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Bigendra Lal Shrestha
Islington College

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☐ **Bigendra L. Shrestha**
Department of Business, Islington College
London Metropolitan University, Kathmandu, Nepal
☐ **Krishna Maya Shrestha**
Ace Institute of Management, Kathmandu, Nepal

Abstracts

Nepalese investors, most of time, uses the conventional approach to diversify their investment and ignores the power of sectoral diversification to minimize their risk. Further there were not much studies done on this area to expand the knowledge base. Selection an optimal portfolio of risky assets using sectoral portfolio optimization can add value to other the conventional strategy of diversification. Using frameworks proposed by Markowitz's Portfolio Theory and Capital Market Line, these optimal portfolios can be selected. This study is based on four sectoral indices of Nepal Stock Exchange based on its higher turnover. The finding indicates a moderate correlation of return exists between the sectoral risky assets which implies investors could gain some benefits by optimally diversifying in the sectoral specific-assets. Even as a naïve investor having equally weighted portfolio could improve their risk-return tradeoffs. A sectoral investment, consisting of homogeneous assets, itself have the diversification embedded in it. Further findings show the investors can still enhance their risk-return tradeoffs by optimally diversifying across the sectors. Being widely used by money managers, these portfolio theories has been subjected to various criticisms.

Keywords: Nepalese Stock Market, Sectoral Diversification, Modern Portfolio Theory, James Tobin, Sharpe model.

Introduction

For more than two decades, risky assets diversification has primarily been designed using traditional parameters like market capitalization and style, and geographic orientation. These frameworks ignore the sectoral/industrial effects when investing in emerging market portfolios. In Nepal, most of the investors usually consider the growth style to make an investment decision and perhaps deemphasizes the volatility and return that are exhibited by the sector or industry in which a company operates (Adhikari & Jha, 2016; Gurung, 2004). This paper aims to demonstrate to select an optimal portfolio of risky assets in Nepal Stock Exchange based on the sector based framework by applying the Markowitz's Portfolio Theory.

The golden rule of any investment the decision is that the investors will take the more risk if they expect the higher return or the investor should expect higher returns if they are willing to take more risk (Markowitz, 1952). It is important to recognize the different factors that investors consider to make investment decisions for having the optimal risk-return profile. Many studies have shown that the relationship of one risky asset with the others in a portfolio largely affect the determination of the total return of that portfolio (Cochrane, 1999). For a naïve investor, the decision to invest in a market like Nepal subject to uncertainty, leading to consider social economic factors that affect the future cash flows and change the perceived risk in investments.

The Markowitz Portfolio Theory is a conceptual framework to construct portfolios for a given collection of risky assets with desirable risk-return features. This theory was introduced by Harry Markowitz in his paper "Portfolio Selection" for which he was awarded a Nobel prize. The core premise of the theory was how an investor can select a portfolio that provides the highest expected return at the given level of the risk (Markowiz, 1971). In the rest of this paper, relevant literature is reviewed, a theoretical framework is developed to identify the best portfolios and an optimal portfolio, and finally finding and implications are discussed.

Review of Literature

When it comes to studying optimizing portfolios, it is beneficial to first define the term and its theories. The literature here shows the theoretical frameworks of the model which was used to conduct the study itself a few empirical studies.

Portfolio Selection Theory

Harry Markowitz is the pioneer for his contributions to different works in financial economics and corporate finance. In 1990, he was awarded a Nobel Prize for his work on the selection of the best portfolios of risky assets. His pioneering contribution to the financial economics was made in the 1950s in which he developed a conceptual framework for risk-averse investors to allocate risky assets under uncertainty (Mangram, 2013). His framework evaluates how investors' wealth could be optimally invested in risky assets having distinct risk-return tradeoffs and thereby reducing the idiosyncratic risks – a risk inherent in a specific asset due to its individual characteristics. This framework laid the foundation for how diversification of wealth should work, so called the 'Modern Portfolio Theory' - MPT (Amu, 2009). Further, it became the premise to the other fellow Nobel Price co-winner, William Sharpe for his contribution to Capital Asset Pricing Model (CAPM) theory of financial asset price formation in the 1960s (Nobel prize, 1990).

MPT gives a rigorous statistical justification for the investors to diversify into multiple risky assets and thereby optimize the expected risk-return tradeoffs in investment decisions. This framework uses the mean-variance analysis to diversify in risky assets rather than the investors' intuition about "not put all your eggs in one basket". Using this systematic approach for managing risky assets in their portfolio, the investor could find efficient portfolios available at the efficient frontier – the frontier is made of all portfolios that are characterized by the highest return at the given level of risk (Malkiel, 2007).

The significant analysis of the MPT depends on mathematical modeling and formulas to back its theoretical assumptions (Mangram, 2013). Generally, we do not observe casual investors adopting these rigorous and complicated processes while making an investment decision on risky assets. But on the other side, there are not enough simplified and robust framework available to make such investment decisions (Omisore, Yusuf, & Nwufo , 2012). Despite its drawbacks, there were many theoretical and technological advancements in the field of the investment since the introduction of the MPT. The world of the financial investment has undergone a major evolution in terms of the tools and methodology available to investors (Fabozzi, Gupta, & Markowitz, 2002).

In 1958, James Tobin added risk-free assets to the MPT to form a capital market line-CML. Then it became possible to have leverage positions – borrow or lend at risk-free rates – in a portfolio. The CML performed better than the efficient frontier as risk-free assets were added while diversifying. Drawing a tangent using the CML on the efficient frontier, Tobin could determine the super-efficient portfolio that gives the perfect portfolio of risky assets having the highest expected return per unit of risk (Tobin, 1958). Since the portfolio could have leveraged positions, the portfolios on the CML could beat portfolios on the efficient frontier (Armstrong III, 2014). The work of Markowitz and Tobin established that it was possible to identify an optimal portfolio of any combination of risky assets based on each asset's expected return and an appropriate covariance matrix of those assets. Later, the CAPM was proposed by William Sharpe to determine the expected return which investors should hold on the basis of return on the super-efficient portfolio, the risk-free rates and a beta risk of the assets. This means all investors should hold the super-efficient portfolio, despite being in leveraged or deleveraged positions in a risk-free asset (Sharpe, 1964).

These three portfolio theories provide a better insight on how the investor should forecast their expected return of the return based on idiosyncratic risks. These frameworks together shaped how portfolios are to be managed using passive investment techniques (Holton, 2003). The mathematics of these portfolio theories are still popular tools used as of today; many professional money managers and investment bankers work on these frameworks on regular basis. (Sabbadini, 2010).

The context of risky assets market in Nepal

The NEPSE market is still a young stock exchange relative to other developing nations. By 2016, the exchange grew to 230 listed companies with market capitalization of $15 billion (Nepal Stock Exchange, 2016). Despite the recent growth in the exchange market in Nepal, most of the investors still struggled to manage their portfolios of risky assets. The selection of the assets was found mostly based on the potential growth, market trend or heuristics decisions (Bajracharya & Koirala, 2004). Most of the household investors ignore the systematic approach to making rational decisions. Further, there is a lack of knowledge on diversifying across different sectors or industries as there have not been enough studies in the sectoral portfolio investment to educate the local investor to minimize the industry risk.

Diversification across sectors and Index tracking

With a growth of business globalization and financial markets integration, risk-averse investors are still looking to minimize their risk by diversifying their portfolios across different industries (Phylaktis & Xia, 2006). Thus, the concept of diversifying across country sectors has received attention in the paper. Diversification not only means distributing the wealth in multiple assets but a prudent investor also considers diversifying across different sectors, class, geographic orientation (Apergis, Christou, & Miller, 2014). The study done in Malaysia compared the diversification across industries against the naïve multi-assets strategy. It showed that the diversification across industries can add value by combining with other diversification strategies (Mohamad, Hassan, & Sori, 2006). Further, the sectoral characteristics give a useful insight to determine the efficient portfolio (Chisholm, O'Reilly, & Betro, 2013).

Today, the NEPSE can provide the sectoral index prices of homogenous risky assets by computing price of those selected equity assets using weighted average prices. These index prices primarily used by investors to describe the sector and to compare the return on specific sectors against others. Supporters of index investing passively manage their investment as they believe that it is impossible to beat the market once transaction expenses and taxes are considered. Investments in index funds usually result in diversification across the multiple assets and lower management fees than active fund management (Vanguard, 2015). Though trading in the sectoral indexes is not available in Nepal yet (Nepal Stock Exchange, 2016), designing an optimal portfolio across different sectors could help the investors to minimize the uncertainty by diversifying across risky assets of a different sector that could replicate the indices performance.

Applying the theory

Optimization of the portfolio requires performing a mathematical procedure called quadratic programming problem to maximize the expected return and minimize the expected risk. The optimal solution can be found using constrained optimization by defining an algorithm based on a non-linear programming problem. (Jobst, Horniman, Lucas, & Mitra, 2001). Tools like matrix inverse, matrix multiplication, and matrix transpose can be used in Excel to determine the portfolio frontier, the global minimum variance portfolio and the super-efficient portfolio (Lee & Su, 2014). Following steps are proposed for this paper:
Determine the sectoral assets class for the portfolio
Calculate inputs of the efficient frontier – portfolios' mean and variance
Calculate the efficient frontier as proposed by Harry Markowitz's portfolio mean-variance analysis.
Determine the global minimum variance portfolio
Determine the highest Sharpe ratio to identify the super-efficient portfolio by using EXCEL Solver.

Research Methodology

The aim of this research is to apply the portfolio theories of Markowitz and Tobin to discover the optimal sectoral portfolio in NEPSE. The study was mainly based on the secondary data available at the exchange market. There were altogether 230 listed companies by 2016 and NEPSE have identified seven sectors based on homogeneous nature of business (Nepal Stock Exchange, 2016). Here the industry sectors have been considered as an asset instead of the individual assets. There were four sectors selected for this model represented in Table 1.

Table 1: Number of listed companies in different Sectoral indices in NEPSE as on DEC 2016

Selected Sectors	**# of listed companies**
Commercial Banks	28
Insurance Companies	22
Development Banks	94
Hydropower Companies	10

Markowitz Mean-Variance Model

The MPT requires the investors to determine the expected return and the expected risk of the portfolio of "n" assets. To analyze risk and return of these sectoral assets, the monthly mean returns and variances were calculated by taking the closing price of the sectoral indices from February 2014. The monthly mean returns, variances (risk) and covariance

were calculated for 36 months then those measures were annualized. Each asset monthly return at T1 was calculated as follow R1 = (P1/P0) -1, where
R1 = return of a risky asset at end of the month
P1 = closing price of a risky asset at the end of the month
P0 = closing price of a risky asset at the end of the earlier month.

The rate of return can be viewed as an interest rate requiring a deposit of P0 into a fixed account to gain the same change in value as the asset over the period [0, T]. For example, if P0 = Rs. 100 and after one month P1 = Rs. 102, the rate of return of the asset is R1 = 2% monthly.
Out of the 36-monthly returns, expected return (mean) and risk (variance) were calculated for individual assets using

Expected return of an asset, $E(R_{Asset}) = \frac{1}{n}\sum_{i=1}^{n} Ri$

While the expected rate of return is helpful to describe a risky asset performance by giving an indication of forecasted high or low returns. However, this measurement does not reveal the uncertainty in achieving a comparable return rate. For describing uncertainty or risk, a better measurement used was variance, given as

Expected risk of an asset, $\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(Ri - E(R_{Asset}))$

While making an investment decision, it is not only important to access the expected return of the assets but also their riskiness. Besides the expected risk and return, the inter-relationship between the risky assets also play a critical role to determine the payoff of the portfolio (Palmliden, 2012). Covariance between the assets can be used to quantify this relationship defined by

We remark that $\sigma_{i,j} = \sigma_{j,i}$ and that when a = b , $\sigma_{i,i} = \sigma^2_i$.

To show the relationship between the "n" of assets we define the covariance matrix by:

$$V = \begin{bmatrix} \sigma_{1,1} & \sigma_{1,2} & \cdots & \sigma_{1,n} \\ \vdots & \vdots & \vdots & \vdots \\ \sigma_{n,1} & \sigma_{n,2} & \cdots & \sigma_{n,n} \end{bmatrix}$$

A portfolio consists of the investment made in "n" number of assets by some level of wealth "W". W_i represent the weight of an asset against the total value of the portfolio. Here we will assume that $W_i \geq 0$, as no short positions are allowed in the risky assets at the NEPSE (Singh, 2011). Since the total wealth invested is W, we have:

$W = \sum_{i=1}^{n} Wi = 1$

Using this information, now we can calculate the expected return and the expected risk of the different portfolios. First, the expected rate of return of the portfolio at time "t" is given by:

$E(R_p) = \sum_{i=1}^{n} Wi * Ri$

Here the expected return of a portfolio is the weighted average of the expected return of individual assets in the portfolio with their weights.

Second, the expected variance of the portfolio at time "t" is given by

$\sigma^2_p = \sum_{i=1}^{n} W_i * \sigma^2_i + \sum_{i=1}^{n} \sum_{j<1}^{n} W_i * W_j * \sigma_{ij} * \sigma_i * \sigma_j$

We considered that the return on the assets was normally distributed, hence the portfolio return was also considered to be normally distributed (Markowitz, 1952). Then the probability distribution of the expected return of the portfolio is fully characterized by the mean and variance. Thus, the wealth of the portfolio at the end of the period can be written as

$Portfolio_1 = Portfolio_0 * [1+E(R_p)]$

Identification of Efficient Portfolios

All possible portfolios of different weights of "n" risky assets were used to determine their respective mean and variances. These portfolios' results were plotted in a scatter diagram, where x-axis was mean and y-axis was standard deviation (√variance). If the correlation between the assets is 1, then there is no benefit of diversification in a portfolio. Logically when the two assets have a correlation of -1, the diversification should result in the highest risk optimization. However, as the correlation start to decrease from 1, the portfolio starts to get diversification benefit (Palmliden, 2012).

The level of correlation between assets will result in the different shape of the frontier. However, the Efficient frontier can be drawn by identifying the portfolios that exhibit the highest mean (expected return) at the given level of standard deviation (risk). This helps the investor to filter out the efficient portfolios at a different level of risk. However, the choice of the efficient portfolio depends on the individual's risk preference.

Global Minimum Variance Portfolio

The global minimum variance (GMV) portfolio is the leftmost point of the efficient frontier. The GMV portfolio reveals that portfolio having the least level risk providing the highest level of expected return (Kempf & Memme, 2006). It can be represented as:

$$\text{Min } \sigma^2_p = \sum_{i=1}^{n} W_i * \sigma^2_i + \sum_{i=1}^{n} \sum_{j<1}^{n} W_i * W_j * \sigma_{ij} * \sigma_i * \sigma_j$$

The Super-Efficient Portfolio

James Tobin proposed that somewhere out there is the perfect risky asset portfolio – the super-efficient portfolio – that generates the highest return per unit of risk. That is the portfolio which all investors in the world of investment would want to hold and it would also outperform all other portfolios (Lee & Su, 2014). The Super-efficient portfolio can be found by drawing a CML as a tangent to the efficient frontier. The CML can be shown as linear equation as

$$E(Rp) = R_f + \sigma_p \frac{E(R_m) - R_f}{\sigma_m}$$

Where R_f is a risk-free rate and $\frac{E(R_m)-R_f}{\sigma_m}$ is the slope that denotes the change in the expected return per unit change in standard deviation, so-called Sharpe ratio. The risk-free rate was taken from the central bank's 364 days short-term Treasury Bills, having an annual rate of 3.25% (Nepal Rastra Bank, 2016).The tangent portfolio of the risky assets has the maximum value of the slope and can be found using optimization of the Sharpe ratio.

These steps were completed using EXCEL solver that intend to maximize the slope with changing variable as weights of the risky assets. Here the only constraint was no short-sell allowed for risky assets.

Results & Findings

In this section, the results are presented based on the methodology proposed in this paper earlier. The mean return, variance, and correlation were calculated for four sectoral assets (indices) and are presented in Table 2.

Table 2: Mean, Variance, & Correlation of the selected risky assets for the portfolio design

Indices	**Mean**	**Variance**	**Correlation Matrix**			
Commercial Banks	24.72%	8.75%	1.00	0.66	0.81	0.59
Insurance Companies	46.80%	17.11%	0.66	1.00	0.68	0.64
Development Banks	44.43%	9.29%	0.81	0.68	1.00	0.65
Hydropower Companies	0.29%	8.39%	0.59	0.64	0.65	1.00

The Insurance sector and Development banks sector offered the significantly higher return compared with other two indices. It appears the Insurance sectors had the highest risk among the four sectors. Hydropower sector was the least performer in term of return to the investors but the best in term of risk. The correlation among the indices was positive. These findings were like other studies done in NEPSE (Paudel, 2002; Adhikari & Jha, 2016) and those correlation value ranged from +0.59 to +0.81. The highest correlation of expected return was between the two banking sectors and the lowest correlation was found between Commercial banks sector and Hydropower sector.

Benefits of Constructing Portfolio

A naïve investor with an expectation of higher return would have heavily invested in Insurance sector due to its highest return. Similar an investor looking for less uncertainty would choose Hydropower sector as the best choice. Since it can be observed that all assets (indices) possess positive correlation among themselves, but not perfectly positive correlation, so there will be a benefit of diversification. Using portfolio optimization, the investor can get better results in both sets of investment objectives – 1) maximize expected return or 2) minimize the expected risk.

Equally weighted portfolio

An investor with no portfolio knowledge and looking to diversify may equally distribute their wealth in four sectors and will end up with the expected return of 29.06% and the expected risk of 7.78% (variance). With a simple diversification, the risk of the investment has already been decreased compared with the individual indices. However, this equal distribution of wealth across the risky assets may not be the better choice which risk-averse investors.

Portfolio Frontier with four risky assets

A series of efficient portfolios were identified that exhibited the highest return at the given level of the risk. Table 3 represents a few efficient portfolios that were determined using the quadratic programming problem using EXCEL solver.

Table 3: Efficient Portfolios of Sectoral Investment in NEPSE

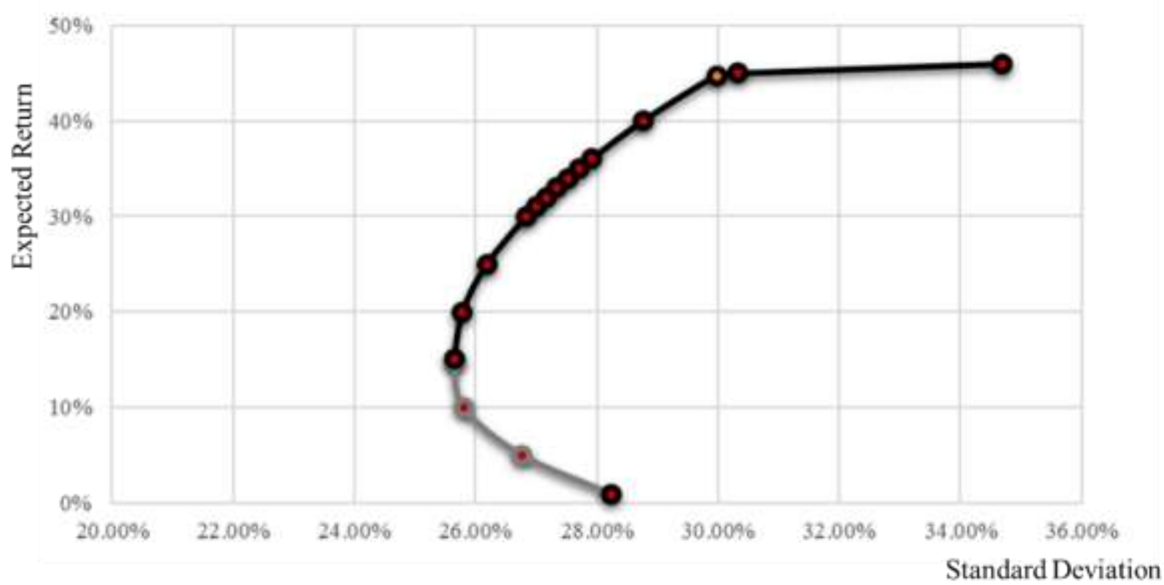
Mean	Variance	Commercial Banks	Insurance Companies	Development Banks	Hydropower Companies
15.0%	6.58%	39%	0%	12%	49%
20.0%	6.65%	35%	0%	26%	40%
25.0%	6.86%	30%	0%	39%	31%
30.0%	7.20%	25%	0%	53%	21%
31.0%	7.29%	24%	0%	56%	20%
32.0%	7.38%	23%	1%	58%	18%
33.0%	7.47%	22%	1%	60%	16%
34.0%	7.57%	21%	2%	62%	14%
35.0%	7.68%	20%	3%	65%	13%
36.0%	7.79%	19%	4%	67%	11%

40.0%	8.27%	15%	6%	75%	4%
44.8%	8.99%	0%	14%	86%	0%
45.0%	9.19%	0%	24%	76%	0%
46.0%	12.04%	0%	66%	34%	0%

The investors wanting the lowest expected risk in their investment decision will select the global minimum variance portfolio. The lowest risk possible here is 6.58% with the expected return of 15.0%. The construction of this lowest risk portfolio includes weights of 39%, 12%, and 49% in Commercial banks, Development Banks, and Hydropower Companies respectively but none is Insurance companies. Comparing the global minimum variance portfolio with the Hydropower sector – the lowest individual risky assets with 8.37%–, the investor with the global minimum variance can decrease almost 2% while increase the expected return by more than 14%. The investor would be in a better-off position in reducing the risk with the global minimum variance portfolio rather than making all investment in the hydropower sectors.

For all efficient portfolios identified, there is a trade-off between the risk and return, a usual risk and return relationship. Plotting these in the graph reveals the risk-averse portfolio choices as shown here.

Figure 1: Efficient Frontier of four sectoral assets in the NEPSE



The Super-Efficient portfolio

Based on the risk-free rate 3.25% p.a., the highest Sharpe ratio was 1.38 for the optimal risky asset portfolio having the expected return of 44.74% and the variance of 8.99%. The Super-Efficient portfolio had weights of 14% and 86% in Insurance sectors and Development banks sectors but none in other two sectors. This portfolio is the optimal one that beats all other portfolios.

The investor would have chosen either Development banks or Insurance companies for the heavy investment if this analysis was not performed. Compared with full investment in Development banks sector, the investor could optimize the risk-return slightly –expected return increased by 0.33% and expected risk decreased by 0.30%. However, the optimization is apparent if compared with full investment in the Insurance sector –expected return decreased by 2.04% but the expected risk decreased by a lot, 8.12%. For other two full sectoral investment, a significant improvement in the risk-return can be observed.

Conclusion

The return of different sectors generally tends to be highly correlated among themselves. Despite having limited benefits of diversification in such case, investors still can yield some benefits in risk reduction by using sectorial optimization based on the portfolio theories. The Harry Markowitz mean-variance model was useful in the selection of efficient portfolios of risky assets traded in the NEPSE.

Commercial banks sector and Hydropower sector appears to be inferior, in term of the individual risk-return profile, compared with other two sectors. However, the diversification of the commercial bank sector and hydropower sector along with development sector in a portfolio could achieve the lowest risk against the four choices of individual sectoral assets. This is mainly due to the lower expected variance across these three sectors compared with the insurance companies. The ideal portfolio includes heavy investment in the Development sectors and rests in the Insurance sectors. This portfolio has the highest Sharp ratio of 1.38 and relatively lower return at risk of 8.99%.

The paper gives a framework to the investors to optimize their portfolio based on the sectoral investment in Nepal. Diversification across multiple sectors could yield some benefits for investors who are looking to get the highest return in the market. These passive tools can be used to get a better result rather than actively looking for the best risky assets based on the growth or following the herd.

Future Scope for Research

Although the paper makes contributions to the both professional and academic, it is limited in some ways, and so further work can be undertaken. However, the constraints of the model, its underlying assumptions (Lydenber, 2009), need to be understood to conduct those studies. It is not by accident that portfolio theory has become a powerful principle of investment since its introduction. A comparative analysis of risk and return trade-offs between sectoral diversification and conventional diversification – growth based – could be done in Nepalese market to demonstrate the strength of each framework.

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