TECHNICAL ANALYSIS OF ETF PORTFOLIO REBALANCING STRATEGY

by

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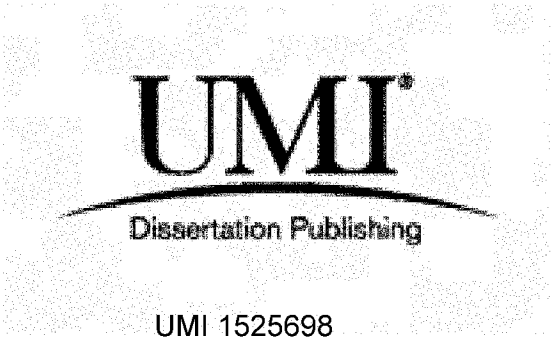

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ABSTRACT

Portfolio rebalancing strategy is of great importance to minimize the risk taken so as to ensure profitable investments. Regular rebalancing keeps the portfolio developing as it was planned and achieved initial invest goals. The relevant literature of the technical analysis on rebalancing strategy is scarce. After elaborating the four traditional rebalancing strategies and a set of risk measurements, the thesis proposes the multiplier rebalancing strategy, which combines the traditional periodically rebalancing strategy with the interval rebalancing strategy, and Relative Strength Index (RSI) rebalancing strategy based on technical analysis. In order to evaluate the effectiveness of the multiplier and RSI rebalancing strategies, the thesis conducts an experiment to compare the performances of two proposed strategies with the other four traditional strategies in terms of the rewards and risk measurements by using nineteen years Canadian stock and bond Indices and Exchange Traded Funds data from 1983 to 2010.

Key Words: Portfolio Rebalancing Strategy; Technical Rebalancing Strategy; Risk Measurements; Traditional Rebalancing Strategies; Exchange Traded Funds.

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Abbreviations

AAR: Average Annualized Return

ARB: Annual Rebalancing Strategy

B&H: Buy-and-Hold Rebalancing Strategy

ETF: Exchange Traded Fund

MDD: Max Drawdown

MPT: Modern Portfolio Theory

Multiplier: Multiplier Rebalancing Strategy

QRB: Quarterly Rebalancing Strategy

RSI: Relative Strength Index Rebalancing Strategy

Threshold: Threshold Rebalancing Strategy

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In writing this paper in a year, and has also experienced a huge test. To subject confusion, then is the literature structure tired, research question is again on the paper to solve the proposed reference point of reasonable when encountered bottleneck, thinking at the same time, their knowledge of precipitation to be accumulated and enriched the discovery in the process, both in the theory and the text of the control needs to be improved and sublimation, finally forming, feels gratified. But all the knowledge can only support them write this level and height, hope in the future continue to process, can improve even more and deeper insights.

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CHAPTER I:

INTRODUCTION

It is prevailing for companies and individuals to hold at least one tax deferred long term investment account(s) for assets appreciation nowadays. However, what leave much to be desired is that the investments may not create as much premium as investors expected, which may lead to panic if there is huge loss in the society. A good management of these long term investments is vital. Portfolio rebalancing not only plays a significant role in individual investments, but also demonstrates remarkable effectiveness in secure institutional investments, especially in the long term, such as investments from mutual fund and insurance companies. Picking the right investment vehicles is far away from sufficient. The compounding power requires further on-going monitors and adjustments. Therefore, portfolio rebalancing presents deeper influential for long-term investments. Like "exercise regularly" and "physical exam yearly", portfolio rebalancing indicates better advice for your investment, the ignorance may do no harm to your portfolio instantly, but in the long run, serious loss may be suffered on your portfolio. The volatility of the rebalanced portfolio is smaller than these have never been rebalanced.

The thesis intends to find out how the rebalancing strategies work under technical analysis compared with traditional rebalancing strategies. Firstly, the thesis will explain the importance of portfolio rebalancing and the backgrounds about technical trading strategies, modern portfolio theory, and Exchange Traded Funds. Secondly, the thesis will utilize technical

analysis to propose two rebalancing strategies, as well as the advantages and disadvantages of all rebalancing strategies. Thirdly, give a comparison results on the proposed methods with other traditional rebalancing strategies. The last part of this thesis is the conclusion.

Portfolio management (PM), to be brief, the management of basket of stocks and (or) bonds, is the art of selecting the right investment policy for the investor in terms of maximum return at a given risk level. Investment policy which is prepared by portfolio manager provides the general investment goals and objectives of the investor and the investment strategies that the manager would apply to meet investor's expectation. That includes specific information such as asset allocation, risk tolerance level, expected performance, and other requirements. PM contains three stages: asset allocation, security selection, and rebalancing strategy. Asset allocation of a portfolio, which is a key factor in investment performance, mainly determines a portfolio's risk-and-return characteristics[1]. Studies has suggested that up to 80% or more of the variability in the portfolio performance is explained by asset allocation, with the rest determined by security selection, market timing, and other factors. By analyzing the expected returns and risks of different securities within various asset classes, portfolio managers can seek to construct portfolios that will yield the highest possible return for a given level of risk.

However, investors should have in-depth understanding about asset allocation. It is a dynamic process. Due to the prices of different securities change over time, change in original target allocations might lead to increasing risk or lower returns and hence make it impossible for investors to achieve initial investment aims. Portfolio managers would monitor their portfolios frequently and have procedures in place to restore their original target allocations, so that the portfolio performance is in line with the investment policy which addressed investors' objectives

[1] Buraschi, A., Porchia P., Trojani, F. "Correlation risk and optimal portfolio choice". *J. Finance* (2010).Vol. 65(1): pp. 393–420.

and risk tolerance level[2]. This dynamic process is called portfolio rebalancing and cannot be ignored during investments. Portfolio rebalancing is accomplished by occasionally resetting the proportions of each asset class back to their original weights.

1.1 The Importance of Rebalancing

Portfolio rebalance is crucial because it can make investors to maintain their target asset allocation. Periodically rebalancing can benefit the maintenance of target allocation of the portfolio. As a result, the exposure to risk relative to target asset allocation can be deducted. By this means, the rebalance of portfolio will bring it back to its original target allocation and reset its routes. Therefore, the primary goal of a rebalancing strategy is to minimize risk of the portfolio relative to a target asset allocation, rather than to maximize returns of the portfolio. The importance of portfolio rebalancing can be explained from following three aspects: firstly, Investors need effective and efficient disciplines to manage their investment portfolio rationally from behavioral finance perspective; Secondly, risk management and diversification is the foundation to offset over risky assets for asset management; Thirdly, as portfolio rebalancing is an inherently contrarian process, additional value for the portfolio can be added.

First, from behavioral finance perspectives, people tend to have "status quo bias" when dealing with their investment portfolios. Market force drives dramatically changes in stock price even every single second and correspondingly leads to a fluctuated financial market over time. It is investors' decision to let the portfolio drift or adjust the portfolio weights to its target asset allocation when come across these changes. A survey of among 1200 pension fund participants from a mutual-fund institute shows that only 25% participants had made some changes to the

[2] Busse, J. A., Goyal A., Wahal. S. "Performance and persistence in institutional investment management". J. Finance (2010). Vol. pp. 65(2) 765–790.

allocation of their portfolio; one or two small changes had been made regarding to the rest[3]. The finding of this survey also recommended that the participants who seldom made any changes in their portfolio tended to be more risk-averse than those who did; as they think the change is dangerous.

Investors' actions through letting their portfolio drift with the prevailing current towards avoid risk often end up with the opposite direction – increasing risk. As the lead or lag characters of the returns on different assets, their portfolios will be transformed accordingly over the long run. The automatic mechanism may raise the allocated weights to the outperforming asset classes while shrink the weight of underperforming asset classes, then the profits made by outperformers can offset the loss resulted from underperformers. In the short run, this automatic change mechanism can enhance a better portfolio performance by elevating the outperforming assets' allocated weight automatically[4]. However, there is no free lunch in investment field. In the long run, the risk level increases as the portfolio grow and concentrate on the outperforming assets. The portfolio becomes more vulnerable to a sea change in the markets.

A great lesson could be learned from Japanese market during the 1980s. Japan experienced one of most dramatic stock-market bubbles in financial history. The Nikkei 225 index was at least trebled from 1984 to 1989. On the contrary, the stock market experienced a great shock and the index dropped nearly 60% over following three years since 1990. If an investor had a portfolio in Japan during 1984 to 1994 without a rebalancing policy, since the equity prices had been raised significantly as years' lifting in the big market, then the losses

[3] John O'Brie. Rebalancing: A Tool for Managing Portfolio Risk. *Journal of financial service professionals.* (2006) Vol.60(3): PP 191-209

[4] This automatic adjustment system can only apply to short term portfolio. When it comes to long term, the precious outperforming assets may turn unsuccessful, rebalancing should intervene. Gary Brinson, P; Randolph Hood, L; Gilbert Beebower, L. "Determinants of Portfolio Performance". *Financial Analysts Journal.* Vol. 42 (4): pp. 39 – 44.

during the subsequent bear market would be magnified as well. Therefore, a rational management of the long term investment and portfolio is essential.

Second, from risk management perspective, rebalancing is necessary. A hypothetical diversified portfolio over 10 year period from May 1994 to May 2004 without rebalancing shows how quickly an untended portfolio can drift into risky zone. Assuming the portfolio contains 50% of Canadian short term bond and 50% of S&P/TSX 60 on May 1994, the weight on equity portion would grow to 66.68% on August 2000, and then changed to 56.24% on May 2004. The portfolio is heavily concentrated on equity market and thus higher risk due to the volatile of the equity market. If the initial invest $100,000 was made on May 2004, the portfolio value in ten years will be $190,147.22 without rebalancing, and its value is $198,244.53 with quarterly rebalancing. That means the value would increase by 4.26% compared to the untended portfolio, and the volatility of the rebalanced portfolio is much lower than the one without rebalancing. Investors could reduce portfolio volatility by keeping up with the target weights. This could also allow the compound growth works more quickly and boosting long term returns. Thus, rebalancing is necessary for risk management and assets diversification for long term investment.

The example below will show you how risks can affect investor's wealth. I use the 15-year S&P/TSX60 total return from January 1995 to February 2010 as an example to show how market volatility can impact the risk and the investment. (Table 1) Assuming I invest $100,000 on January 1995, the returns and risks in the four scenarios below show that the level of risk can be reduced while maintaining stable returns if I can avoid the "market extremes".

Table 1: Examples of How Risks Can Affect Wealth

	Value	%Changes (Return)	Beta(Risk)
Scenario 1: Buy & Hold			
With no months removed	$418,156.03	0	1
Scenario 2: Best months			
6 best months removed	$226,261.09	-45.89%	0.85
3 best months removed	$298,270.97	-28.67%	0.909
1 best months removed	$371,462.46	-11.17%	0.966
Scenario 3: Worst months			
6 worst months removed	$1,139,326.31	172.46%	0.701
3 worst months removed	$828,873.71	98.22%	0.779
1 worst months removed	$589,039.18	40.87%	0.901
Scenario 4: Extremes			
6 best and 6 worst months removed	$549,105.13	31.32%	0.551
3 best and 3 worst months removed	$526,619.39	25.94%	0.688
Best and worst month removed	$466,075.86	11.46%	0.867

Risks can be very harmful to the investment because the more money you lose the harder to make up your initial investment. As the examples shown on Table 3 below, if the investor invest $100 initially, when he lose $75 or 75% of the investment, 300% return will be required to grow back to principal investment value. However, it is unlikely investor can 300% return investment very often.

Table 2: Examples of Risk and Losses

Scenario	**1**	**2**	**3**
Principal Invested	$100	$100	$100
Percent loss	15%	50%	75%
Total	$85	$50	$25
Percent Gain Required to return to principal value	17.65%	100%	300%

Thirdly, the counterintuitive rebalancing process can provide a better understanding of the market force and implement policies to deal with the changing. The rebalancing procedures invite rational consideration to increase the weight of well performed stocks and decrease that of risky ones regarding to the changing market. Investors sell the winners and buy the losers, but it also push investors to buy low and sell high in practice. It also makes big part of the benefit. Rebalancing also can promote return. If there is a long term upwards market trend, the capital injection into undervalued asset class from current outperforming asset class can lift the return. Even in a down market, rebalancing does help reduce losses.

1.2 Technical Analysis

Technical analysis focuses on the price of a share of its stock relative to a company. A technical analyst buys or sells the stock based on the stock past behavior. The differential between market price and underlying value is very elastic. Technical analysis deals with problems posed by changes in investor confidence more efficiently than conventional "fundamental" value analysis. Therefore, technical analysis and fundamental analysis can be regarded as mutually complementary and interdependent. A technical indicator is a series of data points that are derived by applying a formula to the price data of a security. In our study, the price data used in the formula and calculation is the monthly closing prices. For instance, the average of 3 closing prices is one data point ((15+19+16) / 3 = 16.67). However, one data point does not have sufficient much information. A series of data points over a period of time is needed to create valid reference points to enable analysis. Different technical indicators analyze the price action from different perspectives. Two proposed technical rebalancing methods are based on leading technical indicators which are designed to lead price movements. More specifically, both methods are based on the theory of price momentum indicators.

The first method is inspired by a practitioner in the financial service company who manages portfolio for clients. He calculates the average gains and average losses of the securities in the portfolio, and then finds the best selling and buying points by multiplying the average gains and average losses to the multipliers accordingly. This method will be discussed thoroughly in section Three.

The other one is Relative Strength Index (RSI) developed by J. Welles Wilder. RSI is one of the most popular momentum indicators. Momentum measures the acceleration or deceleration of a security's price. As the price of a security rises, price momentum increases. The larger the period-over-period price change, the greater the change in momentum. Once the price change decelerates, momentum would also decelerate. The RSI rebalancing method will be explained in details in section three.

1.3 Modern Portfolio Theory

Modern Portfolio Theory (MPT) assumes that investors are risk-averse. The theory uses standard deviation of return as a proxy for risk, which is valid if asset returns are jointly normally distributed. Under the mathematic model of MPT, portfolio return is the proportion weighted combination of the assets returns in the portfolio; portfolio volatility is a function of the correlation ρ_{ij} of the component assets, for all assets pair (i, j). For simplicity, only two-asset-portfolio will be explained in this study as follows.

Portfolio return:

$$\mathrm{E}(R_p) = w_A\,\mathrm{E}(R_A) + w_B\,\mathrm{E}(R_B) = w_A\,\mathrm{E}(R_A) + (1 - w_A)\,\mathrm{E}(R_B).$$

Where R_p is the return on the portfolio, R_A and R_B are the return on asset A and B; and w_a and w_b are the weighting of component asset A and B.

Portfolio variance:

$$\sigma_p^2 = w_A^2\sigma_A^2 + w_B^2\sigma_B^2 + 2w_A w_B \sigma_A \sigma_B \rho_{AB}$$

Where ρ_{AB} is the correlation coefficient between the returns on assets A and B.

Thus the portfolio volatility (standard deviation):

$$\sigma_p = \sqrt{\sigma_p^2}$$

1.4 Exchange Traded Funds (ETF)

The thesis applies ETFs as the sample portfolio. EFT can be traded as a stock on the exchange, is acting like an index fund which tracks an index, a commodity or a basket of assets. Daily bought and sold in the exchange can influence the price of ETFs throughout the day. As a well-diversified security, ETF presents a lower risk. Advantages of ETFs over Actively-Managed Mutual Funds are as follows: expense ratios are much lower, no investment minimums, option and short-selling opportunities, lower taxes, more trading flexibility. Thus, it's easier and cheaper to be managed for long term investment, especially for retail investors who want to achieve their retirement investment objectives with lower costs and risks.

1.5 Objective of Research

This thesis explains how important portfolio rebalancing is. The main objective of the research is to prove that the technical trading strategy can improve the portfolio performance as

well as reducing risk in the long-run compared to other traditional rebalancing strategies. While the main objective of a rebalancing strategy is to reduce potentially risk and increase returns. This thesis applied various risk measurements to test which strategy is better for risk management propose.

1.6 Structure

The rest of the thesis is structured as follows. Chapter II is the literature review on traditional rebalancing strategy and technical trading techniques; Chapter III presents details about traditional and the proposed technical rebalancing approaches and strategies; Chapter IV discusses the data set and different measurements of risk, reward, and cost, and illustrates the experiments (simulations), and discusses the empirical analysis and experimental results. Finally, Chapter V concludes the findings with some remarks and ideas for future improvements and research.

CHAPTER II:

Literature Review

In academic field of financial investments, scholars have been done lots studies on fundamental analysis rather than technical analysis as it is contradicted to efficient market hypothesis (EMH)[5]. However, technical trading strategies are widely used by practitioners in the investment field. The empirical evidence on technical analysis should be promoted in academic field, especially for portfolio management field.

To the best of my knowledge, there are very few studies on long term portfolio rebalancing strategy based on technical analysis.

2.1 Traditional Rebalancing Strategies

Traditionally, financial practitioners have proposed three broad categories of rebalancing approaches: periodic rebalancing, threshold rebalancing, and combination approach. Jaconetti, Kinniry, and Zibering(2010) and Tokat (2007) at Vanguard studies compared traditional rebalancing approaches and concluded that an annual or semiannual rebalancing and a threshold of five percentage points provide sufficient risk control relative to the target asset allocation for most portfolios with broadly diversified stock and bond holdings.

Several aspects of rebalancing strategies and their practical implications have been analyzed in previous studies. Tokat and Wicas (2007) conducted Monte Carlo simulations to examine the

[5] The EMH was developed by Professor Eugene Fama in his PH.D thesis in 1960s and was widely accepted by 1990s. According to EMH, the information disclosure means a lot to stock prices. But Paul Samuelson argued that this hypothesis can only apply to single stock, rather than the whole stock markets. That is where it is contradicted with technical rebalancing strategy.

periodical rebalancing strategy in trending and mean reverting markets over the period of 1960 to 2003. The findings concluded that annual and semiannual monitoring, with rebalancing at 5% thresholds, produces an acceptable balance between risk control and cost minimization for most broadly diversified stock and bond fund portfolios. In order to model the return generating process of both the bond and the stock market, Tocat and Wicas assume a normal return distribution[6]. However, Mandelbrot (1963), Fama (1965), and Clark (1973) have shown strong evidence that stock market returns are non-normally distributed[7]. Examining periodical, threshold, and combined periodical-threshold rebalancing strategies, Jaconetti, Kinniry and Zilbering (2010) conclude that there is no universally optimal rebalancing strategy, a rebalancing strategy based on reasonable monitoring frequencies and reasonable allocation thresholds is likely to provide sufficient risk control relative to the target asset allocation for most portfolios with broadly diversified stock and bond holdings; and the buy-and-hold exhibits the highest average annualized return with a value of 9.1% after an investment period of 84 years, but also the highest volatility with a value of 14.4% due to an average stock allocation of 84.1% in the portfolio[8]. Cai and Houge (2008) examined the long-term impact of Russell 2000 Index rebalancing on portfolio evaluation from 1979 to 2004, and they found a buy-and-hold index portfolio outperformed the annually rebalanced index by average of 2.22% over one year and 17.29% over five years[9]. Plaxco and Arnott (2002) applied calendar, range, and tactical (or active)

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[6] They mainly presented a conceptual framework for developing rebalancing strategies that can accommodate changes in the financial market environment and in asset class characteristics, as well as account for an institution's unique risk tolerance and time horizon. We conduct simulations to analyze how these different factors and different rebalancing guidelines affect a portfolio's risk and return characteristics. We conclude with a review of practical rebalancing considerations. Yesim Tokat; Nelson W Wicas. (2007). "Portfolio Rebalancing in Theory and Practice". The Journal of Investing. Vol. 16 (2): pp. 52-59

[7] Mandelbrot, B. B. (1963). "The variation of certain speculative prices". *J. Bus.* Vol. 36(4): pp. 394–419.
Fama, E. F. (1965). "The behavior of stock market prices". *J. Bus.* Vol. 38(1): pp. 34–105.
Clark, P. K. (1973). "A subordinated stochastic process model with finite variance for speculative prices". *Econo- metrica* Vol. 41(1): pp. 135–155.

[8] Jaconetti, C. M., Kinniry F. M., Zilbering Y. (2010). "Best practices for portfolio rebalancing". *Vanguard* pp.1–17.

[9] The findings show that the strongest performing funds will enhance their factor adjusted returns by holding index additions. Jie Cai, Todd Houge. (2008). "Long Term Impact of Russell 2000 Index Rebalancing". *Financial Analysis Journal.* Vol. 64(4). pp. 76-

rebalancing strategies compared with those of a portfolio that used a buy and hold strategy during the period 1980 to 2000[10]. The studies show that rebalancing strategy does not always produce superior absolute returns compared to a drifting mix strategy. However, the rebalancing strategy can decide which level of risk adjusted returns is considered. The superiority of the strategy is particularly significant over the long term. Rebalancing reduces the portfolio risk and, most of the time, is a significant source of alpha for the portfolio. Furthermore, the static rebalancing approaches have been conducted as basic rules to make the allocation of asset back to the benchmark where they breached the limit or reached some calendar data[11]. However, static rebalancing strategies are risky as an implicit bet to be either long or short an asset without really focusing on the view on the markets or the assets themselves. Moreover, specific assumptions have to be made in advance which would strongly predetermine the empirical outcomes in many cases from prior studies. The results may not allow reliable interpretations.

2.2 Technical Trading Strategies

Brock, Lakonishok, and LeBaron (1992) have developed simple technical trading rules based on moving averages and support and resistance; and those rules may be applied to the Dow Jones Industrial Average to predict stock price changes[12]. Whereas Neftci (1991) has showed that useful information in non-linear time series and in particular in financial markets can be

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[10] Isa Plaxco M., Robert Arnott D. (2002) Rebalancing a Global Policy Benchmark: How to Profit from Necessity. *Journal of Portfolio Management.* Vol. 28(2) pp. 9-14

[11] Arun Muralidhar, Sanjay Muralidhar. The Case for SMART Rebalancing. Published on Q Finance.

[12] Brock, William, Josef Lakonishok, and Blake LeBaron. (1992), "Simple technical trading rules and the stochastic properties of stock returns", *Journal of Finance* Vol. 47, pp.1731-1764.

detected using moving average rule[13]. Furthermore, the work of Sullivan, Timmermann and White (1999) proved the importance of data-snooping[14].

Scholars such as Kahneman and Tversky (1982) have proposed that irreducible intuitive judgments made by investors are often biased in a predictable manner. Investors tend to overreact to information. De Bondt and Thaler (1985) extended this view and stated that stock prices also overreact to information. Jegadeesh (1990) and Lehmann (1990) have shown short-term return reversals in their studies. They suggested that contrarian strategies, which is buying past losers and selling past winners, achieve abnormal returns. However, Lo and MacKinlay (1990) provide evidences that the reason of abnormal returns documented by Jegadeesh and Lehmann is due to a delayed stock price reaction to common factors rather than to overreaction. Jehadeesh and Titman (1993) have also argued that the short-term return reversals might due to the reflection of the short-term price movements or a lack of liquidity in the market rather than overreaction.

Although the recent academic literature has focused more on contrarian strategies, the earlier literature on market efficiency paid attention on relative strength strategies that buy past winners and sell past losers. For example, Levy (1967) claims that a trading rule that buys stocks with current price that are substantially higher than their average prices over the past 27 weeks realized significant abnormal returns. Moreover, many practitioners still use relative strength as one of their stock selection criteria. Grinblatt and Titman (1989, 1991) has examined that

[13] Neftci, Salih, 1991, "Naive trading rules in financial markets and Wiener-Kolmogorov prediction theory: A study of 'technical analysis," *Journal of Business* Vol. 64, pp. 549-571.

[14]The findings show that the best performing technical trading rule is capable of generating profits when applied to the DJIA stands up to inspection for data-snooping effects. Ryan Sullivan, Allan Timmermann, Halbert White. (1999). "Data- Snooping, Technical Trading Rule Performance and the Bootstrap". *The Journal of Finance*. Vol. LIV (5). PP. 1647-1691.

majority of the mutual funds tend to buy stock which has increased in price over the previous period.

Given the shortcomings of these analyses, this research conducts empirical experiments and tests. Furthermore, there are extreme limited studies on portfolio rebalancing strategies based on technical analysis for long term investments in the literature. This study proposes a multiplier rebalancing strategy and RSI rebalancing strategy which is based on technical trading analysis.

CHAPTER III:

Rebalancing Approaches and Strategies

This chapter introduces the characteristics, benefits, and drawbacks of three types of traditional rebalancing approaches and two types of rebalancing strategies that utilize technical analysis.

Perold and Sharpe (1988) argue that different strategies can produce strongly different risk and return characteristics, the thesis implements the most widely adapted traditional rebalancing strategies by the practitioners and two proposed methods: (1) buy-and-hold, (2) periodic rebalancing, (3) interval rebalancing (threshold and range rebalancing), (4) Multiplier rebalancing strategy, and (5) RSI rebalancing strategy.

The Table 3 below shows the under investigated rebalancing strategies: three types of traditional rebalancing strategies and two types of technical rebalancing strategies. 1 is the buy-and-hold strategy which means no adjustments, no threshold and no reallocation. 2, 3, 4 are the periodic rebalancing strategies which can be characterized by reallocated regularly (usually at the end of each period) to back to the predetermined target weights. The periodic interval rebalancing strategy demonstrated in the below graph can be classified as strategies 5, 6, and 7 that will adjust to the target weights strictly (threshold approach). The threshold and Range rebalancing allows assets to be balanced to the predefined range as presents in strategies 8, 9, and 10. A threshold of ±5% is applied to both periodic interval rebalancing to target weights and periodic interval rebalancing to range. Because the threshold and range rebalancing strategies are very similar, I will only test threshold strategy in this study. The strategies 11, 12, 13, 14, 15,

and 16 are rebalancing strategies utilizing technical analysis. Strategies 11 to 13 are multiplier strategies, and strategies 14 to 16 are RSI strategies. The differences between two strategies are their simulation methods, but they share similar properties which will be discussed later. Both strategies could be monitored on various frequencies. Based on the simulations of technical analysis and the trade triggers, the dynamic thresholds of the securities in the portfolio would be determined. When the buy/sell action triggered, the portfolio rebalance to predetermined range. In this study, I use $\pm 1\%$ as the interval boundaries for both technical rebalancing strategies.

Table 3: The Resulting Classification of All Implemented Rebalance Strategies

Rebalancing Strategies	Frequency	Threshold	Reallocation	Classification	No.
Buy-and-hold	No adjustment	No threshold	No reallocation	Buy-and-hold	1
Yearly rebalancing	Yearly	No threshold	Target weights	Periodic	2
Quarterly rebalancing	Quarterly	No threshold	Target weights	Periodic	3
Monthly rebalancing	Monthly	No threshold	Target weights	Periodic	4
Yearly rebalancing to target weights	Yearly	Threshold	Target weights	Threshold	5
Quarterly rebalancing to target weights	Quarterly	Threshold	Target weights	Threshold	6
Monthly rebalancing to target weights	Monthly	Threshold	Target weights	Threshold	7
Yearly rebalancing to range	Yearly	Threshold	Interval boundaries	Range	8
Quarterly rebalancing to range	Quarterly	Threshold	Interval boundaries	Range	9
Monthly rebalancing to range	Monthly	Threshold	Interval boundaries	Range	10
Yearly rebalancing to target weight	Yearly	Threshold determined by multiplier simulations	Rebalance to target when action triggered, otherwise stay in treasury bills	Multiplier	11
Quarterly rebalancing to target weight	Quarterly			Multiplier	12
Monthly rebalancing to target weight	Monthly			Multiplier	13
Yearly rebalancing to target weight	Yearly	Threshold determined by RSI simulations	Rebalance to target when action triggered, otherwise stay in treasury bills	RSI	14
Quarterly rebalancing to target weight	Quarterly			RSI	15
Monthly rebalancing to target weight	Monthly			RSI	16

3.1 Buy and Hold Strategy

Buy- and-hold strategy is a passive investment strategy in which an investor buys securities and holds them for an extended period of time, regardless of fluctuations in the market. The belief is to let the portfolio drift and allow the securities the opportunity to grow over time, versus attempting to trade in and out of securities for short-term gains.

Buy and hold strategy presents benefits with lower costs, like no taxes, commissions, or trading fees. In the long run, this strategy may perform better since compared with fixed income

securities, equity securities reveals a higher return. But what should be highlighted is that the buy-and-hold strategy has high risk[15].

Buy-and-hold strategy seems to be safer, but it is indeed more risky for a portfolio as the portfolio would be concentrated to the high-return and high-risk security over time; and therefore, the portfolio risk increases. One of the buy-and-hold killers is the bear markets. For example, if a investor uses buy-and-hold strategy for his portfolio prior to a swift market decline similar to the ones in 1987 and 2002, the investor may have to wait 5-10 years to breakeven on their initial investment.

3.2 Periodic Rebalancing Strategy

The periodic rebalancing strategy allows a monthly, yearly or quarterly (period is predetermined) rebalance to make the portfolio back to the initial target weights. In this strategy, investors will sell the over weighted assets relative to the initial asset allocation to purchase more underweighted assets to restore the original allocations16.

It is a simple but requiring frequent and some unnecessary adjustments which may result to high expenses, like taxes and commissions. Besides, this strategy does not allow investors to temporarily over-weight asset classes or sectors that are expected to outperform over the short term.

3.3 Interval Rebalancing Strategy (Threshold and Range Rebalancing)

[15]Investors tend to be risk hater when using this strategy rather than risk lover. The thing is risk could be reversed when letting the portfolio work itself. Kimball, M. S., M. D. Shapiro, T. Shumway, J. Zhang. 2011. Portfolio rebalancing in general equilibrium. Working paper, University of Michigan, Michigan.

[16] By Lisa Plaxco elaborated in the paper named rebalancing a Global Policy Benchmark: How to profit from Necessity

With a threshold rebalancing mandate, one of interval strategy, the investor would adjust the asset allocation whenever an asset moves beyond a pre-specified threshold (e.g., +5%, -5%). For example, if the pre-specified threshold was +/-5% and the target weight for equity securities in the portfolio was 70%, but the market rise caused the weight to climb above 75%, the equity securities in this portfolio should be sold and other securities in the portfolio purchased until the original 70% target had been restored. Range rebalancing is another kind of interval rebalancing strategies. It is similar to threshold rebalancing, the differences is that when an security in the portfolio rises or falls more than the allowed amount, it is rebalanced back to the maximum or minimum, not the target, weight. For example, if a portfolio has a 70% target for equity securities with a +/-5% allowed range; when a sudden market rise takes its weight to 77%, the equity securities in the portfolio would be sold 75%, not the initial 70% weight.

The interval rebalancing method is more flexible, but it may trigger many unnecessary trading events and thus will be more expensive. Furthermore, due to the different volatilities in different securities the determination of the interval should not be the same for all the securities.

3.3 Multipliers Rebalancing Strategy

The multipliers rebalancing method is a combination of periodic and extended interval rebalancing strategies, but technical analysis is applied to define a more flexible and customized interval for every security in the portfolio. Volatilities of various securities are like noises. Securities in the same asset class may share a similar volatility. Riskier securities tend to have bigger noises than the safer securities. The waves of the noises of every security may change over time. Therefore, the rebalancing interval, threshold, and period should be measured specifically to fit every security instead of applying a single rule for all securities in the portfolio

(one set fits all approach). For example, equity A is more volatile than equity B. A small threshold should be given to equity B as it has less potential for short term gains. But if I apply the same threshold for equity A, it may cause unnecessary trades and loss potential short term gain at the same time. In the meantime, the portfolio funds may not be fully invested. Because when the selling signal of one security triggers, there may be a delay for buying another one as there is no any two securities can be that perfectly negatively correlated. The investors could move the funds to treasury bills until the buying signal of the one security reaches. The idea of multiplier rebalancing strategy is to identify the optimal buy and sell signals by multiplying the average ascending and descending returns to multiplier. The determinants of the multipliers and triggers are described below.

First of all, the historical returns of the security are split into two groups, ascending returns and descending returns. Then, calculate the means of two groups separately, which are average gains and average losses. The sell signal is determined by the product of the average gain and ascending multiplier; and the buy signal is determined by the product of the descending average and descending multiplier, both triggers are defined below.

$$\text{Sell Trigger} = A \times \alpha$$

$$\text{Buy Trigger} = B \times \beta$$

Where A is average gain of the predetermined the periods, and B is the average loss of the predetermined periods. The α is the ascending multiplier and the β here is the descending multiplier. The multipliers are normally from numbers 1 to 5, and are determined based on experiences and simulations.

In this study, the rolling window approach was conducted. The buy and sell signals are generated from historical returns to run the simulations for the future period.

The multiplier rebalancing strategy is more flexible than the threshold and range rebalancing strategies as the interval is specified to individual security in the portfolio. It does not trigger any action by any time point and it can avoid unnecessary transaction costs.

A simple example demonstrates how the multiplier rebalancing methodology works. Assume a portfolio with 70% equity securities (e.g. Stock A), 25% fixed income securities (e.g. Bond B), and 5% money market instruments (e.g. Treasury Bills). Based on the multiplier simulations, the Bond B should be sold when the sell signal triggers. For example the average of ascending return of Bond B is 0.5 and the ascending multiplier based on the simulation is 1.5, Bond B would be sold to target weight when its ascending return is 0.75 (0.5*1.5) and buy Treasury bills until the Stock A reaches its buy signal, I would sell some Treasury Bills to buy Stock A. Meanwhile, there could be large amount of funds invested into treasury bills. This is not based on any time points as time is not affecting the price changes of any securities. In all other cases, no transactions are necessary because the securities' target weight falls within the no-trade intervals based on the simulation algorithms. This approach reduces volatility of the portfolio, transaction costs and may potentially lead to superior portfolio performance.

Moreover, this study concentrate on a two-asset-class portfolio with an initial asset allocation of 70% stocks, 25% bonds, and 5% treasury bills. This approach not only adequately reflects common investment behavior in practice but also allows the comparison of the empirical findings with related rebalancing studies. Despite our focus on only two asset classes for the purpose of simplification, one should consider that each index constitutes a well-diversified

representative of an entire asset class. As in many financial institutions, the portfolio management fees are paid annually, so this study ignores transaction costs and conducts a comparative study with numbers of rebalancing events.

3.5 RSI Rebalancing

RSI is a rate-of-change or momentum oscillator, which is introduced by J. Welles Wilder, Jr. in 1978 in his book New Concepts in Technical Trading Systems. It measures the velocity of price movements. Traditionally, according to Wilder, RSI is considered overbought when above 70 and oversold when below 30; and the mid-line is 50. However, the vertical scale for the oscillator should be customized in different scenarios. In this study, the vertical scales for two securities are different to signal buying or selling opportunities. RSI is defined as follows. The relative strength factor is then converted to a relative strength index between 0 and 100. RSI is 0 when the Average Gain equals zero. RSI is 100 when the Average Loss equals zero.

$$\text{RSI} = 100 - \frac{100}{1 + \text{RS}}$$

$$\text{RS} = \frac{\text{Average Gain of N Periods}}{\text{Average Loss of N periods}}$$

$$\text{N} = \text{number of periods used in the calculation}$$

To simplify the calculation explanation, RSI has been broken down into its basic components: RS, Average Gain and Average Loss. The average gain is the average of N periods up closes price. The average loss is the average of N periods down closes. The Relative strength (RS) is calculated by dividing the average up value by the average down value. The RSI

calculation in this study is based on 12 periods, which are previous 12 months' close returns. Losses are expressed as positive values, instead of negative values.

The very first calculations for average gain and average loss are simple 12 months averages, which add the total points gained on the up days during the prior 12 months and divide by 12. The average down value is arrived at by adding the total points lost on down days during the last 12 months and dividing by 12. Insert the RS value in to the formula. I can get the first RSI value.

First Average Gain = Sum of Gains over the past 12 months/ 12.

First Average Loss = Sum of Losses over the past 12 months / 12

The subsequent calculations are based on the prior averages and the current gain loss:

Average Gain = [(previous Average Gain) x 11 + current Gain] / 12

Average Loss = [(previous Average Loss) x 11 + current Loss] / 12

The subsequent RSI is calculated by multiplying the previous up and down average value by 11; add the latest month's gain or loss to the up and down average, and multiply the total by 12. Then, insert the RS value in to the formula and recalculate the RSI. This means that RSI values become more accurate as the calculation period extends.

In this study, the mid-line of the RSI is the average RSI of each security. The vertical scale for more volatile security (the equity index proxy in this case) is +/- 5 of the average RSI, and the veridical scale for less volatile security (the fixed income index proxy) is +/- 10 of the average RSI. The selling and buying signals of RSI rebalancing strategies are defined as below.

$$\text{Selling Trigger}_{\text{Equity}}=\text{RSI Mid-line}+5$$

$$\text{Buying Trigger}_{\text{Equity}}=\text{RSI Mid-line}-5$$

$$\text{Selling Trigger}_{\text{Bond}}=\text{RSI Mid-line}+10$$

$$\text{Buying Trigger}_{\text{Bond}}=\text{RSI Mid-line}-10$$

CHAPTER IV:

Technical Analysis of ETF Rebalancing Strategy

4.1 Data, Measurements of Risk and Experiments

4.1.1 Data Source

This study uses monthly return data of S&P/TSX composite index from January 1982 to September 1999 and monthly return data of XIU from October 1999 to December 2010 as equity security in the test. As for fixed income security, I use monthly return data of DEX Universal Bond Index from Jan 1982 to October 2000 and monthly return data of XBB from November 2000 to December 2010. All the indices data are found from Thomson Reuter and ETFs data are found from Yahoo Finance. The monthly return data of Treasury Bills are found from Canadian socioeconomic database from Statistics Canada. The Treasury bills are a proxy for the risk free rates with 3-month maturities.

Measurements of Risk and Reward

This thesis would compare the performances, volatility, and rebalancing costs of all rebalancing strategies to the index to show that the proposed technical rebalancing methods would be the optimal strategy to manage the long term ETF investments. The Sharpe ratio and average annualized return would be used to measure portfolio performances; maximum drawdown, standard deviation, and beta would be used to measure volatility or portfolio risk; and number of rebalancing events would be used for measurement of rebalancing costs. The optimal rebalancing strategy would generate lower risk and rebalancing cost while maintaining relative higher return. All terms are explained below.

4.1.2 Average Annualized Return (AAR)

It has been a period for investors to use the average annual return is used to measure the performance of investments. It is more accurate to utilize compounding interest to the evaluation of the average annual return than using the simple interest formula. Furthermore, the higher geometric average is, the more promising the asset demonstrates. Hence, it is the geometric average in percentage figure of the historical returns of certain period, such as the 3-, 5- and 10-years' average returns of a mutual fund. The average annual can be a conductive advice in measuring the long term performance of a fund. However, investors should also pay attention to a fund's yearly performance to fully appreciate the consistency of its annually total returns. For example, a 5-year average annual return of 10% fund appears to be attractive. However, the average annual return can be inflated artificially because of a single "lucky" year. The following tables are the share price on December 31 each year (Table 4) and annual returns (Table 5).

Table 4 and 5: Examples of Average Annualized Return

Year	2000	2001	2002	2003	2004	2005
Price per Share	$111.19	$97.80	$76.12	$97.82	$108.32	$113.49

Year	2001	2002	2003	2004	2005
Annual ROR	-12.0%	-22.2%	+28.5%	+10.7%	+4.8%

The arithmetic average return is:

$$[(-12.0) + (-22.2) + (28.5) + (10.7) + (4.8)] / 5 = +2.0\%$$

If you invested $ 10,000 initially, it seems like you can get 10000 (1+2%)5 = $11,041 in 5 years. But if you compute year by year:

At the end ot year 1 it would be worth: $10,000 x (1-.12) = $8,800
At the end of year 2 it would be worth: $8,800 x (1-.222) = $6,846
At the end of year 3 it would be worth: $6,846 x (1+.285) = $8,798
At the end of year 4 it would be worth: $8,798 x (1+.107) = $9,739
At the end of year 5 it would be worth: $9,739 x (1+.048) = $10,206

What went wrong here? The problem here is that arithmetic average does not take the compounding effect of each year's return into account. What if I use geometric average?

The geometric average is

$$[(1-.12) \times (1-.222) \times (1+.285) \times (1+.107) \times (1+.048)]^{(1/5)} = 1.0041 \text{ or } 0.41\%$$

Then with initial invest of $10,000, the worth in 5 years is 10,000 (1+0.41%)5 = $ 10,206. Evidence shows that geometric average can reveal a more accurate return.

4.1.2 Number of rebalancing events

The number of rebalancing events is the number of trading actions trigger. It is used to compare the trading costs. The more the rebalancing events triggered, the higher the transaction costs are[17].

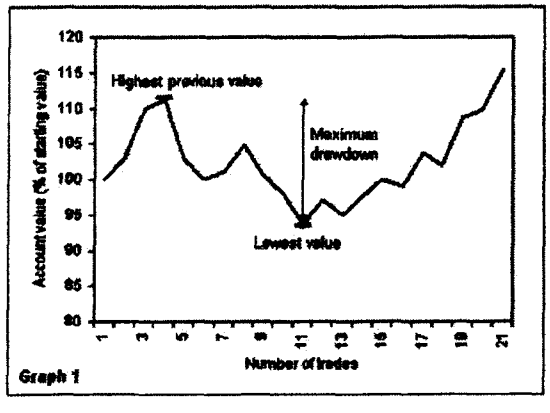
4.1.3 Maximum Drawdown (MDD)

It is a percentage figure that measures the largest single drop from peak to bottom in the value of a portfolio during a specific record period[18]. Seen from the Graph in the right, the

[17] The multiplier rebalancing strategy does not take costs into account because the rebalancing period is regarding to the return rate instead of a predetermined one. Large transaction costs can be saved.

formula of MMD = (Highest previous value before largest single drop- lowest value before new raise) / Highest previous value[19]. MDD measures an investment's financial risk and how sustained investment losses can be. It is an important risk measurement for long term investment portfolio because the larger the drawdown is, the more difficult for it to recover the investment to its previous value and the greater the risk of ruin. For instance, if your portfolio with $100 initial investment lose $10, you have $90 left in your account, then you need a 11% return to get back initial investment of $100; if you lose $30, you have $70 left, and you will need 43% return to get back the initial investment; and so on. The opposite side is, the less you loss, the more money you have in your account to grow over time. Even 1% more money can add great value in the long run as a result of compounding effect.

Figure 1: Maximum Drawdown



Source: MyForexResults

4.1.5 Standard Deviation

[18] Goodman, Beverly. "An Alternative to Hedge-Fund Alternatives." Barron's Magazine. 26 May 2012. Print.
[19] This is the formula for MMD rate, from the formula, the larger gap between the highest previous and the lowest value, the larger rate, which means it is more difficult for investments to recover.

It is a measure of the dispersion of a set of data from its mean[20]. The more spread apart the data, the higher the deviation. In finance, the volatility of investments can be measured by the deviation of actual rate of return from the expected return rate. The greater the deviation from the mean, the more volatile the investment is. Therefore, a large dispersion of returns from its mean represents how much the actual investment return is deviating from the expected investments returns or how risky the investment is.

The formula is

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

In the formula, μ is the mean of return rate, Xi is the observations rate, N is the observation number.

4.1.6 Beta

The beta of a portfolio is a number describing the correlated volatility of an investment in relation to the volatility of the benchmark that the investment is being compared to. Normally, the benchmark is the overall financial market. In this study, I use buy-and-hold strategy as the benchmark to compare volatility of the investment with other rebalancing strategies. The beta of an investment is calculated as:

$$\beta_a = \frac{\mathrm{Cov}(r_a, r_b)}{\mathrm{Var}(r_b)},$$

[20] Definition of Standard Deviation

where r_a measures the rate of return of the investment (in this case, the strategy), r_b measures the rate of return of the portfolio benchmark (in this case, the buy-and-hold strategy), and $\text{cov}(r_a, r_b)$ is the covariance between the rates of return.

4.1.7 Sharpe Ratio

Sharpe ratio is named after Nobel laureate William F. Sharpe[21]. It measures risk-adjusted performance or excess return per unit of deviation in an investment asset or a trading strategy. The Sharpe ratio describes performance of an asset compensated by the risk investors taken. Sharpe ratio can be evaluated as the asset with a higher ratio shows better return than the other when the two assets share the same benchmark (i.e. risk free rate). Higher Shape Ratio means the same return for a lower risk as well. A negative Sharpe ratio indicates that even a risk-free asset (or the benchmark asset) would perform better than the security being analyzed. The Sharpe ratio is calculated by subtracting the risk-free rate (such as Government 90 day bond rate) from the rate of return for a portfolio and dividing the result by the standard deviation of the portfolio returns[22]. The Sharpe ratio indicates whether the preferable return of an investment derives from excess risks or informed investment decisions. In terms of Sharpe ration, higher rate of return does not mean a well performed portfolio, only these demonstrate a higher return rate at a relevant lower risk or no additional risk to be paid can be regarded as good ones.

The formula of the ratio is:

$$= \frac{\bar{r}_p - r_f}{\sigma_p}$$

Where:
$\bar{r}_p$ = Expected porfolio return
r_f = Risk free rate
σ_p = Portfolio standard deviation

[21] He was the winner of the 1990 Nobel Memorial Prize in Economic Sciences. He was one of the originators of the Capital Asset Pricing Model, created the Sharpe ratio for risk-adjusted investment performance analysis, contributed to the development of the binomial method for the valuation of options, the gradient method for asset allocation optimization, and returns-based style analysis for evaluating the style and performance of investment funds.

[22] Sharp Ratio eliminates the risk free return and focuses more on the risk investors took. Ross A. Maller; Robert B. Durand; Hediah Jafarpour. "Optimal portfolio choice using the maximum Sharpe ratio". *The Journal of Risk.* Vol.12(4), 2010 pp. 49-73

Consider the Rf =1.5%, asset A has an expected return Rp=5%, and the Standard Deviation is 0.06. While asset B's Rp equals 15%, Sd = 0.5. Calculated with Shape Ratio, asset A's ratio is 0.58, while that of B is 0.27. From the first sight, asset B has a really attractive expected return, but with deeper analysis according to Shape Ratio, asset A presents a higher return rate at the same risk, or asset B has higher return rate with excess risk taken. Risk lover may choose asset B, but I assume prudent investors will choose asset A.

4.1.8 Rolling Window Approach

The 10-year rolling window approach constitutes the proposed rebalancing strategy. For a 10-year investment horizon of the proposed rebalancing strategy, it requires previous 120 monthly returns observations into the rolling window for the simulation algorithm. The multipliers calculated from the previous 120 monthly returns are used to set the trading boundaries for the individual security in the portfolio. Then, the out-of-sample tests are conducted for the future 10-year investments. This process repeats every 10-year period from January 1992 to December 2010 based on the simulation algorithm from January 1991 to December 2000.

4.1.9 Experiments

For empirical testing, a portfolio with 70% equity, 25% fixed income, and 5% treasury bills have been constructed for all rebalancing strategies. In practice, 70% equity and 30% fixed income mix is preferred by majority of investors based on their risk tolerance level in practice. Moreover, long-term investments are normally chosen younger investors who have sufficient investment horizon to tolerance the risks. All strategies tested in ten periods from January 1992 to December 2010 with an initial investment of $10,000. Every tested period is with 10 years

monthly returns. For example, January 1992 to December 2001 is one signal tested period; and the next tested period is from January 1993 to December 2002, and so on. Following four rebalancing strategies are compared:

- Buy-and-hold strategy
- Periodic rebalancing strategy (Annual Rebalancing)
- Interval rebalancing strategy (+/-5% Threshold Rebalancing)
- Multiplier rebalancing strategy
- RSI rebalancing strategy

As for periodic rebalancing strategies, both annual rebalancing and quarterly rebalancing are tested. +/-5% threshold is applied for interval rebalancing strategy. For the multiplier rebalancing strategy, all multipliers are calculated from previous 10-year returns. For example, period January 1992 to December 2001 simulations are based on the multipliers calculated from January 1991 to December 2000, and period January 1993 to December 2002 simulations are based on the multipliers calculated from January 1992 to December 2001, and so on.

4.2 Empirical and Experimental Results

This section presents the main results of the simulation analyses. In order to proof that the rebalancing strategy using technical analysis could generate superior performance to long-term investment, I start the discussion by comparing the returns of the buy-and-hold, periodic, interval, and the proposed rebalancing strategies, which is annual returns by percentage. The costs of the rebalancing strategy will be briefly presented. Then, risk management of different rebalancing strategies will be discussed. Finally, Sharpe ratio which incorporates both the return and the volatility of the investment strategy will be explained.

A. Returns (%) and number of transactions

Selling of a fraction of the better performing security and investing the proceeds in the less performing or low risk security are generally required by all rebalancing strategies. One would expect that buy-and-hold strategy outperform rebalancing strategies with increasing investment horizons. However, it is not reflected in real world data. In the financial market, there are time periods in which equity market returns substantially outperform fixed income market returns, and other time periods vice versa. The following nineteen 10-year historical data will show you what happen in the real world. Table 6 illustrates the 10-year annual compound returns in percentage of every strategy. In fifteen out of nineteen periods, buy-and hold strategy gives the lowest returns except for period 1983 to 1992, period 1984 to 1993, period 1985 to 1994, and period 1986 to 1995. Also, the quarterly rebalancing is almost always performing better than annual rebalancing strategy at the expense of more frequent transactions. Threshold rebalancing strategies perform better than periodic rebalancing strategy in most of the cases. The multiplier rebalancing strategy and RSI rebalancing strategy give superior returns in most of the cases except for the first and last two periods. For the first one period, the RSI rebalancing performs the same as the buy-and- hold strategy and the multiplier rebalancing strategy outperform all other strategies, but both technical rebalancing strategies still outperform other three traditional rebalancing strategies. For the last two periods, threshold rebalancing strategy performs much better than other strategies; however, it has the highest standard deviations which will be discussed later in this section. This might due to the financial crisis and sudden drop in the financial market, so that the previous trend cannot capture it. Even though the proposed rebalancing strategy gives higher return, dynamic portfolio strategies will produce different risk and return characteristics showed by Perold and Sharpe (1988). Therefore, an appropriate

strategy is subject to the investor's risk preference. Even though the proposed rebalancing strategies give higher returns, I cannot say it is a good strategy until its risk is taken into account carefully. Table 7 shows the dollar amount return in 10 years with initial investments of $100,000 for every strategy. Figure 2 gives the stacked line graph of the 10-year returns for all strategies. Table 8 shows the number of trades of every strategy in every 10-year periods. The quarterly rebalancing strategies give the highest number of trades required, whereas annual rebalancing strategy and threshold rebalancing strategy gives the lowest number of trades. The number of trades required for the multiplier and RSI rebalancing strategies are similar, which are slightly higher than annual rebalancing strategy and threshold rebalancing strategy, but far lower than quarterly rebalancing strategy.

B. Volatility (Standard Deviation, Beta, Maximum Drawdown)

The returns of both technical rebalancing strategies are relatively higher than the returns of traditional rebalancing strategies, but the returns of threshold rebalancing strategy, quarterly rebalancing strategy, multiplier rebalancing strategy, and RSI rebalancing strategy are close to one another. The rebalancing strategy with lower volatility gives better risk management. Table 9, 10, and 11 present the annualized standard deviation, beta, and maximum drawdown classified by strategy. Buy-and-hold strategy clearly has the highest volatility in most of the tested periods after period 1990 to 1999. This illustrates that the rebalancing strategies can reduce volatility of the portfolio in most of the cases. Quarterly rebalancing strategy seems to produce lower volatility than the threshold rebalancing strategy. Both quarterly and threshold rebalancing strategies have lower maxi-drawdown than annual rebalancing strategy. Quarterly rebalancing strategy has relatively lower risk than annual rebalancing strategy. That shows frequent rebalancing can actually reduce drawdown rate except for the last tested period. The multiplier

and RSI strategy produces the lowest risk for the long-term investments as its standard deviation, beta, and maximum drawdown are almost always lower than other strategies except for periods 1988 to 1999. It might due to it is not fully invested in the whole time as part of the money stays in treasury bills. However, the number of transactions is higher than threshold and annual rebalancing strategies. If the investor is in the annual fee based and registered accounts (tax deferred), the proposed strategy may work better. If not, the transaction costs have to be taken into account.

C. Sharpe Ratio

In order to appropriately evaluate portfolio performance, it is necessary to apply a performance measure that incorporates both the rewards and the volatility of the underlying strategies. The Sharpe ratio as a risk-adjusted performance measure is widely applied in practice. The proposed multiplier and RSI rebalancing strategy generates the highest the Sharpe ratio presented on Table 12. From this table, I can see the quarterly rebalancing has higher risk-adjusted returns than annual rebalancing strategy. Threshold rebalancing strategy works better than periodic rebalancing strategy on the risk-adjusted bases.

Overall, the simulations give a clear idea that most of the rebalancing strategy can generate value or lower risks to the portfolio compared to buy-and- hold strategy. The proposed multiplier and RSI rebalancing strategy generate superior returns on the risk-adjusted basis while the volatility of the portfolio was well controlled. From the tests, I found the threshold rebalancing strategy and annual rebalancing strategy produce lowest number of transactions, and quarterly rebalancing strategy, threshold, and technical rebalancing methods give lower risks.

4.2.1 Average Annualized Return

The 10 year annual compounding return rate was calculated for the five mentioned rebalancing strategies. As mentioned earlier, compounding return shows a conductive advice on investment, higher compound return will bring higher return on portfolio investment. From Table 6, I can see the proposed multiplier presents the highest annual compounded returns in the 16 rounds out of nineteen 10-year-periods than buy-and-hold, quarterly, and annual rebalancing methods, which in turn means, a higher performance of the portfolio. The annual compounded return of the multiplier rebalancing strategy was lower buy-and-hold strategy in one period only which is from year 1984 to 1993, but its returns were still higher than buy-and-hold and two periodic rebalancing strategies in all periods. However, the returns of technical rebalancing strategies were higher than threshold rebalancing strategy in only 16 rounds out of 19 periods, because the threshold rebalancing methods outperformed all rebalancing strategies in the last two periods which were period 2000 to 2009 and 2001 to 2010. In the 19 10-year investments, the returns of buy-and-hold rebalancing were lowest in 15 rounds out of 19 periods from periods 1987 to 2010; and its returns are higher than two periodic and threshold rebalancing strategies for the first four periods. In this test, the quarterly rebalancing strategy and threshold rebalancing strategies were outperforming annual rebalancing strategy in all periods.

Table 6: 10-Year Annual Compounded Returns of Six Rebalancing Strategies

Year	B&H	QRB	ARB	Threshold	Multiplier	RSI
Jan 1983 - Dec 1992	7.45%	7.03%	7.00%	7.22%	7.61%	7.45%
Jan 1984 - Dec 1993	8.15%	7.78%	7.76%	7.81%	8.13%	7.91%
Jan 1985 - Dec 1994	7.74%	7.68%	7.63%	7.66%	7.97%	8.54%
Jan 1986 - Dec 1995	7.35%	7.23%	7.19%	7.21%	7.50%	11.27%
Jan 1987 - Dec 1996	8.77%	8.88%	8.84%	8.97%	9.10%	9.01%
Jan 1988 - Dec 1997	9.76%	9.80%	9.86%	9.93%	10.02%	9.92%
Jan 1989 - Dec 1998	9.22%	9.36%	9.29%	9.45%	9.47%	9.43%
Jan 1990 - Dec 1999	9.62%	9.88%	9.85%	9.91%	9.94%	10.03%
Jan 1991 - Dec 2000	11.42%	11.62%	11.50%	11.55%	11.68%	11.81%
Jan 1992 - Dec 2001	8.67%	9.01%	8.84%	8.65%	9.18%	9.13%
Jan 1993 - Dec 2002	7.61%	8.04%	7.83%	8.36%	8.18%	8.03%
Jan 1994 - Dec 2003	7.00%	7.42%	7.22%	7.25%	7.58%	8.52%
Jan 1995 - Dec 2004	8.07%	8.46%	8.27%	8.30%	8.59%	8.57%
Jan 1996 - Dec 2005	8.44%	8.66%	8.49%	8.72%	8.91%	8.76%
Jan 1997 - Dec 2006	7.42%	7.63%	7.46%	7.73%	8.03%	7.69%
Jan 1998 - Dec 2007	6.58%	6.78%	6.61%	6.84%	6.91%	6.95%
Jan 1999 - Dec 2008	3.25%	3.69%	3.70%	3.69%	3.81%	3.76%
Jan 2000 - Dec 2009	3.00%	3.44%	3.44%	5.15%	3.65%	3.64%
Jan 2001 - Dec 2010	3.16%	3.54%	3.58%	5.81%	3.75%	3.62%

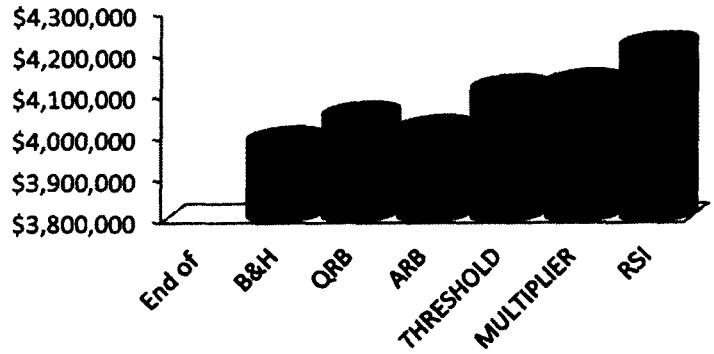
4.2.2 Dollar Amount Returns

Assuming the initial investments are $100,000, the dollar amount returns of every strategy for nineteen periods (Table 7) are more intuitive way to show the reward differences among six rebalancing strategies. Figure 2 gives the accumulative returns of six different rebalancing strategies of 19 tested periods. Both technical rebalancing strategies clearly have the highest rewards compared with other strategies. The returns of threshold rebalancing strategy are lower than the returns of technical rebalancing strategies, but higher than the returns of both periodic rebalancing strategies. Buy-and-hold rebalancing strategy gives the lowest cumulative returns after all.

Table 7: Six Rebalancing Strategies' Dollar Amount Returns at End of Every Period

End of	B&H	QRB	ARB	THRESHOLD	MULTIPLIER	RSI
1992	$205,159	$197,283	$196,730	$200,792	$208,186	$205,150
1993	$218,893	$211,489	$211,049	$212,051	$218,442	$214,092
1994	$210,796	$209,663	$208,654	$209,221	$215,266	$226,944
1995	$203,263	$200,933	$200,168	$200,659	$206,195	$290,980
1996	$231,772	$234,045	$233,237	$236,020	$238,827	$236,856
1997	$253,856	$254,623	$256,208	$257,808	$259,733	$257,461
1998	$241,466	$244,652	$243,122	$246,687	$247,196	$246,165
1999	$250,597	$256,634	$255,946	$257,180	$257,863	$257,180
2000	$294,787	$300,338	$296,933	$298,331	$301,874	$305,231
2001	$229,665	$237,001	$233,190	$229,284	$240,662	$239,530
2002	$208,303	$216,682	$212,507	$223,257	$219,508	$216,452
2003	$196,797	$204,485	$200,839	$201,408	$207,614	$226,597
2004	$217,359	$225,169	$221,272	$221,945	$227,888	$227,523
2005	$224,788	$229,373	$225,816	$230,735	$234,716	$231,679
2006	$204,562	$208,647	$205,325	$210,584	$216,557	$209,714
2007	$189,102	$192,690	$189,649	$193,761	$195,093	$195,724
2008	$137,750	$143,617	$143,806	$143,660	$145,339	$144,623
2009	$134,380	$140,209	$140,231	$165,237	$143,097	$143,031
2010	$136,510	$141,578	$142,100	$175,833	$144,458	$142,678

Figure 2: Accumulated Returns of Six Rebalancing Strategies



4.2.3 Number of Trades

The number of trades of all rebalancing strategies is shown on table 8. It is a proxy for transaction costs of investments. The 5% threshold rebalancing strategy clearly has the lowest number of trades. The quarterly rebalancing strategy has the highest number of trades. Two

technical rebalancing strategies and annual rebalancing strategy have moderate numbers of trades. Even though the transaction costs of the annual rebalancing strategy and threshold rebalancing strategy are relatively lower, but both strategies have higher volatility as well. Therefore, if the investor is paying a flat fee, the more profitable technical rebalancing strategies should be considered. Otherwise, if the transaction costs are higher than profits, the annual rebalancing method and threshold rebalancing method should be considered. However, if the benefits from the rebalancing strategy are higher than the transaction costs, the better rebalancing strategy should be considered as rebalancing can reduce portfolio risk. In this case, the technical rebalancing strategies are recommended as both strategies give higher return and moderate number of trades.

Table 8: Number of Trades in 10 Years

Year	B&H	QRB	ARB	Threshold	Multiplier	RSI
Jan 1983 - Dec 1992	0	120	30	12	29	34
Jan 1984 - Dec 1993	0	120	30	9	38	30
Jan 1985 - Dec 1994	0	120	30	6	37	38
Jan 1986 - Dec 1995	0	120	30	6	28	38
Jan 1987 - Dec 1996	0	120	30	9	36	40
Jan 1988 - Dec 1997	0	120	30	9	38	38
Jan 1989 - Dec 1998	0	120	30	9	33	36
Jan 1990 - Dec 1999	0	120	30	12	27	38
Jan 1991 - Dec 2000	0	120	30	9	40	38
Jan 1992 - Dec 2001	0	120	30	6	28	48
Jan 1993 - Dec 2002	0	120	30	12	39	50
Jan 1994 - Dec 2003	0	120	30	6	34	44
Jan 1995 - Dec 2004	0	120	30	6	37	44
Jan 1996 - Dec 2005	0	120	30	15	39	56
Jan 1997 - Dec 2006	0	120	30	15	35	58
Jan 1998 - Dec 2007	0	120	30	15	64	56
Jan 1999 - Dec 2008	0	120	30	15	27	62
Jan 2000 - Dec 2009	0	120	30	12	38	54
Jan 2001 - Dec 2010	0	120	30	12	29	44

4.2.4 Max Drawdown

Regarding to the analysis of evaluating the max drawdown, the larger the drawdown (smaller rate) is, the more difficult for it to recover the investment to its previous value and the greater the risk of ruin, which discussed the thoroughly on chapter one. What I can see from Table 9 is that fourteen out of nineteen drawdown rates for the proposed multiplier and twelve out of nineteen drawdown rates for RSI rebalancing are the lowest, which means the drawdown is smaller than other four traditional strategies. For RSI rebalancing strategy, other five max drawdown rate is slightly higher than quarterly rebalancing strategy, but still lower than annual rebalancing strategy and threshold rebalancing strategy in the rest seven periods. That is to say, it is easier for investors to recover to the initial investment from the first largest shock when rebalancing with multiplier strategy than others. Except for the last period, annual rebalancing strategy was the worst in respect to max drawdown analysis as its max drawdown rates are highest in all periods. The max drawdown rate of buy-and-hold strategy was lower than annual rebalancing strategy, but higher than all other rebalancing strategies. This result shows the longer the periods to avoid rebalancing the portfolio, the higher the portfolio risks are.

Table 9: Maximum Drawdown in 10-Year Periods of Six Rebalancing Strategies

Year	B&H	QRB	ARB	Threshold	Multiplier	RSI
Jan 1983 - Dec 1992	-16.98%	-16.99%	-18.30%	-16.97%	-14.67%	-16.99%
Jan 1984 - Dec 1993	-16.71%	-16.99%	-18.30%	-17.98%	-14.92%	-17.06%
Jan 1985 - Dec 1994	-17.76%	-16.99%	-18.30%	-17.76%	-14.74%	-15.25%
Jan 1986 - Dec 1995	-17.75%	-16.99%	-18.30%	-17.75%	-15.37%	-16.91%
Jan 1987 - Dec 1996	-18.30%	-16.99%	-18.30%	-16.98%	-17.61%	-16.90%
Jan 1988 - Dec 1997	-12.94%	-13.28%	-12.84%	-12.94%	-13.33%	-13.26%
Jan 1989 - Dec 1998	-19.47%	-19.74%	-20.21%	-19.56%	-19.84%	-19.49%
Jan 1990 - Dec 1999	-19.19%	-19.74%	-20.21%	-20.54%	-19.86%	-19.49%
Jan 1991 - Dec 2000	-20.53%	-19.74%	-20.21%	-20.26%	-19.86%	-19.46%
Jan 1992 - Dec 2001	-33.75%	-30.74%	-31.11%	-31.58%	-30.81%	-30.57%
Jan 1993 - Dec 2002	-40.43%	-36.15%	-36.80%	-36.79%	-35.81%	-36.36%
Jan 1994 - Dec 2003	-39.76%	-36.15%	-36.80%	-36.79%	-35.70%	-36.36%
Jan 1995 - Dec 2004	-39.50%	-36.15%	-36.80%	-36.79%	-35.51%	-35.63%
Jan 1996 - Dec 2005	-39.89%	-36.15%	-36.80%	-36.79%	-35.51%	-36.11%
Jan 1997 - Dec 2006	-38.67%	-36.15%	-36.80%	-36.14%	-35.70%	-36.15%
Jan 1998 - Dec 2007	-37.95%	-36.15%	-36.80%	-36.20%	-36.02%	-36.00%
Jan 1999 - Dec 2008	-38.72%	-36.15%	-36.80%	-35.98%	-35.99%	-35.90%
Jan 2000 - Dec 2009	-36.04%	-36.15%	-36.80%	-35.98%	-35.23%	-35.60%
Jan 2001 - Dec 2010	-34.28%	-32.59%	-32.22%	-35.72%	-32.50%	-32.83%

4.2.5 Beta

Beta is the number to evaluate the risk an asset taken. The higher beta means higher risk investors taken to get excess return. In this test, I used buy-and-hold rebalancing strategy as the benchmark asset for calculating beta. As a key element to evaluate the portfolio, the computed data in the below table 10 briefly illustrates the multiplier has the lower beta compared to periodic and threshold rebalancing strategies in fifteen out of nineteen periods, its betas were higher than the benchmark in two periods which were periods of 1983 to 1992 and 1990 to 1999; and in the rest of four periods, its betas were either equal or slightly higher than other traditional rebalancing strategies. The betas of RSI rebalancing strategies were lower than the traditional

rebalancing strategies in thirteen out of nineteen periods; and in the rest of six periods, its betas were either equal or slightly higher than other traditional rebalancing strategies. The beta of both technical rebalancing strategies is still lower than periodic and threshold rebalancing strategies in most of the case. This is to say, portfolio will become less risky with technical rebalancing strategies and will positively give more profitable space for the investment.

Table 10: 10-Year Beta of Six Rebalancing Strategies

Year	B&H	QRB	ARB	Threshold	Multiplier	RSI
Jan 1983 - Dec 1992	1.00	1.03	1.04	1.03	1.00	1.00
Jan 1984 - Dec 1993	1.00	1.06	1.07	1.06	0.98	1.06
Jan 1985 - Dec 1994	1.00	1.02	1.04	1.02	0.96	1.00
Jan 1986 - Dec 1995	1.00	1.02	1.04	1.03	0.95	0.99
Jan 1987 - Dec 1996	1.00	1.01	1.03	1.00	1.02	1.01
Jan 1988 - Dec 1997	1.00	1.04	1.04	1.05	1.05	1.05
Jan 1989 - Dec 1998	1.00	1.04	1.04	1.03	1.05	1.03
Jan 1990 - Dec 1999	1.00	1.05	1.06	1.07	1.04	1.05
Jan 1991 - Dec 2000	1.00	0.98	0.99	0.99	0.97	0.97
Jan 1992 - Dec 2001	1.00	0.96	0.96	0.97	0.97	0.95
Jan 1993 - Dec 2002	1.00	0.93	0.93	0.95	0.92	0.92
Jan 1994 - Dec 2003	1.00	0.94	0.95	0.97	0.94	0.95
Jan 1995 - Dec 2004	1.00	0.94	0.95	0.97	0.93	0.94
Jan 1996 - Dec 2005	1.00	0.93	0.94	0.95	0.93	0.93
Jan 1997 - Dec 2006	1.00	0.96	0.96	0.97	0.96	0.96
Jan 1998 - Dec 2007	1.00	0.97	0.98	0.98	0.97	0.97
Jan 1999 - Dec 2008	1.00	0.93	0.93	0.94	0.92	0.93
Jan 2000 - Dec 2009	1.00	0.99	0.99	1.02	0.98	0.99
Jan 2001 - Dec 2010	1.00	0.99	0.99	1.03	0.99	1.01

4.2.6 Standard Deviation

It is known that the higher standard deviation means a higher dispersion from the mean and that means more volatile of the portfolio. In other words, the more risky the portfolio was taken. From the table 11 below, the data describes a lower standard deviation of the multiplier

and RSI rebalancing strategies in most of the periods which reflects less volatile when using this rebalancing strategy than other four traditional strategies. The standard deviations of buy-and-hold strategy were the lowest in first eight periods covering years 1983 to 1999, but its standard deviations were highest from year 1991 to 2010. The standard deviations of annual rebalancing strategy were the highest in fifteen out of nineteen periods, and the standard deviations of quarterly rebalancing strategy were lower than annual rebalancing strategies in all periods. It illustrates frequent rebalancing portfolios can actually reduce volatility of the portfolio. The standard deviations of the multiplier rebalancing strategy were the lowest in fourteen out of nineteen periods; and its standard deviations were slightly lower than the quarterly rebalancing and threshold rebalancing strategies in the rest five periods. The standard deviations of RSI rebalancing strategy were lower in eight out of nineteen periods; and in the rest of eleven periods, seven of its standard deviations were slightly higher than the standard deviations of the quarterly and threshold rebalancing strategy during the periods 1985-1994 and 1985 to 1995. In period 1989 to 1998, the standard deviation was only higher than buy-and-hold strategy, and lower than all other strategies. Although the standard deviations of both technical rebalancing strategies were higher in some cases, it may not represent they are bad strategies; because the risk-adjusted performances should always take into consideration in portfolio management. The nest section, Sharpe ratio, will show the risk adjusted performances of all rebalancing strategies. Therefore, the multiplier and RSI rebalancing strategies provides a better way to secure the investment as well as generating more investment incomes as they are less volatile in most of the cases.

Table 11: 10-Year Standard Deviations of Six Rebalancing Strategies

Year	B&H	QRB	ARB	Threshold	Multiplier	RSI
Jan 1983 - Dec 1992	10.31%	10.62%	10.79%	10.61%	10.31%	10.31%
Jan 1984 - Dec 1993	9.89%	10.47%	10.63%	10.51%	9.75%	10.52%
Jan 1985 - Dec 1994	10.30%	10.49%	10.68%	10.53%	9.99%	10.95%
Jan 1986 - Dec 1995	9.97%	10.23%	10.42%	10.26%	9.51%	11.43%
Jan 1987 - Dec 1996	10.35%	10.43%	10.63%	10.42%	10.57%	10.50%
Jan 1988 - Dec 1997	8.99%	9.36%	9.36%	9.43%	9.44%	9.41%
Jan 1989 - Dec 1998	10.45%	10.84%	10.86%	10.82%	11.00%	10.82%
Jan 1990 - Dec 1999	10.75%	11.32%	11.35%	11.46%	11.17%	11.35%
Jan 1991 - Dec 2000	11.86%	11.63%	11.76%	11.77%	11.53%	11.57%
Jan 1992 - Dec 2001	13.05%	12.48%	12.56%	12.72%	12.65%	12.47%
Jan 1993 - Dec 2002	13.67%	12.68%	12.73%	13.01%	12.61%	12.62%
Jan 1994 - Dec 2003	13.29%	12.53%	12.58%	12.87%	12.47%	12.82%
Jan 1995 - Dec 2004	12.92%	12.21%	12.26%	12.52%	12.08%	12.11%
Jan 1996 - Dec 2005	13.15%	12.25%	12.32%	12.49%	12.18%	12.27%
Jan 1997 - Dec 2006	12.52%	12.01%	12.07%	12.14%	12.05%	12.00%
Jan 1998 - Dec 2007	11.97%	11.65%	11.71%	11.78%	11.60%	11.68%
Jan 1999 - Dec 2008	12.56%	11.64%	11.65%	11.79%	11.62%	11.67%
Jan 2000 - Dec 2009	11.88%	11.78%	11.78%	12.97%	11.67%	11.78%
Jan 2001 - Dec 2010	10.99%	10.93%	10.85%	12.50%	10.85%	11.10%

4.2.7 Sharpe Ratio

From the analysis above, the greater Sharpe Ratio is the higher return rate of the portfolio at the same risk. Compared with the buy-and-hold and periodic rebalancing strategies, data in table 12 shows that the proposed multiplier and RSI rebalancing strategies present relevant higher ratio in the nineteen 10-year-period analyses; and Sharpe ratios of both technical rebalancing strategies were higher than threshold rebalancing strategies in fifteen out of nineteen periods. However, their Sharpe ratios are lower than the one with threshold rebalancing strategy in four periods. For the data of Jan 1999- Dec 2008 and Jan 2000- Dec 2009, the Sharpe Ratio of multiplier and RSI rebalancing strategies even double that of the buy-and-hold rebalancing

strategy. For the period 1985 to 1994 and the period 1986 to 1995, the Sharpe ratios of RSI rebalancing strategy were much higher than the Sharpe ratio of the buy-and-hold strategy. The negative Sharpe ratios in earlier years were the results of higher treasury-bill rates. The significance of the proposed technical rebalancing strategies can be proved clearly by the table below. Under the same risk taken, the multiplier and RSI rebalancing strategy achieve better return for the portfolio; or with the same rate of return, multiplier rebalancing strategy undertook lower risk.

Table 12: 10-Year Sharpe Ratios of Six Rebalancing Strategies

Year	B&H	QRB	ARB	Threshold	Multiplier	RSI
Jan 1983 - Dec 1992	-14.62%	-17.60%	-17.39%	-15.96%	-13.23%	-14.62%
Jan 1984 - Dec 1993	-4.89%	-7.37%	-7.27%	-7.03%	-5.35%	-6.11%
Jan 1985 - Dec 1994	-2.81%	-3.11%	-3.30%	-3.25%	-1.15%	4.74%
Jan 1986 - Dec 1995	-4.60%	-5.38%	-5.44%	-5.45%	-3.82%	28.93%
Jan 1987 - Dec 1996	12.98%	13.87%	13.50%	14.68%	15.76%	14.99%
Jan 1988 - Dec 1997	28.84%	28.37%	29.03%	29.55%	30.34%	29.45%
Jan 1989 - Dec 1998	25.62%	26.29%	25.69%	27.10%	27.02%	26.89%
Jan 1990 - Dec 1999	35.01%	35.91%	35.60%	35.80%	36.66%	37.03%
Jan 1991 - Dec 2000	52.31%	54.71%	53.25%	53.64%	55.54%	56.33%
Jan 1992 - Dec 2001	33.02%	36.45%	35.02%	33.41%	37.36%	37.34%
Jan 1993 - Dec 2002	27.73%	31.96%	30.36%	33.77%	33.10%	31.96%
Jan 1994 - Dec 2003	25.32%	29.12%	27.62%	27.53%	30.42%	36.78%
Jan 1995 - Dec 2004	35.80%	40.02%	38.48%	38.21%	41.33%	41.12%
Jan 1996 - Dec 2005	41.09%	44.79%	43.35%	44.65%	46.87%	45.57%
Jan 1997 - Dec 2006	35.15%	37.76%	36.30%	38.25%	40.78%	38.20%
Jan 1998 - Dec 2007	28.81%	30.89%	29.44%	31.16%	32.04%	32.19%
Jan 1999 - Dec 2008	4.51%	7.46%	7.58%	7.54%	8.48%	8.07%
Jan 2000 - Dec 2009	5.51%	9.05%	9.06%	21.98%	10.77%	10.74%
Jan 2001 - Dec 2010	10.81%	14.13%	14.49%	31.15%	16.02%	14.78%

4.3 Summary

In this chapter, the experiment applied 19-year market returns of ETFs from 1983 to 2010 in Canadian market. The portfolio in this experiment is the balanced portfolio, which includes 5%

treasury-bills, 25% fixed income security, and 70% equity security. The reason I choose this asset mix is because this mix is widely applied by average investors, and it is easier to detect how the rebalancing strategy impact the portfolio performances as there are more assets on equity markets and thus more volatile. This study compares the returns, risks, and rebalancing cost proxy of all rebalancing strategies to the index, which is the buy-and-hold strategy in this case, and traditional rebalancing strategies to show that the proposed technical rebalancing methods would be better to manage the long term ETF investment portfolios.

There are two parts in this chapter. The first part introduces the performance and volatility measurements in various perspectives as well as the experiment methodology. The second part of the chapter gives empirical and experimental results. Average annualized return and dollar amount return would be used to measure portfolio performances; number of rebalancing events would be used as a proxy for measurement of rebalancing costs; maximum drawdown, standard deviation, and beta would be used to measure volatility or portfolio risk; and finally Sharpe ratio would be used to measure risk-adjusted performances of the portfolio.

The AAR is the arithmetic mean of a series of rates of return. It is a helpful guide for measuring the long-term performance of portfolios. The average annualized returns of both technical rebalancing strategies were highest in all periods compared to quarterly and annual rebalancing strategies; their AARs were higher than threshold rebalancing strategies in seventeen out of nineteen periods and higher than buy-and-hold strategy in eighteen out of nineteen periods. The percentage figure of AAR might not be intuitive enough. The dollar amount returns of all rebalancing strategies are illustrated in the following section. Assuming the initial investments are $100,000, the accumulative returns of all rebalancing strategies in 10 years are presented on Figure 2. Moreover, the numbers of rebalancing events of both technical rebalancing strategies

are moderate, which are lower than quarterly rebalancing strategy, higher than threshold rebalancing strategy, and similar to annual rebalancing strategy.

With respect to volatility measurements, three types of measurements (max drawdown, standard deviation, and beta) give slightly different results. The MDDs of multiplier rebalancing strategy are lower than the MDDs of traditional rebalancing strategies in thirteen out of nineteen periods; and the MDDs of RSI rebalancing strategy are lower than traditional rebalancing strategies in twelve out of nineteen periods. The betas of multiplier rebalancing strategy are lower than all traditional rebalancing strategies in fifteen out of nineteen periods; and the betas of RSI rebalancing strategy are lower than traditional rebalancing strategies in thirteen out of nineteen periods. The standard deviations of multiplier rebalancing strategy are lower than traditional rebalancing strategies in fourteen out of nineteen periods; the standard deviations of RSI rebalancing strategy are lower than annual rebalancing and threshold rebalancing strategies in thirteen out of nineteen periods but higher than threshold rebalancing strategy in seven periods. The volatilities of annual rebalancing and buy-and-hold strategies appear to be higher compared to other strategies in this test. However, the risk adjusted performance should always be taken into consideration when evaluating a portfolio. The last section of the test results are the Sharpe ratios of all rebalancing strategies.

The Sharpe ratio generally evaluates how well the return of the portfolio compensates the investor for the risk taken. The Sharpe ratios of both technical rebalancing strategies are the highest compared to periodic rebalancing strategies and buy-and-hold strategy in all nineteen tested periods; but they are lower than the threshold rebalancing strategy in five tested periods. In general, the technical rebalancing strategies outperform all other strategies according to risk-adjusted performance.

CHAPTER V:

CONCLUSION AND REMARKS

Benjamin Graham wrote in the Intelligent Investors than, "The essence of Investment Management is the management of risks, not the management of returns. Well-managed portfolios start with this precept." Nowadays, institutional investors often employ mean-variance optimization analysis, also known as modern portfolio theory, to determine optimal portfolio weights. However, the portfolio can drift away from the optimal target weights as the asset price changes over a period of time. Thus, a profitable portfolio rebalancing strategy is significant in this case, because it impacts the returns and risks associated with the portfolio. Most investors apply the traditional rebalancing strategies which are based on the calendar basis (ex: monthly, quarterly, and annually). This study firstly addresses the question why institutional investors prefer rebalancing even though these strategies require the selling of a fraction of the better performing assets and investing the proceeds in the treasury bills and later in the less performing assets. First of all, investors need disciplines to avoid "status quo bias". Secondly, minimizing risk (defined as return volatility) with respect to a given asset allocation is the primary objective of any rebalancing strategy. The diversification of investment leads to the risk reduction. Rebalancing the portfolio back to the original target allocation prevents the portfolio drifted away from the worse performing security with lower volatility towards the better performing security with higher volatility, thereby increasing risk and reducing diversification. Thus, rebalancing to the less risky security ultimately leads to a reduced volatility. Risk control is especially important for long-term investment because of the compounding powers. The less the

investor loses, the faster the money could grow in the long-run. Thirdly, portfolio rebalancing adds value due to its contrarian process in natural.

In contrast to prior rebalancing studies, this study proposed technical analysis to form rebalancing strategy for long-term investments. The portfolio performance can be optimized by using technical analysis or proposed rebalancing strategies. The proposed multiplier and RSI rebalancing strategies combine the periodically rebalancing with the interval rebalancing strategy. By specifying the trading range for every individual security in the portfolio, it improves the portfolio performance while minimizing portfolio volatility in the long run compared to other traditional rebalancing strategies for various risk preferences.

The tests are based on two asset-class portfolio. Monthly return data of a stock index, a bond index, and treasury bills are used for the simulation. As for the proposed rebalancing strategy, out-of-sample tests from January 1983 to December 2010 are conducted based on the simulation algorithms of 10-year rolling returns from historical data of period from January 1982 to December 2000. Buy-and-hold, interval, range, multiplier, and RSI rebalancing strategies are compared in terms of performance, volatility, and number of transactions.

The different risk and return measurements represent different aspects investors take into consideration when evaluate a portfolio. The compounding rate demonstrates a more accurate return of rate and the higher rate means a better performance. Maximum drawdown is used to measure the risk of the portfolio. It is more appropriate for the long term investments as the deeper the drawdown the harder for the investment to recover. The standard deviation presents the dispersion from the average returns and the higher standard deviation means more risky of a portfolio. Moreover, the Sharpe Ratio is used to measure portfolio performance as it incorporates

both the return and the risk of any given portfolio strategy. The findings indicate that the rebalancing methods based on technical analysis give lower level of risks and superior returns in most of the cases during the sample periods. In addition, the proposed multiplier and RSI rebalancing strategies allow a better recovery from the Maximum drawdown. This implies that technical analysis could add value for well diversified portfolio under normal conditions, but it could not work when big events affect financial market such as financial crisis in 2008. Therefore, using technical analysis to manage portfolio does not mean to leave fundamentals alone. Technical analysis is to deal with problems posed by changes in investor confidence more efficiently than conventional "fundamental" value analysis. Therefore, technical analysis and fundamental analysis are mutually complementary and interdependent. The study also exhibits that all other rebalancing strategies generate a significantly lower volatility compared to the corresponding buy-and-hold strategy.

The findings of the thesis lead to in-depth studies in many aspects. This study is focus on Canadian market, which is relative small and less volatile. The technical rebalancing strategies could work more significant in bigger and more volatile markets such as China or US. The technical rebalancing strategies in this study may be calculated by other methods so that the trading range can be better defined for every security in the portfolio. In addition, the proposed method can be improved by adding relative algorithms. There are many other technical analysis indicators that can be tested into rebalancing strategies such as moving average convergence or divergence (MACD), point and figure charting, and so on. Moreover, why the multiplier and RSI rebalancing strategy relatively work better than other rebalancing strategies might be explained by behavior economics or behavior finance's point of view, which focus on the effects of social, cognitive, and emotional factors on the economic decisions of individual and institutions and

consequences for market prices, returns, and the resources allocation. To find which factor(s) essentially add value or reduce volatility to the portfolio, all portfolio rebalancing strategies can be statistically tested in terms of statistical inference.

Bibliography

Arun Muralidhar, Sanjay Muralidhar. "The Case for SMART Rebalancing". Published on Q Finance.

Brock, William, Josef Lakonishok, and Blake LeBaron. "Simple technical trading rules and the stochastic properties of stock returns", Journal of Finance. Vol. 47 (1992), pp.1731-1764.

Buraschi, A., Porchia P., Trojani, F. "Correlation risk and optimal portfolio choice". *J. Finance*.Vol. 65 No.1 (2010), pp. 393–420.

Busse, J. A., Goyal A., Wahal. S. "Performance and persistence in institutional investment management". *J. Finance*. Vol. 65 No. 2 (2010), pp.765–790.

Chambers, D., E. Dimson, A. Ilmanen. "The Norway model". J. Portfol. Manage. Vol. 38 No. 2 (2012), pp. 67–81.

Clark, P. K. "A subordinated stochastic process model with finite variance for speculative prices". Econo- metrica Vol. 41 No.1 (1973), pp. 135–155.

Cremers, K. J. M., A. Petajisto. "How active is your fund manager? A new measure that predicts perfor-mance". Rev. Finan. Stud. Vol. 22 No.9 (2009), pp. 3329–3365.

DeBondt, W., Thaler, R., 1985. Does the stock market overreact? Journal of Finance 40, 793-805.

Fama, E. F. "The behavior of stock market prices". J. Bus. Vol. 38 No. 1 (1965), pp. 34–105.

Fama, E. F., K. R. French. "Luck versus skill in the cross-section of mutual fund returns". J. Finance Vol. 65 No.5 (2010), pp. 1915–1947.

Gary Brinson, P, Randolph Hood, L, Gilbert Beebower, L. "Determinants of Portfolio Performance". Financial Analysts Journal. Vol. 42 No.4, pp. 39 – 44.

Goodman, Beverly. "An Alternative to Hedge-Fund Alternatives." Barron's Magazine. 26 May 2012. Print.

Grinblatt, Mark and Sheridan Titman, 1989, Mutual fund performance: An analysis of quarterly portfolio holdings, Journal of Business 62, 394-415.

Grinblatt, Mark and Sheridan Titman, 1991, Performance measurement without benchmarks: An examination of mutual fund returns, Working paper, University of California at Los Angeles.

Harjoto, M. A., F. J. Jones. "Rebalancing strategies for stocks and bonds asset allocation". J. Wealth Man-age. Vol. 9 No.1 (2006), pp. 37–44.

Isa Plaxco M., Robert Arnott D. Rebalancing a Global Policy Benchmark: How to Profit from Necessity. Journal of Portfolio Management. Vol. 28 No. 2 (2002), pp. 9-14.

Jaconetti, C. M., Kinniry F. M., Zilbering Y. "Best practices for portfolio rebalancing". Vanguard (2010). pp.1–17.

Jegadeesh, Narasimhan, 1990, Evidence of predictable behavior of security returns, Journal of Finance 45,881-898.

Jegadeesh, N., Titman, S., 1993. Returns to buying winners and selling losers: implications for stock market efficiency. Journal of Finance 48, 65-91.

Jie Cai, Todd Houge. "Long Term Impact of Russell 2000 Index Rebalancing". Financial Analysis Journal. Vol. 64 No. 4 (2008), pp. 76-91.

John O'Brie. "Rebalancing: A Tool for Managing Portfolio Risk". *Journal of financial service professionals.* Vol. 60 No.3 (2006), pp. 191-209.

Kahneman, D., Tversky, A., 1982. Intuitive predictions: biases and corrective procedures. Reprinted in Kahneman, Slovic, and Tversky, Judgement under Uncertainty: Heuristics and Biases.Cambridge University Press, Cambridge, England.

Kimball, M. S., M. D. Shapiro, T. Shumway, J. Zhang. "Portfolio rebalancing in general equilibrium". Working paper, (2011). University of Michigan, Michigan.

Ledoit, O., M.Wolf. "Robust performance hypothesis testing with the Sharpe ratio". J. Empirical Finance Vol. 15 (2008), pp.850–859.

Lehmann, Bruce, 1990, Fads, martingales and market efficiency, Quarterly Journal of Economics 105, 1-28.

Levy, Robert, 1967, Relative strength as a criterion for investment selection, Journal of Finance 22,595-610.

Lo, Andrew and Craig MacKinlay, 1990, When are contrarian profits due to stock market overreaction?, Review of Financial Studies 3, 175-205.

Mandelbrot, B. B. "The variation of certain speculative prices". J. Bus. Vol. 36(4) (1963), pp. 394–419.

Neftci, Salih. "Naive trading rules in financial markets and Wiener-Kolmogorov prediction theory: A study of 'technical analysis," *Journal of Business.* Vol. 64 (1991), pp. 549-571.

Ross A. Maller; Robert B. Durand; Hediah Jafarpour. "Optimal portfolio choice using the maximum Sharpe ratio". The Journal of Risk. Vol.12 No. 4 (2010), pp. 49-73.

Ryan Sullivan, Allan Timmermann, Halbert White. "Data- Snooping, Technical Trading Rule Performance and the Bootstrap". *The Journal of Finance.* Vol. LIV No. 5 (1999), pp. 1647-1691.

What is maximum drawdown? . N.d. Graphic. MyForexResultsWeb. 16 Sep 2013. <http://www.myforexresults.com/article.php?product_id=2>.

Yesim Tokat; Nelson W Wicas. "Portfolio Rebalancing in Theory and Practice". The Journal of Investing. Vol. 16 No. 2 (2007), pp. 52-59.