Portfolio Selection Utilizing Safety-First Optimization Model on Exchange Traded Funds in Asia

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Abstract

This paper presents a portfolio selection framework exploiting exchange traded funds in ASIA considering different portfolio weight thresholds for individual asset within the portfolio of a safety-first model investor. Back-test result shows that the safety-first portfolios of exchange traded funds can significantly outperform the benchmark considered. It was also observed that safety-first investors who doesn't limit the portfolio weights of individual asset can significantly outperform the benchmark. Overall, this study offers an alternative equitable investment option for safety-first investors which, on the long run, can probably be considered as a generic investment procedure for any investor.

Keywords
portfolio selection, safety-first model, exchange traded funds, risk-return management;

1. Introduction
Exchange-Traded Funds (ETFs) are relatively new Financial instrument that is made for the purpose of tracking a specific index, the very first ETF created was the SPDR ETF which tracks the S&P500, today the cash invested in ETFs is around $5.1 trillion dollars as shown in Figure 1 courtesy of investopedia.

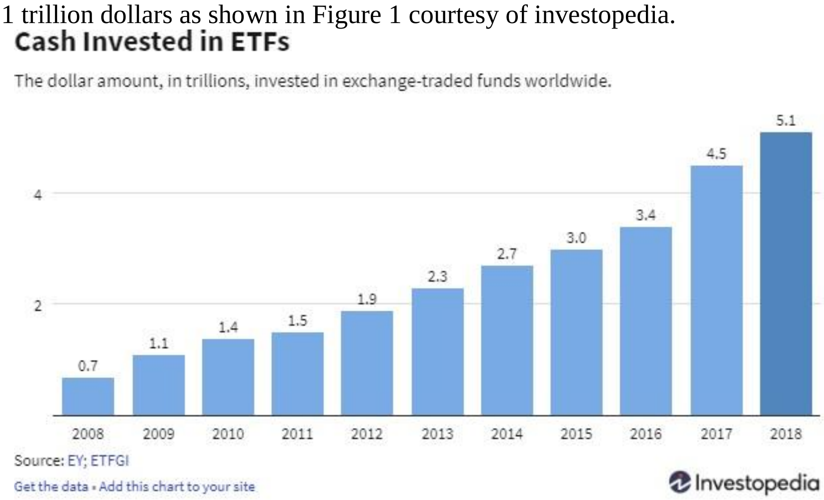


Figure 1. Cash Invested in ETFs

Some say that there are similarities between ETFs and mutual funds in a sense that they both are a pooled investment. However, mutual funds can only be traded once a day while ETFs can be traded as many times as the investor wishes. Plus, ETFs has a lower transaction costs and it can be made up of several different investments including stocks, commodities, bonds etc. Since ETFs purpose is to track an underlying index, it can be managed passively. But not all ETFs are passively managed as discussed by Lettau and Madhavan (2018).

Safety-First criterion was established with the idea of companies prioritizes preventing a catastrophe during uncertainty (Roy 1952), a lesser famous theory; it was established at the same time during the conception of the eventual 1990 Nobel Prize winning theory, the Mean-Variance Portfolio Selection of Markowitz (1952). However, Nobel Laureate Henry Markowitz himself wrote "On the basis of Markowitz (1952), I am often called the father of modern portfolio theory (MPT), but Roy (1952) can claim an equal share of this honor." recognizing the significance of Roy's SF model.

Roy's Safety-First model pioneers the concept of an optimal portfolio strategy with the goal of minimizing the probability of the catastrophe happening. As of now several studies have been done since 1952. Chiu et al. (2012) applied the SF model with mean and budget constraint. Day et al. (1971) examined the factors affecting decision making and the relationship among full cost pricing and safety margin maximization.

Asia's economy continuous to rise, activities continuous to shift towards the economies of East Asia (Morgan 2018). Political stability, elimination of corruption is a major factor in Asia's integration both global and regional (Caporale et al. (2019). China's business culture relies on familism and informal networks, this proved to be effective in overcoming restrictive policies of its Asian neighbors. Using connections with networks both financial and international traders in SEA, HK and Australia (Brown 2018).

During the recent China market crisis, China has a significant impact on Asian market being solely responsible for its Asian downturn (Fang and Bessler 2018). It cannot be denied that China has played a crucial role in recent decades in Asia's economic performances, this is why this study used China as a benchmark for the highest performing indices.

This study aims to find an alternative investment vehicle and profitable model utilizing Exchange-Traded Funds.

This paper is organized as follows. Section 1 presents a brief introduction of the study. Section 2 explains the methodology employed in obtaining the optimal portfolios. Section 3 discusses the back-test results and analysis. Section 4 provides the concluding remarks. Lastly, the list of cited studies is also available in the references.

2. Methodology

2.1 Investment Pool

In this study, the investment pool comprises of 8 Asian ETFs and 1 benchmark which is the ETF from China. The assumption is that there are ETFs that directly tracks the performances of respective market indices, such that the first eight markets indices in Table 1 are considered as part of the investment pool and the last one is considered as the benchmark.

Table 1. List of Index and Consideration

Index	Country	Consideration
FTSE Malaysia	Malaysia	Investment Pool
FTSE Sing	Singapore	Investment Pool
Hang Seng Index	Hong Kong	Investment Pool
Jakarta Composite Index	Indonesia	Investment Pool
KOSPI Composite Index	Korea	Investment Pool
Nikkei 225	Japan	Investment Pool
S&P BSE SENSEX	India	Investment Pool
TSEC Weighted Index	Taiwan	Investment Pool
SSE Composite Index	China	Benchmark

2.2 Portfolio Selection Model

In selecting the optimal portfolio, this study utilizes the safety-first portfolio selection model in choosing the assets to be included into the portfolio. As mentioned, the portfolio is chosen among 8 ETFs in Asia and the resulting portfolio is compared with the benchmark index (China ETF). The concept of the safety-first model is to limit the probability of losing a certain amount (threshold loss) at a given probability (threshold probability).

Suppose there are k stocks and l scenarios, let $p = (x_1, x_2, \ldots, x_k)$, where $\sum_{i=1}^{k} x_i = 1$, be the portfolio and r_p be the return of portfolio p. Given that R_L is the loss threshold or the acceptable level of loss and γ is the threshold probability or the acceptable probability of having R_L, the generic SF portfolio selection model is written as

$$Max\ E\big[r_p\big] \tag{1}$$

$$s.t.\ P\big(r_p \leq R_L\big) \leq \gamma \tag{2}$$

$P\big(r_p \leq R_L\big)$ can be viewed as the downside risk of the portfolio and should not be larger than γ or the threshold probability of having R_L. Let scenario j be represented by a row vector of returns such that $\big(R_{1j}, R_{2j}, \ldots, R_{kj}\big)$ where R_{ij} is the return of stock i on scenario j. Let P_j be nominal probability weight on scenario j. For scenario j, let r_{p_j} denote the return of portfolio p on scenario j and $r_{p_j} = \sum_{i=1}^{k} x_i R_{ij}$. Let I denote the threshold weight that can be given to an individual asset, thus, the scenario-based SF portfolio selection model is written as

$$Max\ E\big[r_p\big] = \sum_{j=1}^{l} r_{p_j} P_j \tag{3}$$

$$s.t.\ r_{p_j} = \sum_{i=1}^{k} x_i R_{ij}\ , j = 1,2, \ldots, l \tag{4}$$

$$R_L - r_{p_j} \leq M\omega_j, j = 1,2, \ldots, l \tag{5}$$

$$\sum_{j=1}^{l} P_j \omega_j \leq \gamma \tag{6}$$

$$x_i \leq I \tag{7}$$

$$0 \leq x_i \leq 1, \omega_j\ is\ binary \tag{8}$$

In summary, Eq. (3) is the objective function which maximizes the total expected return of portfolio p. Eq. (4) is how return of the portfolio at scenario j is calculated. Eq. (5) and eq. (6) are the safety-first constraints that ensure that the $P\big(r_p \leq R_L\big)$ will not fall below the threshold probability γ. Eq. (7) ensures that the portfolio does not invest on a particular asset at a total weight exceeding the threshold portfolio weight (I). The resulting portfolios using this model are called SF-I portfolios.

2.3 Performance Evaluation

Following the works of Chang and Young (2019a), Chang and Young (2019b), Chang et al. (2018a), Chang et al. 2015, Chang et al. (2018b) on how to evaluate portfolio performance, the portfolios obtained are then analyzed and compared to the considered benchmark (China ETF). First, basic statistics are observed. Then, cumulative returns are also analyzed. Later on, for accuracy of comparison with the benchmark, pair-return difference T tests are also applied. Accordingly, the null (H_o) and alternative (H_a) hypothesis are as follows: (H_o) there is no significant difference between the return of the portfolio and the return of the benchmark; (H_a) the return of the portfolio is significantly larger than 0. The outliers are also removed before the implementation of T tests. The level of significance considered for the pair-t tests is also based from the abovementioned references. Note, on a side analysis, the distribution of portfolio weights is also tracked for each type of SF investor.

3. Back-Test Results and Analysis

3.1 Data Description

The closing indices of the investment pool (8 Asian countries) and the benchmark (China) are collected from the internet through yahoo finance. The corresponding returns of these indices are considered as the return of their representative indices that perfectly tracts their performance. The data collected is from September 1, 2015 to August 20, 2018 and the back-test period is from December 22, 2017 to August 20, 2018 which is equivalent of 100 trading days. The optimal portfolios are identified using AIMMS 4.70. All in all, there are 5 resulting portfolios witch is eventually compared to the benchmark. The safety-first portfolio are denoted as SF-I where $I = \{1, 0.8, 0.6, 0.4, 0.2\}$. As the value of I increases the less diversified the portfolio becomes. As for the scenarios, the past 400 daily returns are considered as the return scenarios. Accordingly, the portfolios are as follows:

- SF-1 denotes the safety-first portfolio without weight restriction on individual asset
- SF-0.8 denotes the safety-first portfolio with weight restriction of at most 80% of the total portfolio on individual asset

- SF-0.6 denotes the safety-first portfolio with weight restriction of at most 60% of the total portfolio on individual asset
- SF-0.4 denotes the safety-first portfolio with weight restriction of at most 40% of the total portfolio on individual asset
- SF-0.2 denotes the safety-first portfolio with weight restriction of at most 20% of the total portfolio on individual asset
- B denotes the index return of the benchmark (China)

3.2 Back-test Results

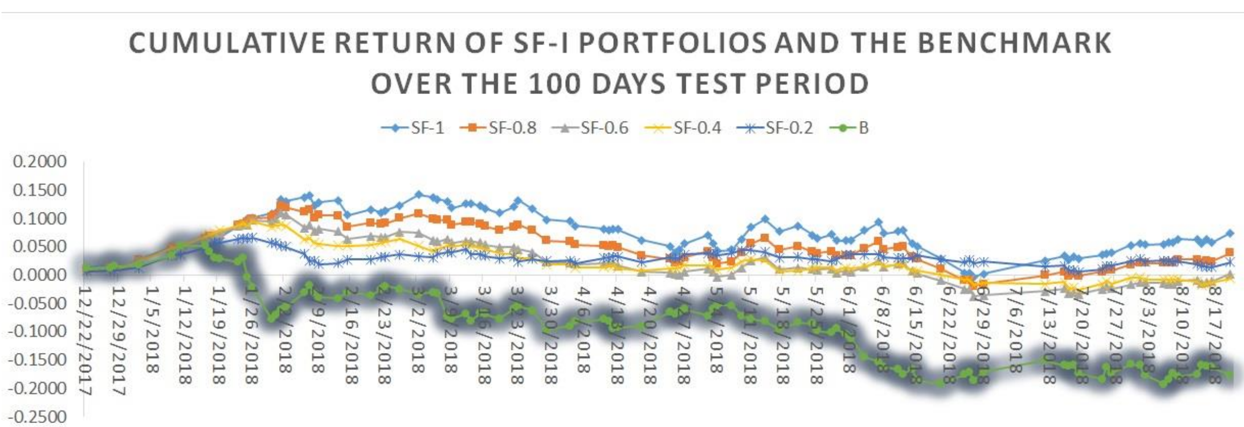
In evaluating the performance of the portfolio throughout the 100 days back-test period, the SF-I portfolios are compared with the benchmark (B) in terms of descriptive statistics and pair-return difference as shown in Table 2.

Table 2. Return Comparison for 100-days Back-test Period

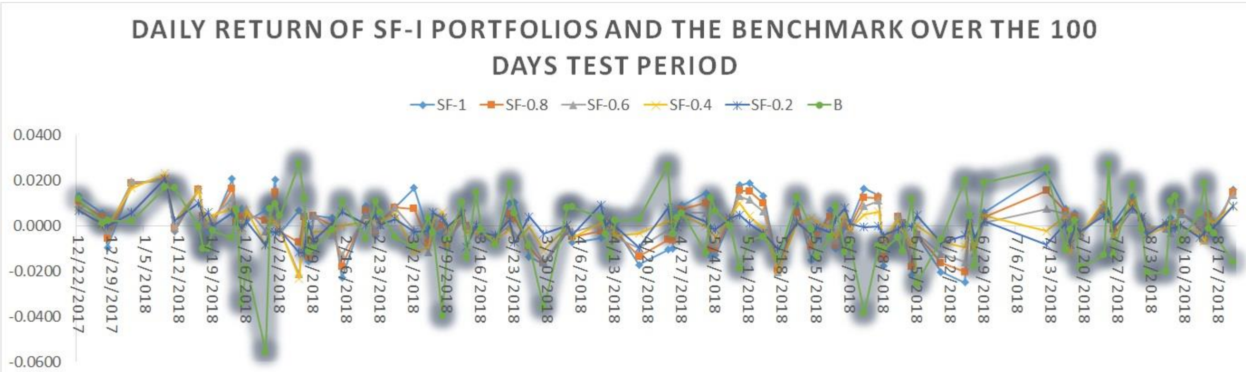
	SF-1	SF-0.8	SF-0.6	SF-0.4	SF-0.2	Benchmark
Mean Return (MR)	0.0008	0.0004	0.0000	0.0000	0.0002	-0.0018
Standard Deviation (SD)	0.0107	0.0087	0.0077	0.0066	0.0052	0.0149
Days with + Return (+R)	54	54	52	51	51	45
Days with – Return (-R)	46	46	48	49	49	55
Ending Cumulative Return (CR)	0.0745	0.0389	0.0020	-0.0055	0.0227	-0.1766
Mean Cumulative Return (MCR)	0.0755	0.0515	0.0261	0.0250	0.0312	-0.0866
Days with + Cumulative Return (+CR)	99	93	75	76	100	12
Days with - Cumulative Return (-CR)	1	7	25	24	0	88
Pair-Return Difference with Benchmark (T-tests)	0.080*	0.100	0.136	0.131	0.088*	

* denotes significance at 0.1 level

Table 2 shows that all SF portfolios have higher mean return than the benchmark with (0.0008, 0.0004, 0.0000, 0.0000, 0.0002) over -0.0018. Observing the risk, all SF portfolios have less volatile returns than the benchmark with (0.0107, 0.0087, 0.0077, 0.0066, 0.0052) over 0.0149. Intuitively the number of positive (negative) returns of SF portfolios are larger (small) than the husband or benchmark. In terms of cumulative return, over the 100 days trading period, the SF portfolios also accumulated higher cumulative return than the benchmark with (0.0745, 0.0389, 0.0020, -0.0055, 0.0227) over -0.1766. Naturally, the mean cumulative returns also show that they outperform the benchmark with (0.0755, 0.0515, 0.0261, 0.0250, 0.0312) over -0.0866. In relation with the cumulative return, the number of days with positive and/or negative is better with the SF portfolio than the benchmark with +CR(99, 93, 75, 76, 100) vs 12 and -CR(1, 7, 25,24,0) vs 88.



The descriptive statistics shows that SF-I portfolios can outperform the benchmark, such that SF-I portfolios are more profitable and less risky than the benchmark. This statement is supported by Figure 2 wherein it visually shows that all SF-I portfolios have better returns than the benchmark. It is also supported by Figure 3, wherein it is visually evident that the returns of the benchmark is more volatile compared to all SF-I portfolios.



These above mentioned comparisons are still not enough to accurately conclude that SF-I portfolios are superior portfolios than the benchmark. Thus, more rigorous tests (pair-return difference T tests) were done to compare the respective performances of SF-I portfolios against the benchmark. Again, the null hypothesis is that the average difference between the respective SF-I portfolio and the benchmark is equal to 0. The alternative hypothesis is that the average difference between the respective SF-I portfolio and the benchmark is greater than 0. Result shows, as seen also in Table 2, SF-1 and SF-0.2 have significantly larger returns than the benchmark with respective P-values for the pair-return difference T tests of (0.080 and 0.088). SF-0.8, SF-0.6, and SF-0.4 are also close to having significantly larger return than the benchmark with respective P-values for the pair-return difference T tests of (0.1, 0.136, 0.131).

Now that it is known that SF-I portfolios can significantly outperform the benchmark, the SF-I portfolios are compared to one another to determine the best portfolio among the SF-I portfolios. It is evident in Table 2 that SF-1 has the best descriptive statistics among the SF-I portfolios. Except for risk (standard deviation) wherein it is the highest among the group. It is expected that as the value of I increases the risk considered is also higher compared to those with lower values of I. This is evident in Table 3 which shows the composition of the SF-I portfolios that as the value of I increases the distribution of portfolio weights is getting concentrated to fewer stocks. SF-I portfolios with lower I values are more diversified than those with higher I values but the reward is also lower.

Table 3. Portfolio Composition

	SF-1	SF-0.8	SF-0.6	SF-0.4	SF-0.2
Hong Kong	0.2900	0.3120	0.3380	0.3260	0.2000
India	0.2400	0.2720	0.3000	0.3180	0.2000
Korea	0.0000	0.0000	0.0000	0.0000	0.0920
Japan	0.0000	0.0280	0.0560	0.1080	0.1280
Indonesia	0.4700	0.3860	0.3020	0.2280	0.1900
Singapore	0.0000	0.0000	0.0000	0.0000	0.0260
Taiwan	0.0000	0.0020	0.0040	0.0200	0.1640
Malaysia	0.0000	0.0000	0.0000	0.0000	0.0000
Total	1	1	1	1	1

Similarly, the descriptive statistics are not enough to have an accurate conclusion thus for further support, pair-return difference T-tests were also done between the SF-I portfolios such that although not significant, only SF-1 portfolios have P-values, as shown in Table 4, which are very close to being significant. Thus, it is advisable to consider SF-I as the best SF portfolio where larger I values correspond to superior portfolios.

Table 4. Pair-Return Difference T-Test P-values

	SF-1	SF-0.8	SF-0.6	SF-0.4	SF-0.2
SF-1		0.772	0.780	0.808	0.695
SF-0.8	0.228		0.787	0.763	0.588
SF-0.6	0.220	0.213		0.721	0.388
SF-0.4	0.192	0.237	0.279		0.158
SF-0.2	0.305	0.412	0.612	0.842	

4. Conclusion

This researched analyzed the indices of Asian Markets namely Hong Kong, India, Korea, Japan, Indonesia, Singapore, and Taiwan, and Malaysia. Then, it is assumed that there are exchange-traded funds that correspondingly tracts the performances of these indices perfectly such that these indices are considered as the investment pool of the portfolio selection considering the safety-first portfolio selection model. The resulting portfolios are then compared with the market or index with biggest influence to Asian Markets. This index is the China Index which is considered as the benchmark or point of comparison of the SF portfolios. Back-test results show that the SF-I portfolios can significantly outperform the benchmark. It can also be concluded that it might be better to invest on multiple assets instead of just investing on the asset with the biggest influence (China ETF).

Overall, this study contributed in 3 ways: (1) it provides a strategy on how to exploit exchange traded funds.; (2) it presents an alternative investment option which is profitable and can significantly outperform the benchmark (market).; and (3) it offers a simple variation to basic portfolio selection framework of return estimation, assignment of weights, and selection model.

Further improvements can still be done to improve the results of this study. One way is to consider the actual investment environment wherein trading costs are considered which plays a huge role in the profitability of any portfolio. Next is to consider the actual ETF indices of respective countries to lessen estimation errors. Another one is to consider other portfolio selection models like different variations of the mean-variance model to have another point of comparison. Application of the strategy to other continents can verify the applicability of this strategy to other continents or data. Lastly, modification of the 3 basic parts of portfolio selection framework can also be a starting point for further studies.

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References

Brown, R. A. (2018). Chinese business enterprise in Asia: Routledge.

Caporale, G. M., You, K., & Chen, L. (2019). Global and regional stock market integration in Asia: A panel convergence approach. International Review of Financial Analysis, 101381

Chiu, M. C., Wong, H. Y., & Li, D. (2012). Roy's Safety-First Portfolio Principle in Financial Risk Management of Disastrous Events. Risk Analysis: An International Journal, 32(11), 1856-1872.

Chang, K. H., & Young, M. N. (2019a). Behavioral stock portfolio optimization considering holding periods of B-stocks with short-selling. Computers & Operations Research, 112, 104773.

Chang, K. H., & Young, M. N. (2019b). Portfolios Optimizations of Behavioral Stocks with Perception Probability Weightings. Annals of Economics and Finance, 20(2), 817-845.

Chang, K.-H., Young, M. N., & Diaz, J.F.T. (2018b). Portfolio Optimization Utilizing the Framework of Behavioral Portfolio Theory. International Journal of Operations Research, Vol. 15, no. 1, 1-13

Chang, K. H., Young, M. N., Liu, C.-C. & Chung, H.-P. (2018a). Behavioral Stock Portfolio Optimization through Short-Selling. International Journal of Modeling and Optimization, Vol. 8, no. 2, 125-130.

Chang, K. H., Young, M. N., Hildawa, M. I., Santos, I. J. R., & Pan, C. H. (2015). Portfolio selection problem considering behavioral stocks. In Proceedings of theWorld Congress on Engineering (Vol. 2).

Day, R. H., Aigner, D. J., & Smith, K. R. (1971). Safety margins and profit maximization in the theory of the firm. Journal of political Economy, 79(6), 1293-1301.

Fang, L., & Bessler, D. A. (2018). Is it China that leads the Asian stock market contagion in 2015? Applied Economics Letters, 25(11), 752-757

Lettau, M., & Madhavan, A. (2018). Exchange-traded funds 101 for economists. Journal of Economic Perspectives, 32(1), 135-154.

Markowitz, H. (1952). Portfolio selection. the Journal of Finance, 7(1), 77-91.

Morgan, S. L. (2018). East Asia. In An Economist's Guide to Economic History (pp. 301-308): Springer.

Roy, A. D. (1952). Safety first and the holding of assets. Econometrica: Journal of the econometric society, 431-449.

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