dividend event, so that investors would be eligible to receive dividend. In the meanwhile, these investors should be able to make profits by holding stocks only during the period if there is opportunity arbitrage. In reality, the selection of P_0 and P_1 may not be the best choice for investors and they could buy stocks earlier than our choice and sell stocks later if they want to receive the dividend. The trading strategy would be based on the same choice for buying and selling stocks. In addition, as we do not include intercept in our regression, β could be interpreted as $\frac{E(\text{Price change ratio})}{E(\text{Dividend yield})} = \frac{E(P_0 - P_1)}{E(D)}$ and should be equal to one after the 2003 tax reform according to the no-arbitrage formula proposed by Elton and Gruber.

In the real world, $\rho := \frac{1-t_d}{1-t_g}$ would not be equal to one after the 2003 tax reform, since all agents do not face the same tax rates. They may be in different tax brackets, or, some of them are tax-exempt. Poterba (2004) computed the overall ex-day tax preference ratio weighted by share of stock ownership in the US economy. The estimates of Poterba (2004) could be found the estimate of ρ in the appendix of Chetty, Rosenberg and Saez's paper (2005) [10] for the period 1962 through 2004. As the information about share of stock ownership in the US economy could not

be collected for the period 2005-2017, we assume ρ be equal since 2003. This assumption is acceptable based on the fact that the capital gains tax and the tax on dividends have not been largely modified since 2003. In the following figure, the blue line represents the estimates of ρ found in Chetty, Rosenberg and Saez's paper (2005), the orange line represents the median of ex-dividend premium during that year, and the red line represents the median of dividend-yield-weighted ex-dividend premium during that year. We could remark that during most of the years before 2006, the tax preference is larger than the median premium, and this relation has become more uncertain since 2006. We may conclude from this figure that dividend puzzle has become less significant since the 2006 tax reform and the period 2003-2006 could be regarded as an interim period to adapt to the new tax.

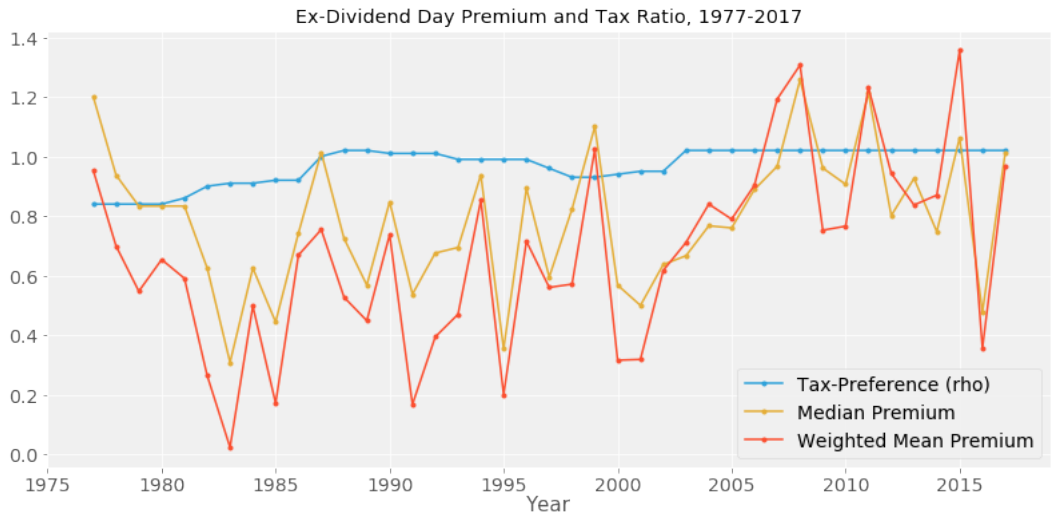

Figure 4.1: Ex-Dividend Day Premium and Tax Ratio

Next, we would run the 1-year rolling regression of Price change ratio on Dividend yield, and we would like to compare $\beta = \frac{E(P_0 - P_1)}{E(D)}$ to ρ every year. According to the no-arbitrage formula, if $\beta < \rho$, there should be arbitrage opportunity in that year when buying stocks to receive dividends. Considering the cross-section correlation among companies in different industries, clustered standard errors would be applied in regression.

4.2 Short-Term Dividend Triggered Trading Strategy

Dividend puzzle creates a potential arbitrage opportunity. Assuming that dividend entitlement is the only factor driving stock price movement on ex-dividend date. Purchasing the stock before ex-dividend date and sell it afterwards would generate profit with amount $D - \Delta P$. However in reality due to limitations such as transaction cost, minimum holding requirement and stock price movement not caused by dividend, profitability of such strategy is not easy to predict. In this session, various versions of short-term dividend triggered trading strategy is implemented to see whether dividend puzzle can be transferred as trading signal.

4.2.1 Definitions and Assumptions

Six Day Holding Period Due to settlement system presently used in North America, in order to be registered as dividend receiver, investor must purchase the stock before ex-dividend date and after record date. Based on records from WORD database, majority of record dates are four days after ex-dividend date. Thus for simplicity, we assume six day holding period for.

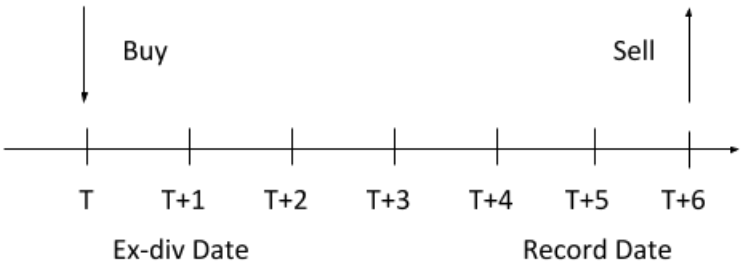

Figure 4.2: Six Day Holding Period Illustration

Payment Date There is no fix relationship between ex-div date and payment date. Based on CRSP records payment date is no more than one month after ex-div date. Thus for simplicity we make a conservative assumption that payment date is one month after the holding period.

Risk Free Rate 4-week daily yield from CRSP is used.

Trading Cost Based on order book downloaded from OneTick database, bid ask spread for equity is as low as one basis point. Thus in the portfolio construction, transaction cost is set to be a variable with default value to be one basis point.

Initial Value Set 100USD as initial value.

Amount Invested in Each Stock Define NAV to be the total value of the portfolio, i.e. cash plus current value of all stock investment. Unpaid dividend will not be included in NAV but will be record as cash on the payment day. At each day, invest NAV divided by n in each new stock to be included in the portfolio. n is defined to be maximum portfolio size (stock number) during the holding period of the stock. Since ex-dividend date will be announced at least two weeks before, we are able to calculate n without being considered as using future information.

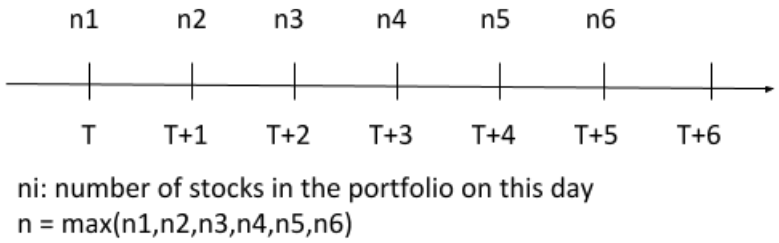

Figure 4.3: Amount Invested in Each Stock Illustration

Stock Filtering For each year, only stocks with top 500 capital size calculated using previous year data will be included in the portfolio. Since stock market is dynamic, some large company may only have history of less than 20 years. Thus with 40 years trading horizon, we decide not to choose large cap company based on only current quotes.

Benchmark 100USD accumulated at risk free rate is used as benchmark to reflect the level of inflation. SP500 index starting with 100USD is used as reference of market performance.

Stock Pool For each year stock pool is defined to be top 500 stocks based on previous year's market capitalization.

4.2.2 Simple Portfolio: Invest in every stock that pays dividend

Based on assumptions described in previous session, investment schedule is based on ex-dividend date of each stock. In this stock, all stocks from stock pools are included in the portfolio.

4.2.3 Modified Portfolio 1: Large vs Small Stocks

Stocks with large capital size are considered more liquid compared with small stocks. Thus difference performances are expected for portfolios separating these two features. In this modified version, large capital size portfolio is constructed using stocks with top 30% capital size from stock pool. Comparatively small capital size portfolio is constructed using stocks with bottom 30% capital size from stock pool.

4.2.4 Modified Portfolio 2: Large Dividend Yield vs Small Dividend Yield

Dividend yield is an effective indicator in trading strategy construction. If a company has steady increasing dividend yield, it is viewed as positive signal by investors. In contrast, sudden divided decrease is considered a bad signal. However high dividend yield is not equivalent to good yield. When a company keeps large dividend payment, it may also face under-investment problem. Due to the undeniable linage between dividend yield and stock performance, in this modified portfolio, portfolios constructed with large dividend stocks and small dividend stocks are compared. Large dividend is defined to be dividend with yield greater than previous year's 30 percent quantile, while small dividend is defined to be dividend with yield smaller than previous year's 70 percent quantile.

4.2.5 Modified Portfolio 3: Dividend Seeking and Avoiding Investors' Signal

As we mentioned in the previous section, most transaction happened right before ex-dividend day are motivated by capture or avoiding that dividend. When market liquidity is an issue and dividend-pursuing investors outnumbered the dividend-avoiding investors, the stock price will go up as more buy order push the price. This is usually the case for the large fund to buying dividend.

Thus we incorporate the idea of price pressure as a trading signal. We confirm the buy order only when six-day return before ex-dividend day is greater than the negative of dividend yield.

4.2.6 Modified Portfolio 4: Signal Detection using Rolling Regression

For each month, investors would run regression of Price change ratio on Dividend yield using the dividend event data occurred in the past year, and compare the coefficient obtained to the tax preference in that month. If $\beta < \rho$, for all dividend events during this month, they would buy stocks on the day before the ex-dividend day and sell them on the day after the record day. Otherwise, they would invest in risk-free rate. According to the level of prudence, investors could compare the upper confidence interval of β to ρ, instead of using the estimate of β. In our study, we would consider the investors using 90%, 95% or 99% confidence interval based on clustered standard errors. In this analysis, dividend events with change in dividend yield of less than 1 percent are discarded, based on the observation that price changes would be dominated by other factors than dividend distribution when dividend yield is too small.

4.2.7 Modified Portfolio 5: Signal Detection using Rolling Regression (by industry division)

Similar to the above strategy, this strategy separately run the 1-year regression each month for ten different industry divisions based on Standard Industrial Classification (SIC) codes, and independently generate signal for each division. White standard errors are applied to obtain confidence interval. Similar to the previous analysis, dividend events with change in dividend yield of less than 1 percent are discarded.

4.2.8 Modified Portfolio 6: Increasing Dividend Signals with Systematic Rebalancing

4.2.8.1 Increasing Dividend Signals

Dividend distributions and share repurchases are two main approaches for companies to distribute profits to shareholders. Without tax differentials, these two approached are supposed to be treated equivalently. However, in the real

world, both investors and companies tend to treat these two methods differently. From a company's perspective, reducing its dividend amount or terminating its future dividends might be considered a negative signal by the market and further deteriorate its short-term stock price return. On the other hand, if a company declares an increasing dividend announcement, it should attract more investors because investors might treat such an announcement as an indicator that the company is confident enough regarding its future performance.

To capture the effective signal that an increasing dividend announcement can bring to the market, we have to assume the tax differentials between dividends and share repurchases are negligible. Therefore, we propose to incorporate increasing dividend signals only after 2003 Tax Reform into a portfolio and rebalance the portfolio according to a systematic way.

4.2.8.2 Systematic Rebalancing

Our main motivation is to capture an increasing dividend signal; therefore, The general idea of constructing this portfolio is very straightforward. Given a stock with an announcement of increasing dividend today, we expect its price will go up in the next future days so that we buy it on its declaration date. With another incentive of capturing the "mispricing" involved with the Dividend Puzzle, we would hold the stock until the next business day of its declaration date and sell it after obtaining its dividend. To avoid embedding future information into our portfolio, we only make long decisions when an increasing dividend announcement is coming and accordingly make short decisions because we already know its record date when a dividend is announced. However, one challenge in our portfolio construction is that we do not know the next increasing dividend event and we have many stocks to consider. In general, we want to have an exposure to every single increasing dividend signal; therefore, we need a systematic approach to rebalance our portfolio according to every declaration date and record date. We elaborate our systematic rebalancing approach in the following example.

Suppose we have an initial fund of $1. As Table 4.1 shows, we start by investing $1 in Apple on its declaration date, 2016-01-04. For next event on 2016-01-07, we observe there are two companies Facebook and Microsoft that announce increasing dividends on the same day. We calculate the Net Asset Value (NAV) on that day and reallocate equal proportion of NAV to each stock. By achieving such a rebalance, we need to short a proportion of existing stocks in our inventory and

TABLE 4.1 Timeline

2016-01-04	Apple announces an increasing dividend
2016-01-07	Microsoft and Facebook announce an increasing dividend
2016-01-20	Apple's dividend record date
2016-01-25	Facebook's dividend record date
2016-01-27	Microsoft's dividend record date

use the proceed to buy new stocks. The rationale of such a rebalance is that we want to obtain exposure to every stock that declares an increasing dividend. We can sell some proportion of existing stocks because we expect their prices would rise after their declaration dates, and we reallocate equal value to each stock to ensure that our portfolio's NAV is not sensitive to the price movement of large-cap stocks. On 2016-01-20, we observe our first record date. We should short our Apple stocks on the next business day to ensure we obtain its dividend payouts. If there are no more stocks to buy on that day, we just deposit our proceeds from selling into a risk-free account and keep the rest of the stocks in our inventory. Finally, we can clear our inventory as the remaining stocks approach their record dates. With such a systematic rebalancing approach, we evaluate the performance of our portfolio by calculating its NAV at the end of each event date (either a declaration day when we long or the next business day after a record date).

Chapter 5

Results and Discussion

5.1 Tax Effect on Dividend Puzzle

We would like to compare the US equity market before and after the 2003 tax reform by two separate regressions. The following result is based on the stocks data on the NYSE, AMEX and Nasdaq.

The following figure collects dividend yields and price change ratios for all dividends events in our dataset. When dividend yield is small, the price change of stock would not be dominated by the dividend distribution, and the price change ratio could be positive or negative. When dividend yield becomes larger, more positive price change ratios could be observed.

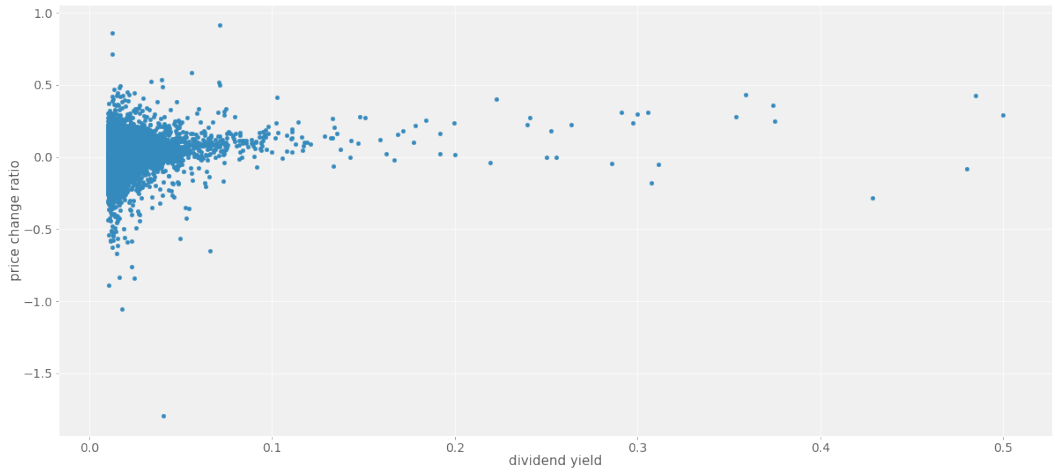

Figure 5.1: Price Change Ratio vs Dividend Yield

In particular, for the division Finance, Insurance and Real Estate and for the division Service, we observed that the positive relation between price change ratio

and dividend yield is more significant according to Figure 6.3 and Figure 6.4 in Appendix.

The first regression that we are interested in is:

$$\text{Price change ratio}_i = \beta \, \text{Dividend yield}_i \tag{5.1}$$

where Price change ratio is given by $\frac{P_0 - P_1}{P_0}$, and Dividend yield is given by $\frac{D}{P_0}$. P_0 is the stock price on the day before the ex-dividend day and P_1 is the stock price on the day after the record day for a given dividend event.

According to the regression results (c.f. Figure 6.1 and Figure 6.2 in Appendix), we could see that before the 2003 tax reform, the coefficient is 0.5845, and after the reform, the coefficient becomes 1.0516 which is not significantly different from 1 using t-test.

In the next step, we would like to run the 1-year regression of price change ratio on dividend yield, and we also computed the 95% confidence interval using OLS standard errors and clustered standard errors respectively. The comparison between the tax preference (green line) and the estimated coefficient (blue line) is similar to that in Figure 4.1: the tax preference was higher before 2006 and their relation has become uncertain since then. If we compare Figure 6.1 to 6.2, we could observe a wider confidence interval for the regression using clustered standard errors especially during the period before 2006, which could also be confirmed by comparing standard errors of two regression types. This remark could imply that before the tax reform, investors were interested in the arbitrage opportunity in some specific industries, and after the reform, they became less interested in this type of arbitrage.

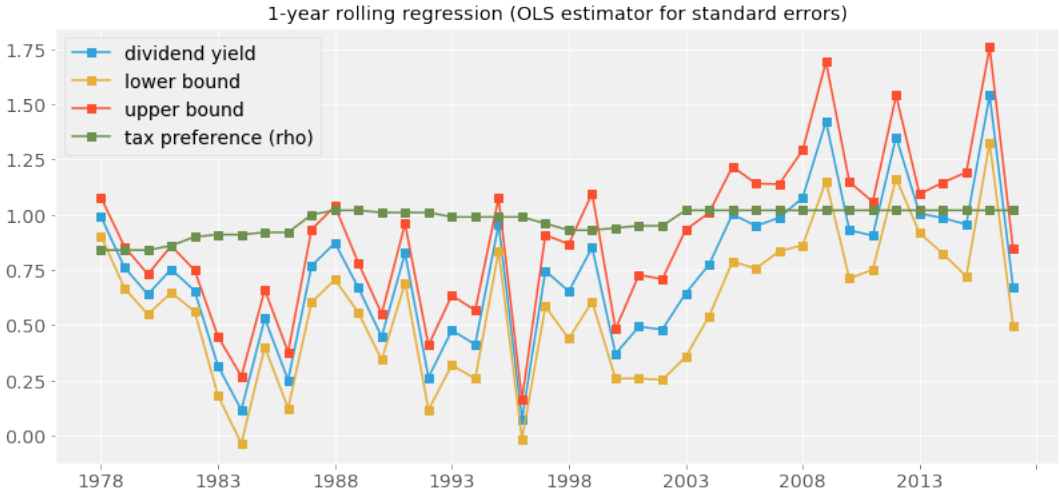

Figure 5.2: 1-year Rolling Regression (OLS Estimator for Standard Errors)

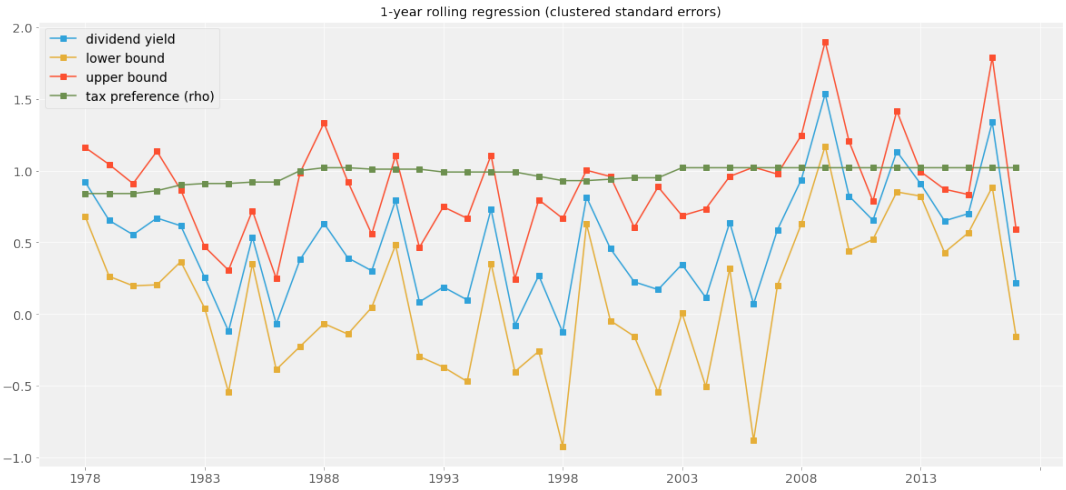

Figure 5.3: 1-year Rolling Regression (Clustered Standard Errors)

5.2 Short-Term Trading

For each strategy, three groups of performance matrices are designed.

Accumulated Returns are used to measure overall performance of each strategy over time.

Number of Stocks in Portfolio and Percent of Cash in Portfolio are used to measure liquidity and portfolio diversification.

Return Distribution for Each Investment is used as risk measurement which generates 95% VaR.

5.2.1 Simple Portfolio: Invest in every stock that pays dividend

Based on the vanilla portfolio performance, a strategy to capture the difference between dividend payment and stock price decrease will outperform inflation and S&P 500 portfolio. However without further considering the factors causing dividend puzzle, the portfolio's accumulated return is almost flat after 2000. In modified version when the factor exposure and dividend movement are incorporated as trading signal, consistent NAV increase can be archived.

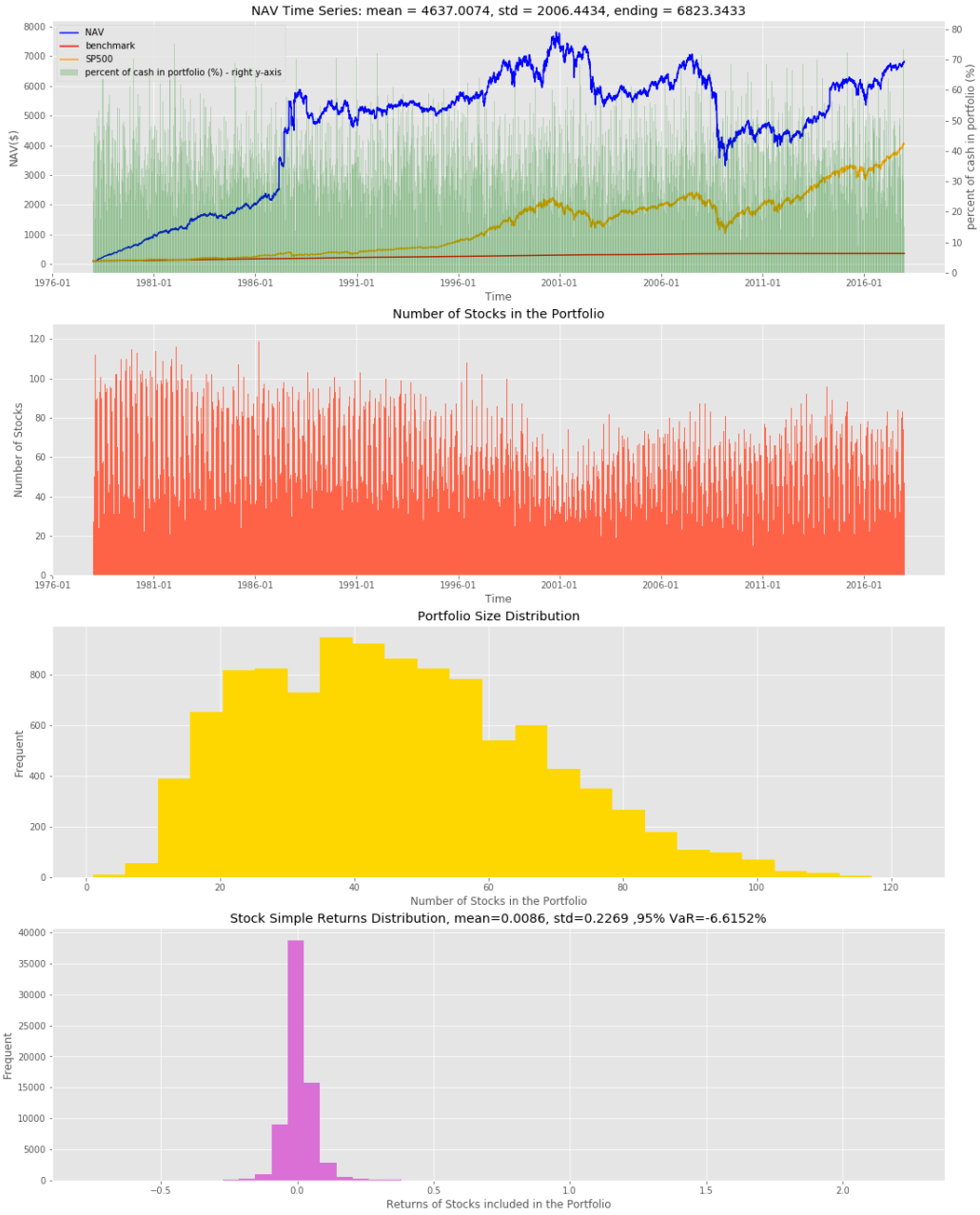

Figure 5.4: Simple Portfolio Performance

5.2.2 Modified Portfolio 1: Large vs Small Stocks

In the experiments separating bid and small-cap stocks, there is not enough evidence to conclude that portfolio performance is associated with capital size.

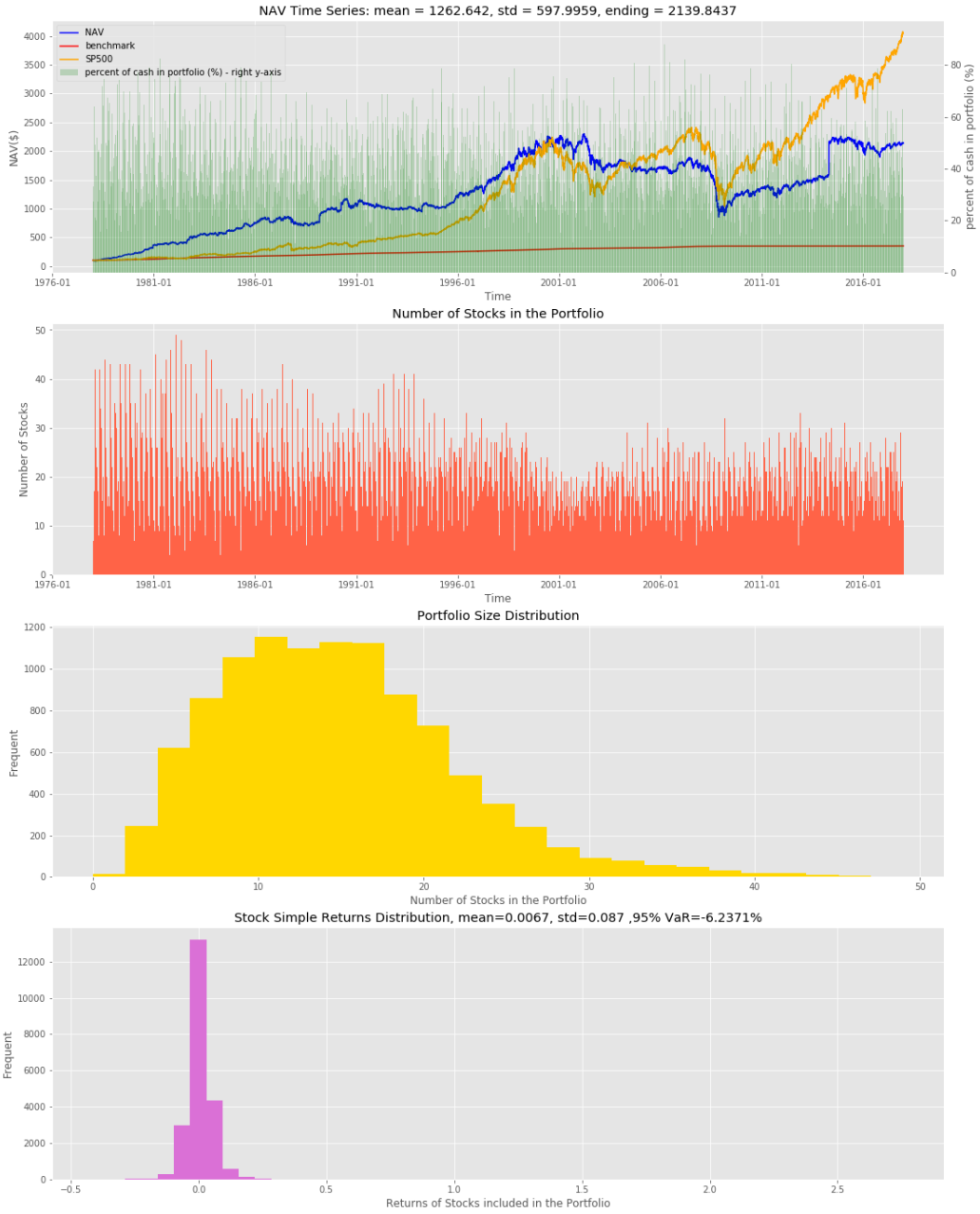

Figure 5.5: Modified Portfolio 1: Large Stocks

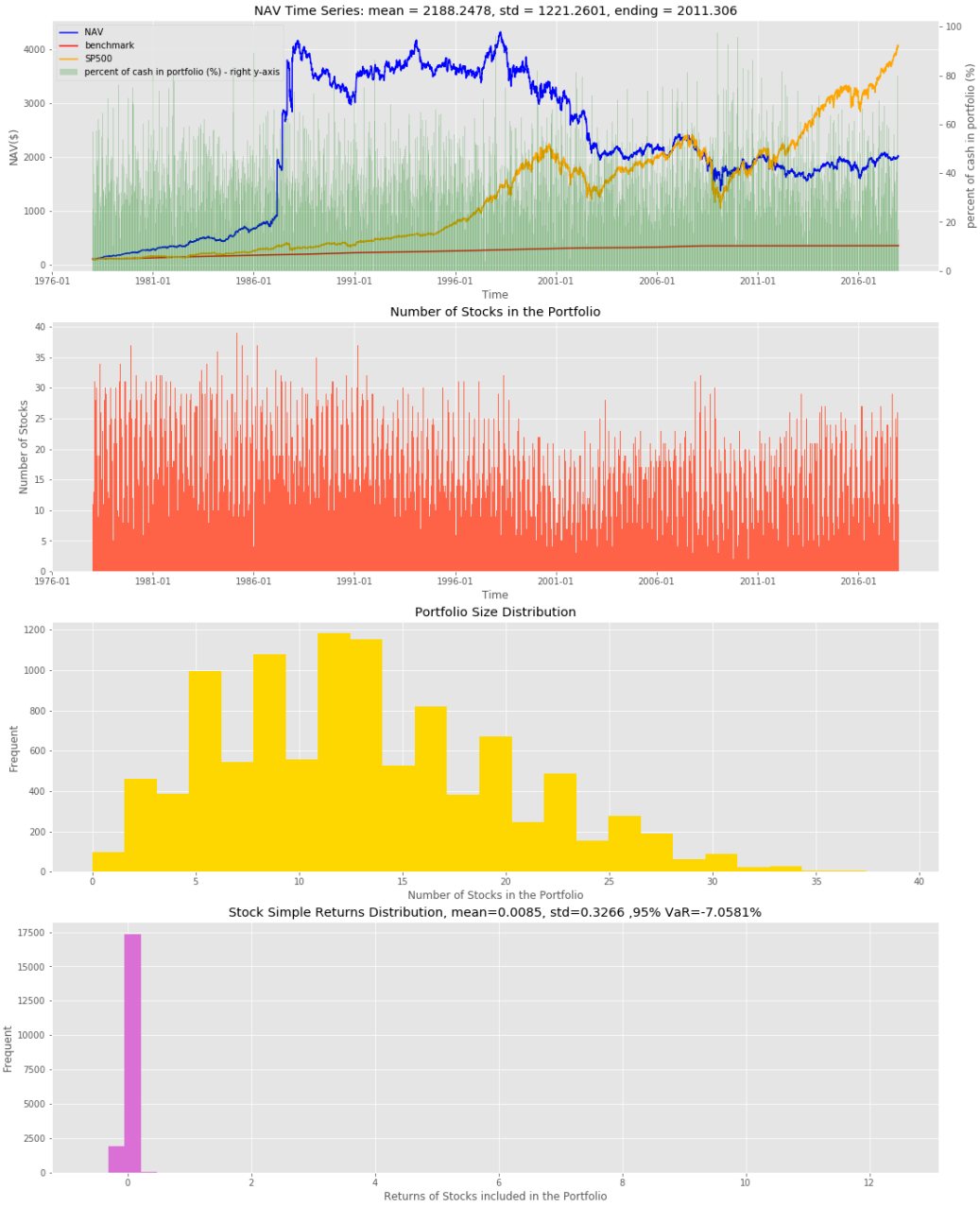

Figure 5.6: Modified Portfolio 1: Small Stocks

5.2.3 Modified Portfolio 2: Large Dividend Yield vs Small Dividend Yield

In the experiments separating high dividend yield and low dividend yield stocks, equity paying smaller dividend yield tends to have more substantial profit potential compared with high dividend yield stocks. Thus dividend yield as one potential factor is developed into signal in later modified portfolio.

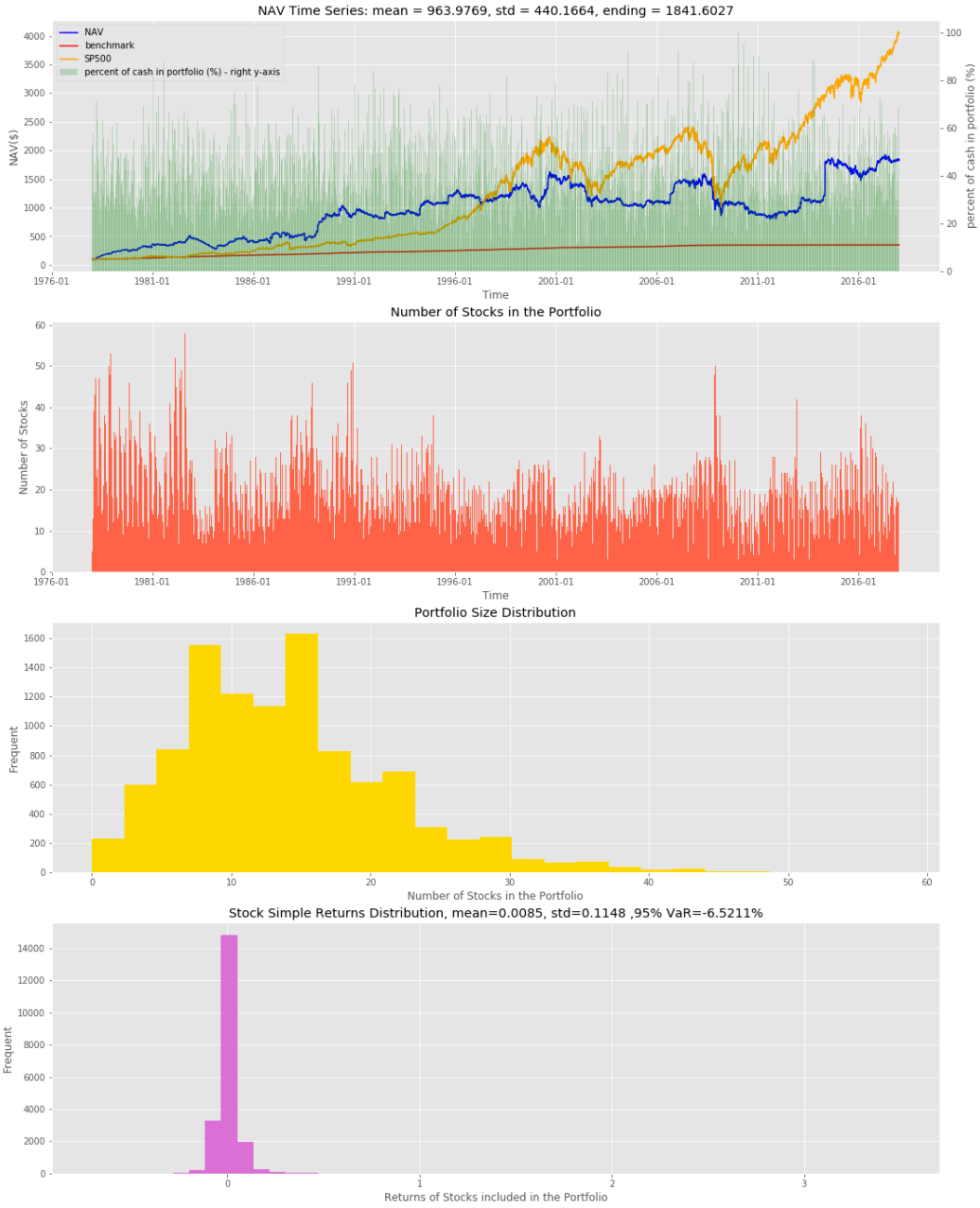

Figure 5.7: Modified Portfolio 2: Large Dividend Yield Stocks

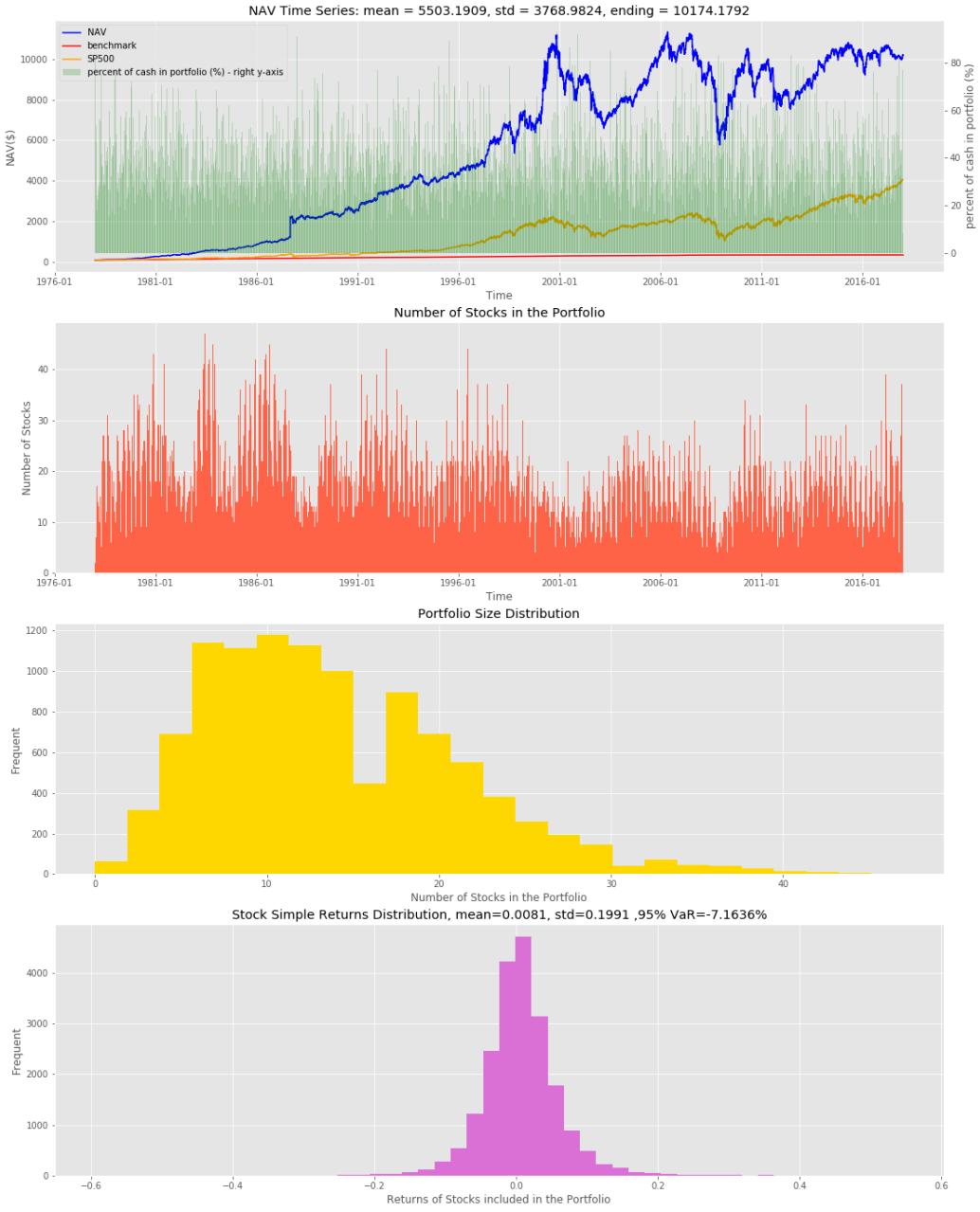

Figure 5.8: Modified Portfolio 2: Small Dividend Yield Stocks

5.2.4 Modified Portfolio 3: Dividend Seeking and Avoiding Investors' Signal

The performance of this strategy is not stable compared to other approaches. It first made relatively large returns but later flatten for a very long time. This might because we unintentionally incorporate the momentum signal by taking previous days' return into deciding our position. This combined our very short holding

period will result in the worse performance as the momentum signal only works in not-too-long and not-too-short term.

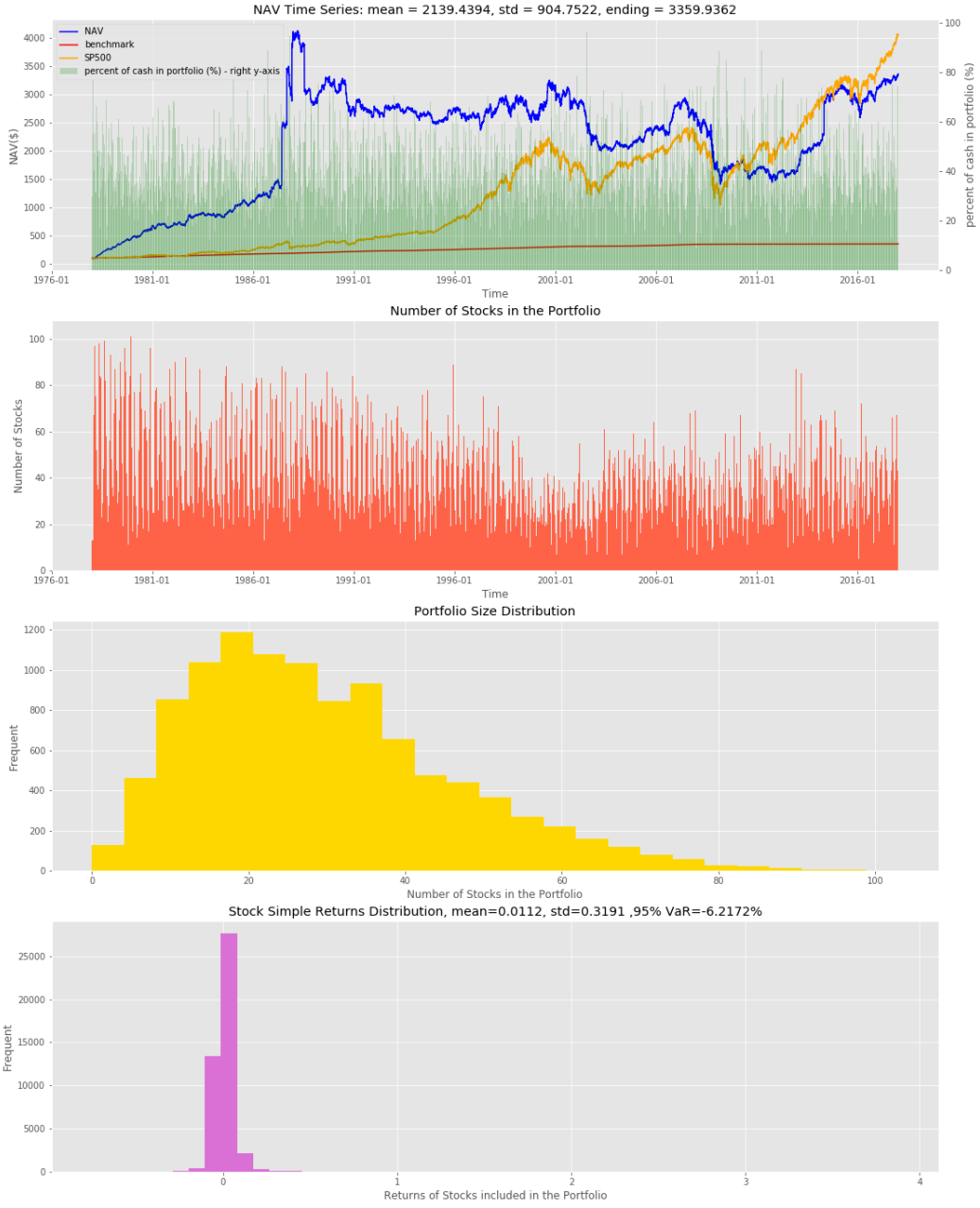

Figure 5.9: Modified Portfolio 3: Dividend Seeking and Avoiding Portfolio

5.2.5 Modified Portfolio 4: Signal Detection using Rolling Regression

This strategy would compare the implied ex-day premium (blue line) obtained by regression to the tax preference (green line) and when the latter is bigger, the

strategy would suggest to buy stocks which distribute dividends during that month. During the period 1977-2017, our strategy encourages us to buy stocks for most of months (90.8%). In particular, it discourages us to buy stocks during the 2008 financial crisis, since the large increase in stock prices brings the implied ex-day premium up and the tax preference is relatively stable when there is no big tax reform. Therefore, this strategy helps us avoid bubble in equity market.

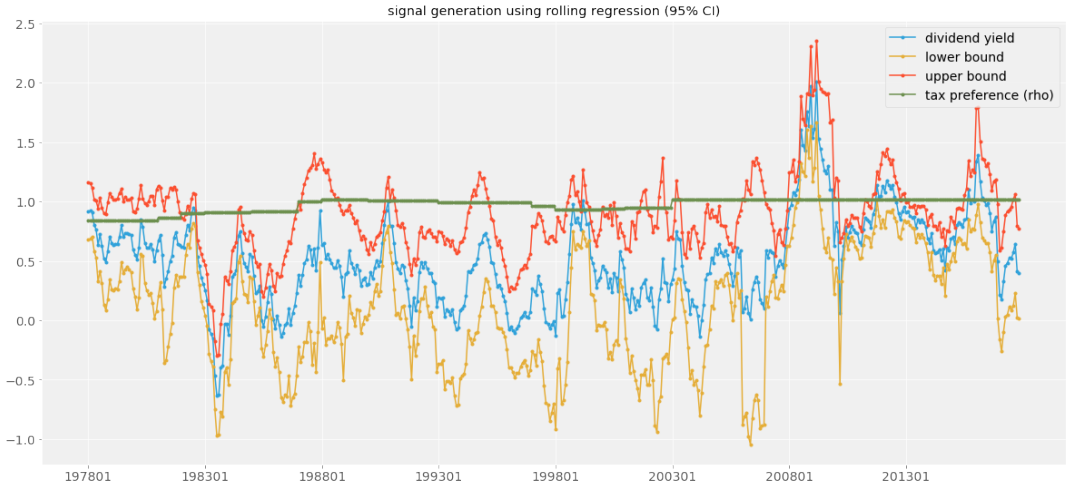

Figure 5.10: Signal Generation using Rolling Regression (95% CI)

If we test the strategy using the data after 2010, we could see from the following figure that, at the beginning, our strategy has comparable cumulative returns to that of SP500 index, but the cumulative returns stop to increase during the year of 2002 when we are not suggested to buy stocks and we invest only in the risk free rate. Since 2013, the increase in cumulative returns have been continuing with a similar speed to SP500, but slows down gradually, then stops during 2016 when U.S. stocks soared. In conclusion, the speed of increase in equity price dominates the relationship between the implied ex-day premium and the tax preference: when stock prices too aggressively increase, the strategy suggests more often not to buy stocks. Originally, we want this strategy to reflect the sensitivity of arbitrage opportunity's existence to the change in marginal tax rate $(t_g \ and \ t_d)$. However, this strategy seems not to be able to well capture this information.

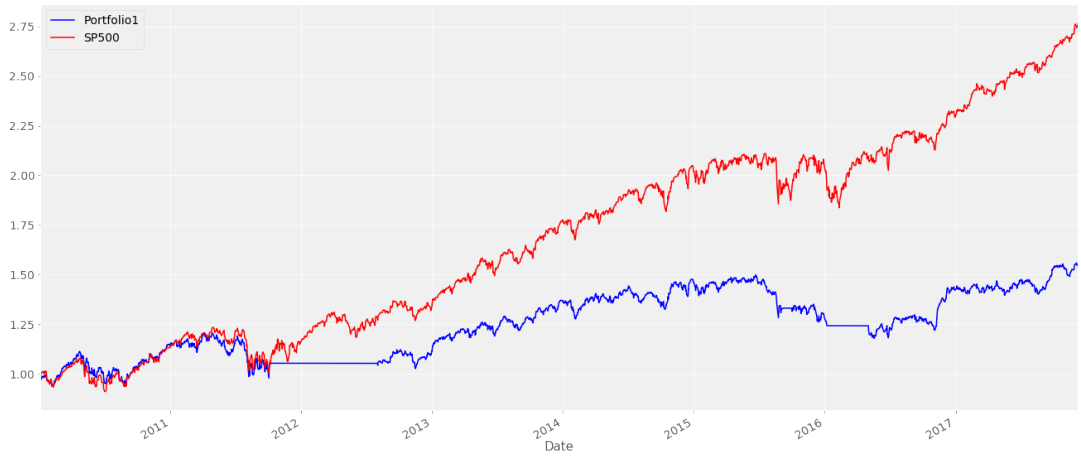

Figure 5.11: Cumulative Return using Rolling Regression Signal since 2010

5.2.6 Modified Portfolio 5: Signal Detection using Rolling Regression(by industry division)

In this strategy, we slightly change the approach to generate buy signals by separately running regression for different industry divisions. We could see from the following figure that, the situation when we invest in only risk-free rate is avoided, though it would also suggest not to buy stocks of a specific sector when a quick increase occurs (c.f. Figure 6.5 and Figure 6.6 in Appendix). Moreover, its cumulative returns are lower than SP500 in average and they are in general more volatile. For instance, they have a bigger drawdown at the beginning of 2016 and a larger increase at the beginning of 2017. The performance of this strategy seems in average better than the previous strategy.

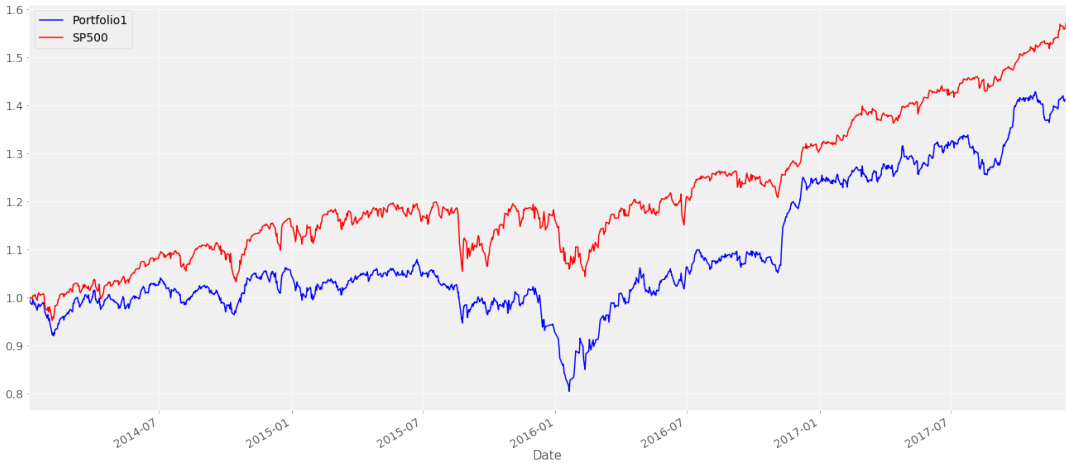

Figure 5.12: Cumulative Return using Rolling Regression Signal since 2014 (by industry division)

5.2.7 Modified Portfolio 6: Increasing Dividend Signals with Systematic Rebalancing

Before constructing our portfolio, we attempt to look at a single stock to investigate its price movements between its two dividend periods. We select Microsoft as an example since its dividend amounts are stable in history. Figure 5.13 illustrates its historical dividend periods with each switching color representing each dividend period. As we can observe from the graph, Microsoft started its first dividend payment in early 2003 and the frequency of its future dividends is quite stable. Figure 5.14 separates all the historical increasing dividend periods of Microsoft in red. We observe that Microsoft's stock prices kept moving down in some red intervals, which indicates that the general increasing dividend signal might not work all the time.

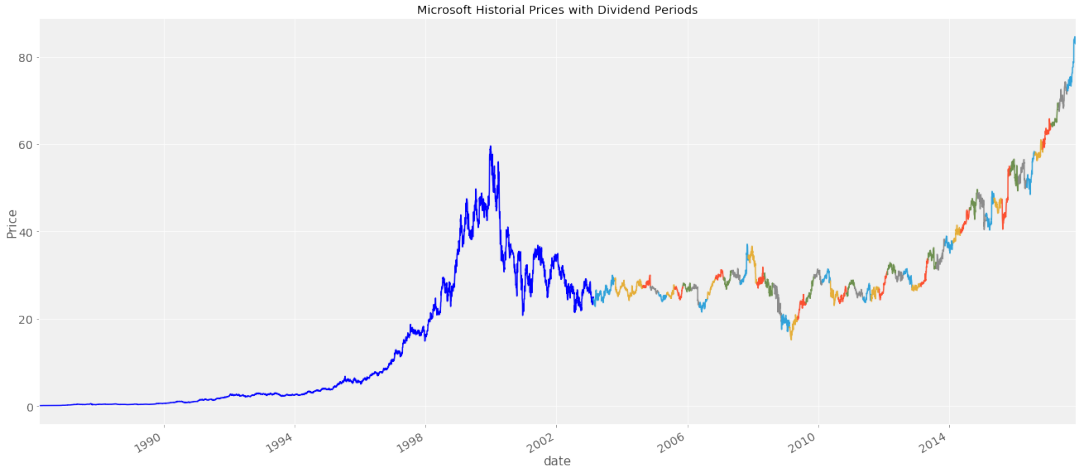

Figure 5.13: Microsoft Dividend Periods Visualization

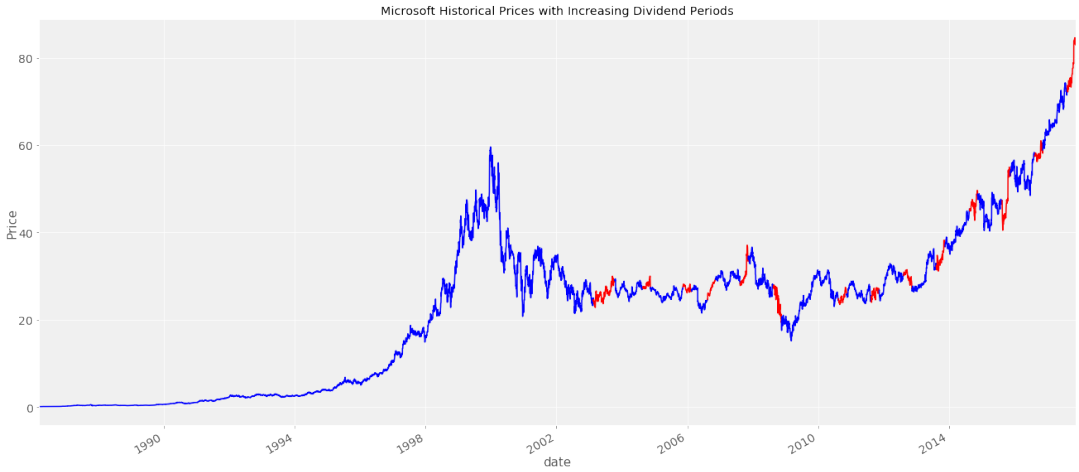

Figure 5.14: Microsoft Increasing Dividend Periods Visualization

We construct a portfolio by capturing all the increasing dividend signals of Microsoft. The portfolio starts from investing in Microsoft on its first declaration date in early 2003. It is not involving systematic rebalancing because we are focusing on one single stock and its record date should be earlier than its next declaration date. Figure 5.15 demonstrates the cumulative return of our portfolio and a comparison with US Treasury rates and a portfolio of longing and holding Microsoft throughout the time.

Since there are sparse increasing dividend events for one single stock over its lifespan and every time after we sell the stock we put the proceed into a risk-free account, this portfolio behaves like risk-free rates most of time. Moreover, the

benefit of our systematic rebalancing approach cannot be demonstrated through this portfolio.

For our general portfolio with increasing dividend signals, we consider all stocks traded trading on either the NYSE, AMEX, or NASDAQ with ordinary dividends paid in U.S. dollars on ordinary common shares. In addition to all the increasing dividend events, we also include all dividend initiations for companies which stay in the CRSP dataset for at least 6 quarters before announcing a dividend.

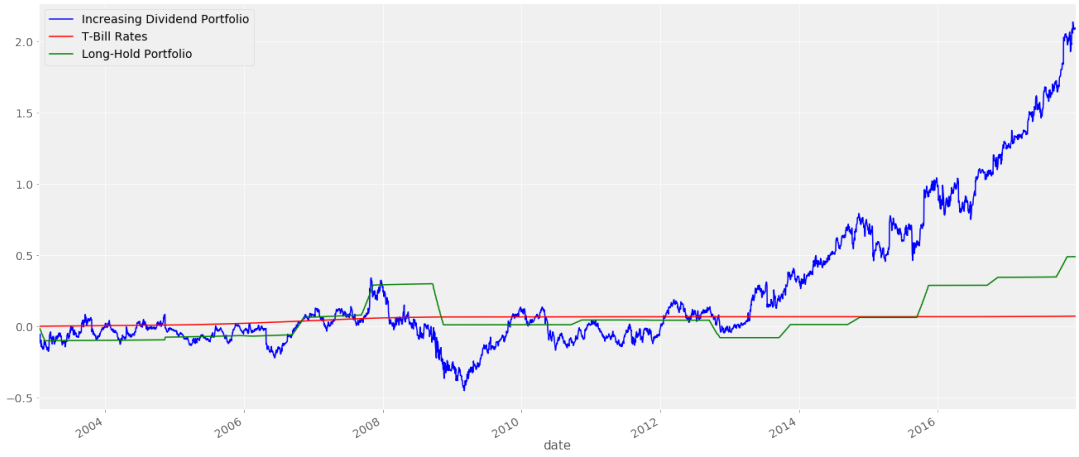

Figure 5.15: Cumulative Return of the Microsoft Portfolio with Increasing Dividend Signals

Figure 5.16 shows the cumulative Net Asset Value (NAV) of our portfolio (labeled as Portfolio6) with systematic rebalancing to capture all the increasing dividend events for the most recent year. We compare our portfolio with the market index S&P 500 and a well-performed stock, Apple. We can clearly observe that our portfolio outperforms the others almost 100% of the time throughout the year. Such outstanding performance indicates the systematic rebalancing approach can effectively capture the increasing dividend signals by allocating equal-weighted value to each stock in the inventory and obtaining the increasing dividend which can somehow compensate for the price drop around ex-dividend date. Figure 5.17 shows the performance of Portfolio 6 over a longer investment horizon.

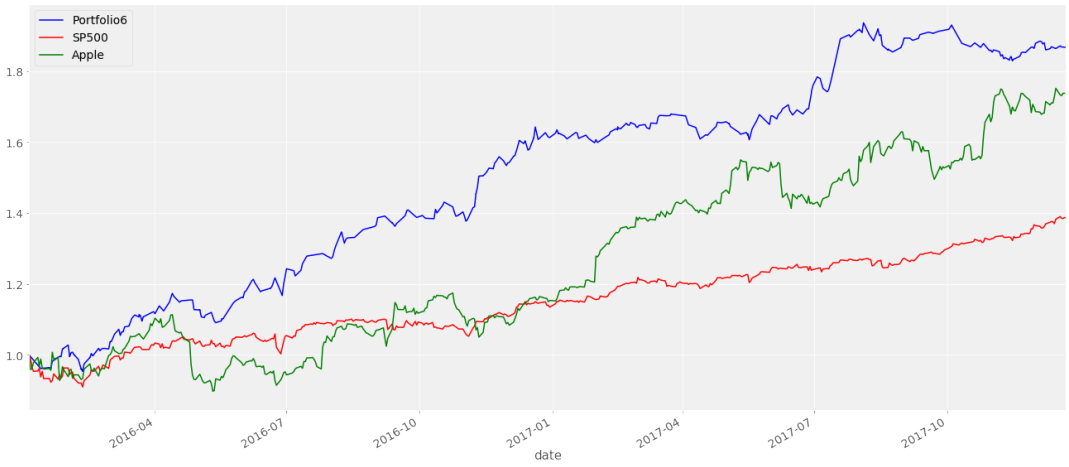

Figure 5.16: Cumulative Net Asset Value of the Portfolio6 with Increasing Dividend Signals

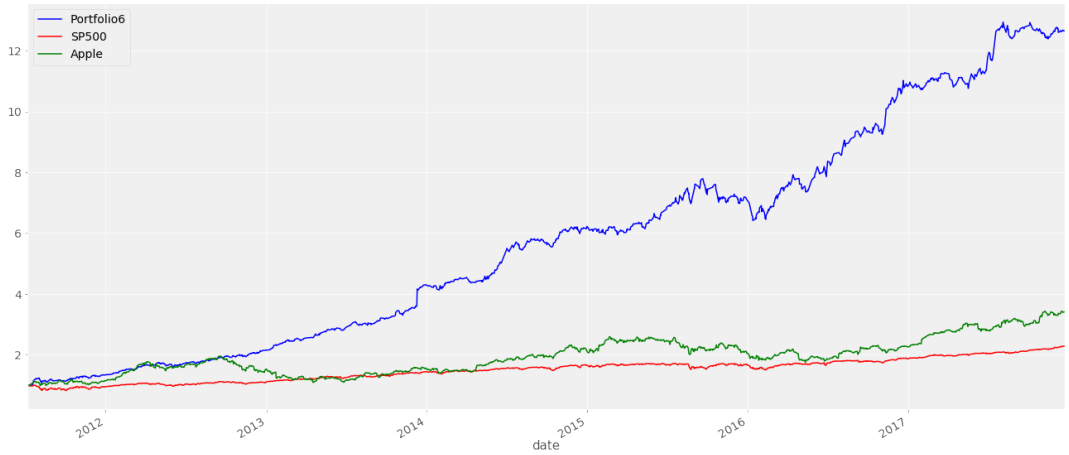

Figure 5.17: Cumulative Net Asset Value of the Portfolio6 Starting from 2011

In this general portfolio with increasing dividend signals, we have 383 events in total (either long a new stock or short an existing stock). People might be curious about the transaction costs associated with every rebalance. We imposed 0.05% transaction costs in the Portfolio6 based on trading value for each stock traded. However, we did not take liquidity cost into serious consideration, which might be a main difficulty of implementing this portfolio because for some small-cap stocks in the inventory, they are hard to trade in our systematic rebalancing framework.

Chapter 6

Conclusion and Further Study

By studying the 2003 tax reform in the US, we further understand the influence of tax factor on dividend puzzle. When the capital gains tax rate is different to the tax rate on dividends, the puzzle indeed exists while the tax difference becomes smaller or even disappears like what happened in the US, the puzzle becomes less significant, and investors are indifferent to capital gains and dividends. Inspired by this finding, further research could be conducted for countries with a substantial difference in these two taxes, such as China where there is currently almost no capital gains tax. If we want to generate investment signals by rolling regression considering the fact that the change in stocks' ownership weights (different shareholders may have different marginal tax rates), then the signals obtained usually capture more about how fast stock prices change rather than what we want, as people are more sensible in price changes and the changes in shareholder's weights are less frequent and have less influence.

Based on the vanilla portfolio performance, a strategy to capture the difference between dividend payment and stock price decrease will outperform inflation and S&P 500 portfolio. Due to six-day holding period, there can be observed co-integration between simple portfolio NAV and S&P 500 portfolio NAV. In the experiments separating bid and small-cap stocks, there is not enough evidence to conclude that portfolio performance is associated with capital size. In contrast, equity paying smaller dividend yield tends to have more substantial profit potential compared with high dividend yield stocks. On explanation is that low dividend yield is caused by stock payback which suggesting good company performance. (try link this to later strategy considering dividend yield.)

The increasing dividend announcement can be considered as a positive trading signal and easily incorporated in portfolio construction. Taking into account the sparsity of increasing dividend events for an individual stock, we should better include a sufficient number of stocks in our portfolio by capturing their increasing dividend signals more comprehensively. We have developed an efficient way of portfolio construction with systematic rebalancing. Our empirical study demonstrated that the systematic rebalanced portfolio could capture increasing dividend signals using allocating equal-weighted value to each stock to guarantee comprehensive exposure and obtaining increasing dividends that compensate the price's volatility around ex-dividend date.

The feasibility of implementing the portfolios mentioned above need to be investigated in the future. The main factors to consider are transaction costs and liquidity issues. An accurate estimation of transaction costs is crucial to portfolio implementation in practice, especially for portfolios with high turnovers. Our portfolio with increasing dividend signals is very vulnerable to liquidity issues because we are likely to include very illiquid stocks in our inventory so that their value is hard to be adjusted when next rebalancing period comes. Strategic asset selection might alleviate this liquidity issue by considering assets with easy access and high liquidity.

The tax reform recently announced by President Trump could also produce exciting data for dividend puzzle analysis. Thus far, however empirical study of the few data points after the announcement is hardly meaningful. Further investigation can be conducted when enough data become available.

Bibliography

[1] E. J. Elton and M. J. Gruber, "Marginal stockholder tax rates and the clientele effect," pp. 3–9, 2011.

[2] A. Kalay, "The ex-dividend day behavior of stock prices: a re-examination of the clientele effect," *The Journal of Finance*, vol. 37, no. 4, pp. 1059–1070, 1982.

[3] R. Bali and G. L. Hite, "Ex dividend day stock price behavior: discreteness or tax-induced clienteles?," *Journal of Financial Economics*, vol. 47, no. 2, pp. 127–159, 1998.

[4] D. C. Heath and R. A. Jarrow, "Ex-dividend stock price behavior and arbitrage opportunities," *Journal of Business*, pp. 95–108, 1988.

[5] S. Dutta, V. M. Jog, and S. Saadi, "Re-examination of the ex-dividend day behaviour of canadian stock prices," 2004.

[6] T. R. Henry and J. L. Koski, "Ex-dividend profitability and institutional trading skill," *The Journal of Finance*, vol. 72, no. 1, pp. 461–494, 2017.

[7] S. M. Hartzmark and D. H. Solomon, "The dividend month premium," *Journal of Financial Economics*, vol. 109, no. 3, pp. 640–660, 2013.

[8] L. E. Harris, S. M. Hartzmark, and D. H. Solomon, "Juicing the dividend yield: Mutual funds and the demand for dividends," *Journal of Financial Economics*, vol. 116, no. 3, pp. 433–451, 2015.

[9] L. Bauer, S. Beveridge, and R. Jha, "The dividend puzzle: the influence of taxes, tick size and short-term trading on ex-dividend day prices in canada," 2006.

[10] R. Chetty, J. Rosenberg, and E. Saez, "The effects of taxes on market responses to dividend announcements and payments: What can we learn from the 2003 dividend tax cut?," tech. rep., National Bureau of Economic Research, 2005.

Appendix

Dep. Variable:	price change ratio	**R-squared:**	0.092
Model:	OLS	**Adj. R-squared:**	0.092
Method:	Least Squares	**F-statistic:**	109.9
Date:	Sun, 04 Mar 2018	**Prob (F-statistic):**	5.96e-06
Time:	23:32:59	**Log-Likelihood:**	17010.
No. Observations:	13711	**AIC:**	-3.402e+04
Df Residuals:	13710	**BIC:**	-3.401e+04
Df Model:	1		
Covariance Type:	cluster		

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
dividend yield	1.0516	0.100	10.483	0.000	0.855	1.248

Omnibus:	8571.703	**Durbin-Watson:**	1.922
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	1558421.596
Skew:	-1.966	**Prob(JB):**	0.00
Kurtosis:	55.081	**Cond. No.**	1.00

Figure 6.1: OLS Regression Results of Price Change Ratio on Dividend Yield (After 2003 Tax Reform)

Dep. Variable:	price change ratio	**R-squared:**	0.037
Model:	OLS	**Adj. R-squared:**	0.037
Method:	Least Squares	**F-statistic:**	12.21
Date:	Sun, 04 Mar 2018	**Prob (F-statistic):**	0.00815
Time:	23:33:02	**Log-Likelihood:**	79479.
No. Observations:	50247	**AIC:**	-1.590e+05
Df Residuals:	50246	**BIC:**	-1.589e+05
Df Model:	1		
Covariance Type:	cluster		

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
dividend yield	0.5845	0.167	3.494	0.000	0.257	0.912

Omnibus:	19081.521	**Durbin-Watson:**	1.949
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	527404.375
Skew:	-1.239	**Prob(JB):**	0.00
Kurtosis:	18.677	**Cond. No.**	1.00

Figure 6.2: OLS Regression Results of Price Change Ratio on Dividend Yield (Before 2003 Tax Reform)

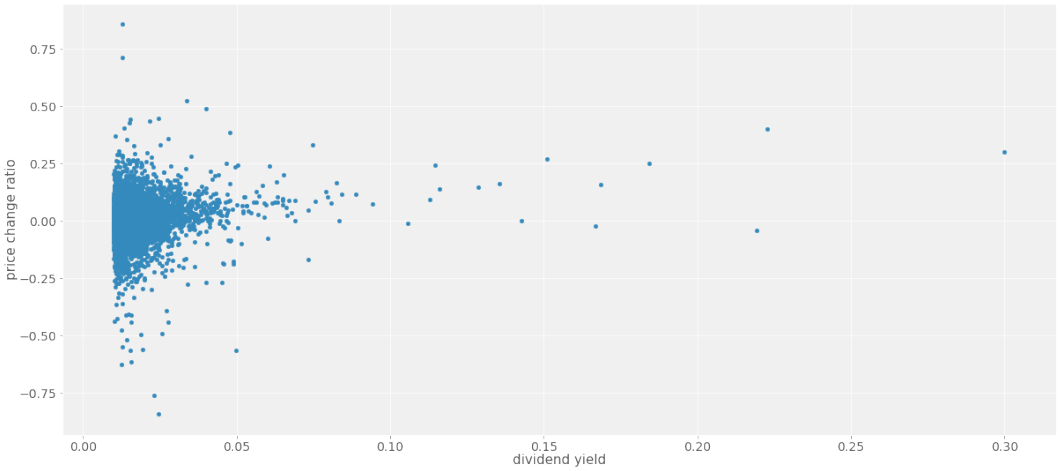

Figure 6.3: Price Change Ratio vs Dividend Yield (Division: Finance, Insurance and Real Estate)

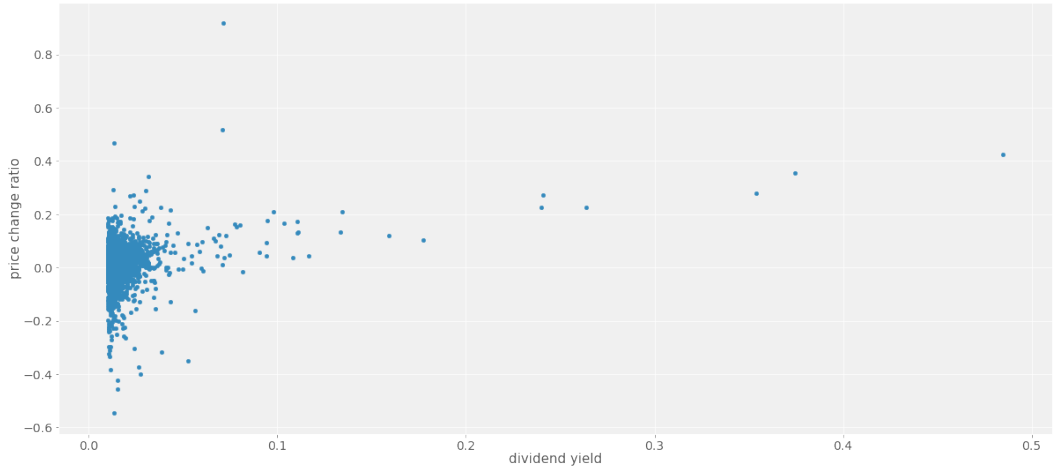

Figure 6.4: Price Change Ratio vs Dividend Yield (Division: Services)

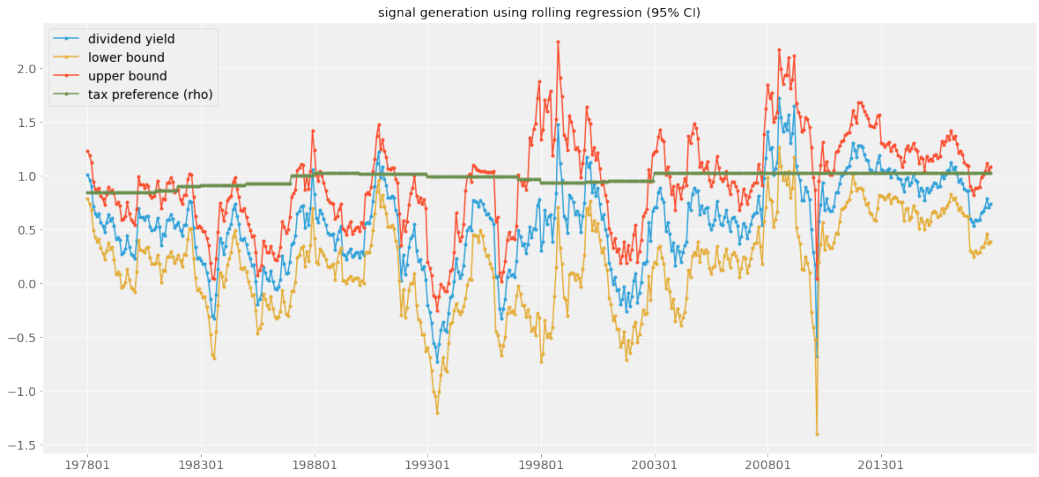

Figure 6.5: Signal Generation using Rolling Regression (95% CI) (Division: Finance, Insurance and Real Estate)

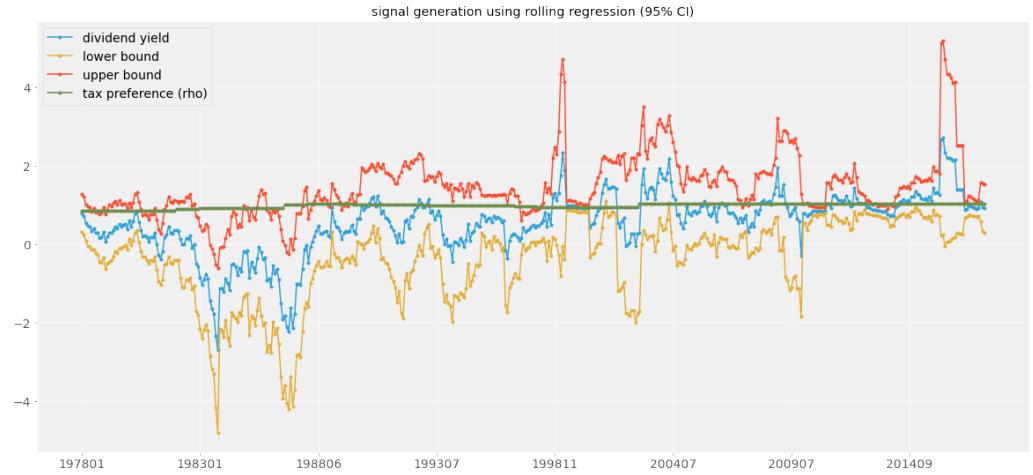

Figure 6.6: Signal Generation using Rolling Regression (95% CI) (Division: Services)