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Markowitz theory in S&P 500 portfolios

Teoría de Markowitz en portafolios del S&P 500

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Abstract

The objective of this article was to analyze Markowitz's Theory to identify its impact on performance because investors require optimizing the balance between risk and return. Methodologically, the study used the type of basic research with a quantitative approach; in addition, a non-experimental design of a retrospective type and a descriptive and explanatory scope. Regarding the sample, the monthly historical price of the shares of the companies listed in the S&P 500 stock index was used, covering a period from January 2023 to August 2024 and processed through the Solver program. As findings, it was found that the efficient frontier was useful to identify portfolios with the same level of risk and different returns, the lower dispersion of data and the lower beta coefficient allowed to obtain a return higher than the risk. In this sense, it was concluded that Markowitz's theory favorably affects the performance of a portfolio since it allowed to identify investment alternatives that simultaneously minimize risk and maximize return.

Keywords: Markowitz, performance, risk, efficient frontier, diversification, beta coefficient

JEL Classification: G11, D81, G14

Resumen

En el presente artículo se propuso como objetivo analizar la Teoría de Markowitz para identificar su incidencia en el rendimiento debido a que los inversionistas requieren optimizar el equilibrio entre riesgo y rendimiento. Metodológicamente, el estudio empleó el tipo de investigación básica con enfoque cuantitativo; además, un diseño no experimental de tipo retrospectivo y un alcance descriptivo y explicativo. En cuanto a la muestra, se utilizó la cotización histórica mensual de las acciones de las empresas listadas en el índice bursátil S&P 500 abarcando un periodo comprendido entre enero del 2023 hasta agosto 2024 y procesados a través del programa Solver. Como hallazgos se encontró que la frontera eficiente fue útil para identificar portafolios con el mismo nivel de riesgo y rendimientos diferentes, la menor dispersión de datos y el menor coeficiente beta permitieron obtener un rendimiento superior al riesgo. En ese sentido, se concluyó que la teoría de Markowitz incide favorablemente en el rendimiento de un portafolio ya que permitió identificar alternativas de inversión que simultáneamente minimizan el riesgo y maximizan el rendimiento.

Palabras claves: Markowitz, rendimiento, riesgo, frontera eficiente, diversificación, coeficiente beta

Clasificación JEL: G11, D81, G14

INTRODUCTION

The growing integration of different economies is not only oriented towards the purchase and sale of goods; this process also puts the purchase and sale of fixed-income and variable-income financial securities in the spotlight as an attractive investment alternative, especially for surplus agents who constantly seek alternatives to increase their assets. On the one hand, bonds are identified as fixed-income securities that generally do not represent a greater risk since the terms and conditions are agreed upon from the moment they are acquired. On the other hand, shares are identified as variable-income securities that, compared to the first option, are characterized by their price fluctuating daily, which represents a greater risk; however, they tend to offer a higher return compared to bonds.

Under these approaches, the investor who acquires variable-income securities must face the risk, since investing all of his monetary resources in a single company could mean a total loss in the event that the share price collapses; In light of this, Markowitz, through his portfolio theory, points out that in order to mitigate risk, one must invest in more than one company, an effect known as diversification. This problem seems to be resolved; however, the new issue to be faced is the uncertainty that arises in identifying which companies should be selected.

Considering these problems, the general objective is to analyze the impact of Markowitz's theory on the performance of a portfolio, which is supported by the following specific objectives. First, to identify the impact of the efficient frontier on the performance of a portfolio; second, to evaluate the impact of data dispersion on the performance of a portfolio; and third, to examine the impact of the beta coefficient on the performance of a portfolio. In addition, it is proposed as a general conjecture that Markowitz's theory has a favorable impact on the performance of a portfolio. Among the specific conjectures; first, the efficient frontier has a favorable impact on the performance of a portfolio; second, data dispersion has a favorable impact on the performance of a portfolio; and finally, the beta coefficient has a favorable impact on the performance of a portfolio.

The study is theoretically justified because it seeks to explain, through the theory proposed by Markowitz (1952), how the efficient frontier, data dispersion and beta coefficient affect performance, for which the study proposed by Sharpe (1963) is used, which includes the risk-free rate, standard deviation and the performance of a portfolio. Regarding the methodological justification, the method proposed by Ardelia and Ratna (2017) is used since through a sequential process that starts from the estimation of historical returns, standard deviation, correlation coefficient and covariance, the optimization of a portfolio is carried out with the Solver program, using the restrictions of minimizing risk and maximizing the Sharpe ratio. Finally, regarding the practical justification, the results obtained serve to increase existing theories, as well as support investors who are constantly focused on reducing the level of uncertainty and optimizing a stock portfolio.

From the perspective of Blanco, Ferrando and Martínez (2015), Markowitz's theory is a model that allows the optimal selection of an investment portfolio in financial assets to be analyzed; in addition, it allows the estimation of the return and risk according to the rational behavior of each investor.

In the research of Molina, Molina and Flores (2023), it is argued that the behavior of investors is oriented to maximize their assets, which is achieved by identifying the efficient frontier, since it contains portfolios that are distributed according to the optimal percentage proportion of an investment and offer an expected return based on the lowest possible risk (Chalkis, Christoforou, Emiris and Dalamagas, 2021), thus making the Markowitz model an adequate tool for managing portfolios; however, to have accurate data, the historical performance and the covariance between its assets must be correctly estimated (Franco, Avendaño and Barbutín, 2011); In addition to these indicators, it is proposed to use a factor that allows selecting companies, such as market capitalization, since in this way the investor will be able to select a set of shares according to their level of risk aversion (Ossa, 2023).

For their part, Franco, Avendaño, and Barbutín (2011) argue that the portfolio theory is used by rational investors to minimize risk taking into account performance or to maximize performance taking into account the level of risk, which is measured through the dispersion of data with the standard deviation; as indicated by Betancourt, García, and Lozano (2013); however, they state that to mitigate risk it is necessary to apply the diversification criterion, a procedure that is carried out using at least 8 companies from different economic sectors since the purpose is to vary the percentage weights to invest (Zavaleta, 2023); in addition, the fact of having more than two assets is

useful so that the performance is not harmed, since the loss of an asset can be offset by the gain of another asset (Conti, Simó, and Rodriguez, 2005).

In the words of Gomero and Gutiérrez (2013), the stock market is very volatile, which requires using tools to optimize the expected return through the estimation of non-diversifiable risk, among which the beta coefficient stands out, which shows the relationship between the covariance of the asset and the market as a whole with respect to the variance of the market; In addition, considering that the risk analysis is measured from the perspective of historical sensitivity or with respect to the general behavior of the market, it is most appropriate to use the beta coefficient since it represents an ideal tool for managing investment portfolios (Cortes and Bravo, 2023); in this sense, assets with a β equal to one have a behavior similar to the market, while a β greater than or less than one reflects a behavior similar or inverse to the market respectively (Brenes, 2019).

Regarding performance, Ardelia and Ratna (2017) point out that this variable depends on uncertainty, so to create a portfolio, stocks that show low volatility and high historical returns should be used (Chalkis, Christoforou, Emiris and Dalamagas, 2021). In addition, one should not lose sight of the securities that periodically deliver profits to their investors (Chen and Israelov, 2024); another strategy is to take into account the trading price and its evolution over time, since a high price shows that there is great demand to acquire the rights of a company that provides attractive returns (Aprilianti, Suharti and Azis, 2022). This idea is associated with the theory of the momentum effect that is used by those investors to obtain a return in the short and medium term (Civiletti, Campani and Roquete, 2020).

On the other hand, performance estimation requires paying attention to the distribution of data, since a normal distribution allows unbiased estimates (Gutiérrez, Laniado and Medina, 2018); in addition, its measurement requires the use of the Sharpe, Treynor and Jensen ratio since these models base their analysis on past returns to predict future returns and risks (Aprilianti, Suharti and Azis, 2022), the first focuses on total risk, the second on systematic risk and the third on the comparison of excess return with expected return; however, Sharpe is the most consistent since it measures the excess return for each unit of risk accepted (Lousius and Ekadjaja, 2023).

For their part, Gitman and Joehnk (2009) define performance as the monetary resources acquired by the transfer of rights to another investor and the benefits acquired by the increase in the initial value.

Finally, the expected findings in this research are the identification of an optimal portfolio and the efficient frontier, since they are tools to improve investment decisions and obtain the balance between risk and return.

MATERIAL AND METHODS

In this research, basic research has been used, since the objective is oriented to strengthen existing theories (Hernández-Sampieri and Mendoza, 2018); in addition, a quantitative approach has been used since the acceptance or rejection of the hypothesis requires that the variables can be measured through a sequential process (Niño, 2011). Regarding the design, the non-experimental retrospective type has been used since there is no deliberate manipulation of the variables, with an analysis of historical data and finally, a descriptive and explanatory scope because it begins by describing approaches of other researchers and ends with the explanation of the cause and effect between the intervening variables (Bernal, 2010).

Regarding the population, the S&P 500 stock market index has been used since, compared to other stock market indexes, this index groups the 500 most liquid companies and with the highest trading value of shares; In addition, the information is updated quarterly, which allows for an adequate analysis to be carried out for portfolio optimization. To estimate the sample, the convenience method was used, which is used to identify certain individuals or phenomena that meet the characteristic proposed by the researcher (Bernal, 2010). In this way, 198 companies were selected according to the criteria of stock market capitalization, data dispersion and beta coefficient.

The selection process was carried out by grouping the companies according to the economic sector in which they carry out their activities, which are eleven, then they were ordered in ascending order under the criteria indicated in the previous paragraph and then the first 3 companies in each sector were classified with the highest selected criterion and the last 3 companies in each sector with the lowest selected criterion. In this way, 6 portfolios were obtained composed of 33 companies, such amount was established under the criterion of the average proportional weight of the number of companies that make up a certain economic sector.

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- Portfolio 1: companies with the highest market capitalization.

- Portfolio 2: companies with the lowest market capitalization.

- Portfolio 3: companies with the highest data dispersion.

- Portfolio 4: companies with the lowest data dispersion.

- Portfolio 5: companies with the highest beta coefficient.

- Portfolio 6: companies with the lowest beta coefficient.

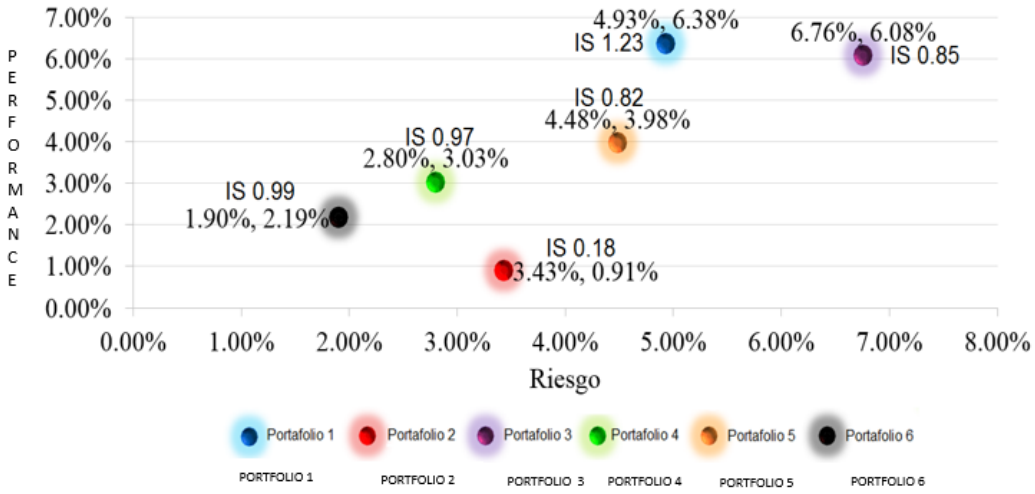
As for the techniques, firstly, documentary analysis has been used, which serves as support for the theoretical review of the findings presented by other researchers, and secondly, statistical analysis has been used since the data of historical quotes between January 2023 and August 2024 are processed with statistical formulas. This period has been used because the year 2023 marked the beginning of a cycle with positive returns after negative returns had been recorded during the previous year, a situation that became attractive for investors. Finally, the Solver program has been used as an instrument in order to optimize both risk and performance.

RESULTS

After processing the historical data of the six portfolios through the method proposed by Ardelia and Ratna (2017), which includes the estimation of historical returns, the average expected return, the allocation of investment weights, the covariance between the participating companies and the optimization through the Solver program under the restriction of maximizing the Sharpe ratio for each portfolio with a risk-free rate of 0.3105% per month, the following result has been obtained with respect to the general conjecture:

Figure 1

Sharpe ratio of the selected portfolios



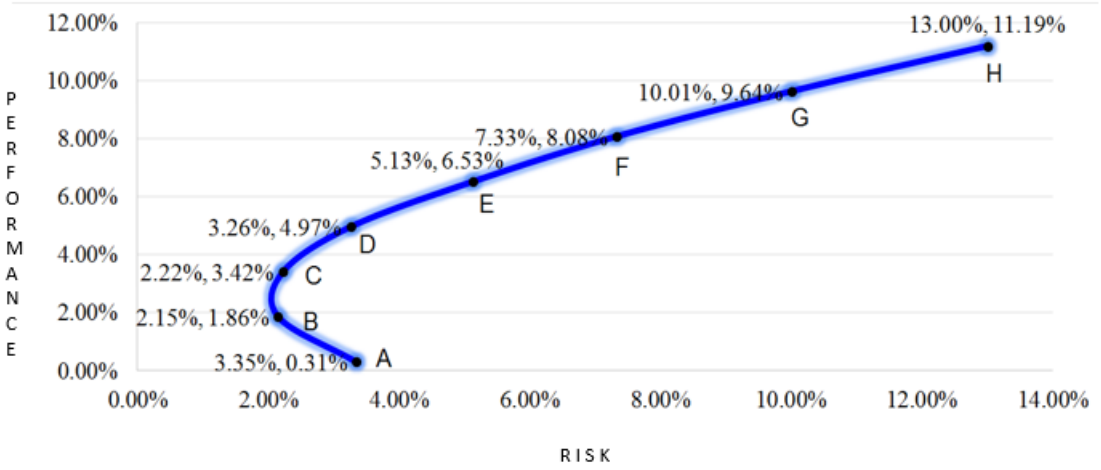
Note: Yahoo Finance (2024)

Portfolio 1 is the optimal investment alternative, since it offers the highest possible return (6.38%) with a risk level of 4.93% and a Sharpe ratio of 1.23; that is, this portfolio offers the highest return per unit of risk compared to the other alternatives. Therefore, the general conjecture is accepted, since the use of Markowitz theory allows comparing portfolios and favors the identification of the highest possible return. As pointed out by Condori and Jinchuña (2023), who argue that the Markowitz model and the use of the Sharpe ratio are adequate to identify the portfolio that optimizes the relationship between return and risk.

Regarding the first specific conjecture, the following results have been obtained:

Figure 2

Efficient frontier of portfolios with higher market capitalization



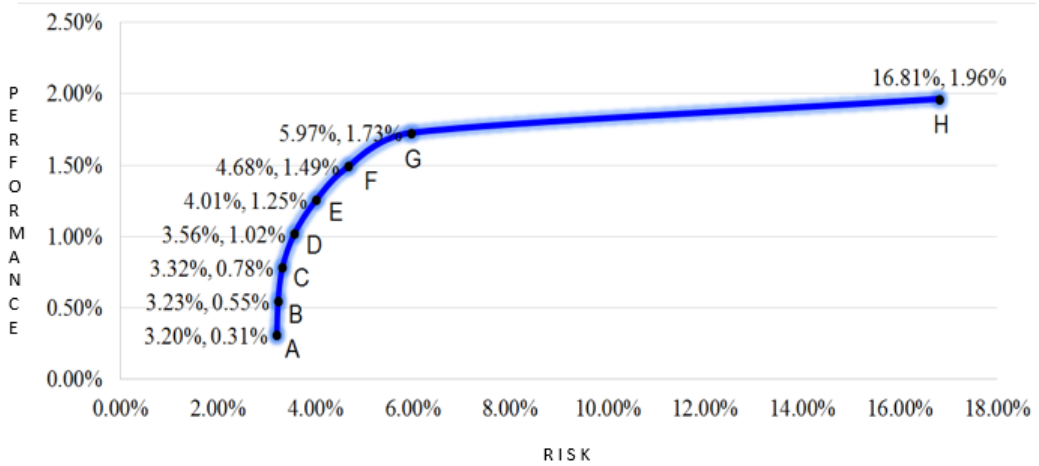
Note: Yahoo Finance (2024)

Portfolios A and D offer a return of 0.31% and 4.97% with a risk level of 3.35% and 3.26% respectively. As can be seen, these portfolios have a similar risk since the difference between them is only 0.09%; however, portfolio D offers a higher return of 4.66% compared to portfolio A.

This situation can also be observed in figure 3. In this case, portfolio A is already located on the efficient frontier; furthermore, as it is joined to the other portfolios through a line, it can be seen that both the return and the risk are increasing. However, if the graph is reflected as a mirror, the existence of portfolios that offer lower returns with a higher level of risk could be identified.

Figure 3

Efficient frontier for portfolios with lower market capitalization



Note: Yahoo Finance (2024)

As can be seen, portfolios that are on the efficient frontier line clearly provide a higher return compared to portfolios that are below this parameter. This is why their identification is necessary to mitigate risk and select portfolios that provide better benefits to investors. Considering these arguments, the first specific conjecture is accepted because it has been shown that the efficient frontier has a favorable impact on the performance of a portfolio. In relation to these results, Molina, Molina and Flores (2023) argue that portfolios located on the efficient frontier show lower risk and higher returns compared to portfolios located below the minimum variance.

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Regarding the second specific conjecture, the following results have been obtained:

Table 1

Risk-performance relationship with dispersion criteria

	Performance	Risk	Sharpe Ratio
Portfolio with the highest dispersion	**6.08%**	**6.76%**	**0.85**
Portfolio with the lowest dispersion	**3.03%**	**2.80%**	**0.97**

Note: Yahoo Finance (2024)

The estimated return is 6.08% and 3.03% with a risk level of 6.76% and 2.80% for the portfolios with the highest and lowest dispersion, respectively. Using the approach of selecting portfolios with the highest return, the investor should probably invest in the first portfolio; however, adding the approach of minimizing risk, the investor would choose to invest in the second portfolio. The existence of uncertainty to select the optimal portfolio requires the estimation of the Sharpe ratio; in this sense, the second portfolio meets this condition because it offers the highest return for each unit of risk. Taking these results into account, the second specific conjecture is accepted because it has been shown that data dispersion favorably affects performance. However, in the study carried out by Betancourt, García and Lozano (2013) it has been determined that a greater dispersion is associated with a lower risk.

Finally, for the third specific conjecture, the following results have been obtained:

Table 2

Risk-performance relationship with beta coefficient criterion

Portfolio with higher beta				Portfolio with lower beta			
N°	Company	Sector	Beta	N°	Company	Sector	Beta
1	Targa Resources	XLE	2.26	1	Coterra Energy Inc.	XLE	0.23
2	Builders FirstSource	XLI	2.04	2	CME Group Inc.	XLF	0.53
3	Advanced Micro Devices	XLK	1.68	3	The Allstate Corp.	XLF	0.48
4	PG&E Corp.	XLU	1.09	4	Progressive Corp.	XLF	0.36
5	Vistra Corp.	XLU	1.07	5	Tyler Technologies	XLK	0.76
				6	International Business	XLK	0.70
				7	Akamai Technologies	XLK	0.67
				8	Digital Realty Trust	XLRE	0.60
				9	Regeneron Pharmaceuticals	XLV	0.13
				10	Biogen Inc.	XLV	-0.04
Performance			3.98%	Performance			2.19%
Risk			4.48%	Risk			1.90%
Sharpe ratio			0.82	Sharpe ratio			0.99

Note: Yahoo Finance (2024)

According to the data shown in Table 2, at first glance portfolio 1, composed of companies with a higher beta coefficient, represents the most attractive investment alternative since the return is 3.98%, exceeding the second portfolio by 1.79%. However, this situation is contrary from the perspective of the level of risk, since portfolio 2 is lower by 2.58%. In this way, it can be verified that the higher the return, the higher the risk; however, to identify the optimal portfolio, the Sharpe ratio was estimated in order to identify the alternative that offers the highest return for each unit of risk. In this sense, it was determined that portfolio 2 represents the most attractive investment alternative considering the relationship between risk and return; furthermore, considering the diversification criterion, this portfolio is more attractive since it is composed of 10 companies, while the first portfolio only contains 5 companies. Taking into account these arguments, the third specific conjecture is accepted because it has been shown that the beta coefficient has a favorable impact on the return. In this regard, Gomero and Gutiérrez (2013) confirm that to minimize risk, one should take portfolios with a beta less than 1 as well as those stocks that have a negative correlation with the market.

DISCUSSION

In the research carried out, the general objective was to analyze the impact of Markowitz's theory on the performance of a portfolio; for this purpose, the performance and risk of 6 investment portfolios composed of companies from the S&P 500 stock market index were estimated. The results showed that it is possible to analyze different investment portfolios to identify the alternative that provides a higher return for each unit of risk through the Sharpe ratio; in this sense, it was found that the portfolio composed of companies with the highest market capitalization offers the highest index, which is 1.23 with a return of 6.38% and a risk level of 4.93%.

This finding agrees with the study carried out by Condori and Jinchuña (2023) who obtained as a result that the use of the Sharpe ratio in the mean variance theory allows to identify the existence of the portfolio that maximizes the return with respect to the risk; under this method they obtained an index of 10.56%; However, it differs in terms of the criteria applied to group the companies, since this result corresponds to the portfolio of companies with the highest standard deviation in the price of their shares, which offers an expected return of 0.36% with a risk level of 3.42%.

Regarding specific objective 1, to identify the impact of the efficient frontier on the performance of a portfolio, two composite portfolios were used with companies with lower and higher capitalization. The results of the second portfolio allowed us to identify the existence of investment portfolios that offer the same level of risk but with different expected returns, as is the case of portfolio A compared to portfolio D, in which its risk and return differ by -0.09% and 4.66% respectively, which means that portfolio D is less risky and more profitable; therefore, the portfolios located on the line of the efficient frontier maximize the return compared to the portfolios located below this indicator.

This finding is consistent with the research carried out by Molina, Molina and Flores (2023) in which their results showed that portfolios located below the minimum variance are inefficient because they offer a lower return and a higher risk compared to those portfolios located on the efficient frontier; To do this, they made a comparison of two portfolios, the first of them composed of 2 companies that is located below the minimum variance and offers a return of -0.15% with a risk level of 5.94%; while the second of them composed of 1 company is located on the line of the efficient frontier and offers a return of 0.4% with a risk level of 5.38%. Although the results support the findings of this research, the quantity that makes up the evaluated portfolios is refuted, since its optimal portfolio is composed of a single company, thus contravening the diversification rule.

Regarding specific objective 2, to evaluate the impact of data dispersion on portfolio performance, two composite portfolios were used with companies with lower and higher variability, considering the standard deviation as a measure. The results allowed us to evaluate the relationship between expected performance, its risk and the Sharpe ratio between both variables and it was found that the first portfolio maximizes the relationship between risk and performance, since a risk of 2.80%, an expected performance of 3.03% and a Sharpe ratio of 0.97 were obtained compared to a risk of 6.76%, an expected performance of 6.08% and a ratio of 0.85 corresponding to the second portfolio.

This finding is inconsistent with the results obtained by Betancourt, García, and Lozano (2013) since in their research they argued that greater volatility can result in lower risk; To do this, a comparison was made between two portfolios, the first composed of companies from the Colombian market and which presents a higher volatility than the second portfolio which was formed with companies from the international market. In the first scenario, a portfolio of 3 companies was obtained which offers a return of 0.118% with a risk level of 1.43%; while in the second scenario, a portfolio of 2 shares

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was obtained which offers a return of 0.165% with a risk level of 2.33%. However, this result is refuted since in order to compare the risk of a developing economy with a developed economy, it is necessary to make an adjustment with its respective risk country.

Considering the specific objective 3, to examine the impact of the beta coefficient on the performance of a portfolio, two composite portfolios were used with companies with higher and lower β. The results showed that the best investment alternative is the second one, because its optimization through the Solver yields a composite portfolio with 10 companies that have a β<1 and offers a return of 2.19%, with a risk level of 1.90% and a Sharpe ratio of 0.99; while for the first alternative, the portfolio is made up of 5 companies with a β>1 and offers a return of 3.98%, with a risk level of 4.48%, a Sharpe ratio of 0.82 and groups 5 companies.

This finding is consistent with the research conducted by Gomero and Gutiérrez (2013) since their results showed that risk management is carried out through the use of stocks that have a negative correlation with the evolution of the market, emphasizing that as long as this indicator is as close to -1, the risk will be minimized. This argument is supported after making a comparison between companies in the mining and industrial sectors with respect to the behavior of the stock market index of the Lima stock exchange ISBV and determined that a portfolio with β <1 provides a lower risk compared to a portfolio with a β> 1 since in the latter, the investor will face a level of risk that exceeds the market average.

Finally, with regard to the limitations of the study, it should be noted that macroeconomic factors have not been considered in the optimization of the relationship between risk and performance, since the decisions adopted of a social, political or economic nature can suddenly cause a variation in the price of the shares.

CONCLUSIONS

With respect to the general objective, it is concluded that Markowitz's theory favorably affects the performance of a portfolio, since its use allows estimating the benefit for each unit of risk and making a comparison between different portfolios in order to determine the appropriate investment alternative for an investor.

With respect to the first specific objective, it is concluded that the efficient frontier favorably affects the performance of a portfolio, since the results obtained allowed identifying the existence of investment alternatives with the same level of risk but with different performance; so that, those portfolios located on the line of the efficient frontier offer the highest performance.

With respect to the second specific objective, it is concluded that the data dispersion favorably affects the performance of a portfolio, since its use employs the standard deviation as a measure and after comparing portfolios composed of companies with greater and lesser volatility; it has been identified that the portfolio with the lowest dispersion offers the investor the highest performance for each unit of risk.

Finally, with regard to the third specific objective, it is concluded that the beta coefficient has a favorable impact on the performance of a portfolio, since the portfolio composed of companies with a beta lower than one allowed obtaining, on the one hand, the best relationship between performance and risk, which was compared after estimating the Sharpe ratio; and on the other hand, it supports the argument put forward by Markowitz, which indicates that greater diversification reduces risk, an argument that is supported by the result of the identified portfolio since its optimization is achieved by using 10 companies from different economic sectors.

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