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Analysis of the relationship between the profitability of market portfolios and the profitability of shares of companies in the oil sector

Análisis de la relación entre la rentabilidad de las carteras de mercado y la rentabilidad de las acciones de las empresas del sector petrolero

Análise da relação entre o retorno de carteiras de mercado e o retorno das ações de empresas do setor de petróleo

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Abstract

Purpose: This article aims to elucidate whether the particularity of the high level of explanation of the relationship between the return on the market and the return on shares of companies in the oil sector in Brazil occurs similarly in other markets.

Methodology: The oil companies considered were listed as the main ones by Forbes, Fortune and Exame magazines. Their shares and market movement were obtained from their respective host countries stock exchanges, and other information on institutional websites (e.g: OPEC - Organization of the Petroleum Exporting Countries). As theoretical support, CAPM and APT metrics were applied between from January 2, 2015, to March 31, 2021.

Results: Considering the privileged position of the fuel sector for the movement of the level of economic activity of the countries, the result of this research confirmed that the particularity of the Brazilian scenario is observed in other countries with regard to the high level of explanation of the return of the superior market portfolio at 50%. The research observed that the Explanation Coefficient tends to capture in a more significant way the effects of crises that come from local economic contexts and impacts on the world economy, such as a possible reduction in the level of gross domestic product of countries such as the United States or China. As for the unexpected event, such as Covid-19, the model, in principle, did not present the same result, which could be observed in the quarterly analyses.

Contributions of the Study: Research can help managers and investors, as by demonstrating similarities one can predict future events or assist in decision-making.

Keywords: APT; Stock Exchange; CAPM; Covid-19; Petrobras.

Resumen

Objetivo: Este artículo busca aclarar si la particularidad del alto nivel de explicación de la relación entre el rendimiento de la cartera de mercado y el rendimiento de las acciones de empresas del sector petrolero en Brasil ocurre de manera comparable en otros mercados.

Metodología: Las empresas petroleras consideradas fueron listadas como las principales por las revistas Forbes, Fortune y Exame, el movimiento de sus acciones y mercado fueron obtenidas de las bolsas de valores de los países anfitriones y otras informaciones en sitios web institucionales (ej.: OPEP - Organización de los países exportadores de petróleo). Como soporte

teórico se utilizaron las métricas CAPM y APT para el período del 2 de enero de 2015 al 31 de marzo de 2021.

Resultados: Considerando la posición privilegiada del sector de combustibles para mover el nivel de actividad económica de los países, esta investigación confirmó que la particularidad del escenario brasileño se observa en otros países en referencia al alto nivel de explicación de la rentabilidad de la cartera de mercado por superior a un 50%. La investigación observó que el Coeficiente de Explicación tiende a capturar de manera más significativa los efectos de las crisis que surgen de los contextos económicos locales y los impactos en la economía mundial, como una posible reducción del nivel del producto interno bruto de países como Estados Unidos o China. En cuanto a un evento inesperado, como el Covid-19, el modelo, en principio, no presentó el mismo resultado, lo que se pudo observar en los análisis trimestrales.

Contribuciones del Estudio: La investigación puede ayudar a los gerentes e inversores, ya que al demostrar similitudes se pueden predecir eventos futuros o ayudar en la toma de decisiones.

Palabras clave: APT; Bolsa de Valores; CAPM; Covid-19; Petrobras.

Resumo

Objetivo: Este artigo busca elucidar se a particularidade do alto nível de explicação da relação do retorno da carteira de mercado e o retorno das ações de empresas do setor de petróleo no Brasil ocorre de maneira semelhante em outros mercados.

Metodologia: A pesquisa considerou as principais petrolíferas elencadas pelas revistas Forbes, Fortune e Exame a partir de seu valor de mercado e de receita em dólar no ano de 2018, assim como a movimentação de suas ações e das respectivas carteiras de mercado no período de 02 de janeiro de 2015 e 31 de março de 2021. Inicialmente foi efetuada uma regressão simples considerando um fator sistêmico, através da métrica do CAPM. Posteriormente, foram acrescidos outros fatores (taxa do dólar e preço do barril de petróleo tipo *Brent* e *WTI*) com vistas a eventual melhoria do modelo, utilizando-se a métrica multifatorial – APT. Como forma de identificar os impactos da Covid-19, os períodos foram segregados em integral, *ex-ante* e *ex-post.* Neste formato, o período *ex-post* apresentou resultados "não esperados", o que levou a pesquisa a segregá-lo em trimestres.

Resultados: Os resultados obtidos em todos as análises confirmaram, embora parcialmente, que o alto poder de explicação (superior a 50%) da variabilidade do retorno das ações ordinárias da Petrobras pela variabilidade do retorno da carteira de mercado do Ibovespa (B3), ocorre em outros mercados. A pesquisa observou que o Coeficiente de Explicação tende a captar de forma mais significativa os efeitos de crises que advêm de contextos econômicos locais e impactos para a economia mundial, a exemplo de eventual redução no nível do produto interno bruto de países como os Estados Unidos ou a China. Já para evento inesperado, a exemplo da Covid-19, o modelo, em princípio, não apresentou igual resultado, o que pôde ser observado nas análises trimestrais.

Contribuições do Estudo: A pesquisa contribui nas tarefas de gestores e investidores, ao demonstrar as similaridades que preveem eventos futuros relacionados à cotação do mercado acionário e que, por consequência, auxiliam em tomadas de decisões dos *stakeholders*.

Palavras-chave: APT. Bolsa de Valores. CAPM. Covid-19. Petrobras.

1 Introduction

The fuel sector holds a privileged position for the movement of the level of economic activity of the countries and among them. In this context, Klare (2008) mentions that the economic growth of a country necessarily has oil as an important resource for its development. He even points out that the functioning and the development of the global economy depend on this energy source, which can be observed in the factories, in the Transportation of people, goods and products, in agricultural production, in airplanes, trains and in whatever means use oil derivatives.

Data from 2014, from the World Trade Organization (WTO), in their publication of World Trade Statistics, show that the main sellers of merchandise in 2013 were China, the United States, Germany, Japan, France and the Netherlands, which represent Around 24% of the commercial services of the world. Oi is the main energy source applied for the trade of goods of the top 10 exporting countries, accountable for 50% of global commerce.

Companies that act in this sector, many times, have State participation and in other times are exclusively private. Petrobras is a semi-public (mixed economy) Corporation which acts in the exploration, production, refinement, transportation and commercialization of oil and natural gas. Its revenue is generated, mainly, from the sale of fuels for all segments of the economy. In this aspect, the oscillation of fuel sales may reflect in the return of the stocks of the oil company.

Studies carried out by Harris and Ohlson (1987), Barry, Hasan and O'Bryan (1997) and Domingues (2016) seek to explain the behavior of oil companies stock prices from the market. A similar result is found in an article published by Silva and Santos (2019), which highlights the importance of Net Equity and Net Profit for the capital market, demonstrated from the statistically relevant relation with the oil companies' market.

Similarly to the Brazilian oil company, international competing companies of the oil and gas sector perform a relevant role in the economic activity of their countries of origin, and, eventually, are also affected by systemic factors, related to the situation in the local and external economic scenario.

Based on this assumption, it was considered opportune to carry out this research, which seeks to answer whether the occurrence of a statistically significant relationship between the return on ordinary shares of a local reference company in the oil sector and the return on the local market portfolio in other countries would be similar to the Brazilian scenario, whose analyzes carried out over five years (2015 to 2019) found a significant contribution of explanatory power exceeding, on average, 50% for Petrobras.

This research selected the five largest oil companies with State shareholding, and two largest American oil companies based on their market value and revenue in dollars in 2018, as shown in Table 3. As it is supported by the use of only one independent variable (market portfolio), the simple linear regression methodology was used, supported by specific assumptions of the Capital Asset Pricing Model known by the acronym CAPM.

Studies on asset pricing have always gained the interest of researchers and investors, Markowitz (1952) being the pioneer on the analysis of assets risk and return evaluation. His model was later Enhanced by Sharpe (1964), Lintner (1965) and Mossin (1966), by replacing the variances of the original model by known indexes. Over time, other models came along, amongst which Fama and French (1992, 2015) three- and five-factor models can be pointed out.

According to the CAPM, the return variability of the object stock is broadly explained by the market portfolio's return variability.

This research considered the time frame between January 2015 and March 2021 as an integral period. Taking into consideration the relevant fact of Covid-19, which strongly impacted the economic activities of the countries, the integral period was segregated in *ex-ante* and *ex-post* SARS-CoV-2. The first period extends until December 2019 and the second period starts in January 2020. Curiously, the results of the *ex*-post period presented themselves, mainly, superior to the results of the *ex-ante* and integral periods, which led to a partial quarterly opening of the *ex*-post period and to a partial quarterly opening of the *ex-ante* period, which considered only the last trimester of 2019.

Another aspect that motivated the quarterly opening of the *ex*-post period was the release by China to the WHO (World Health Organization), on the mysterious Wuhan pneumonia, on December 31st, 2019 (Reuters, 12/31/2019) and, later on, the definition of a pandemic adopted by this Organization on March 11th 2020, in Geneva, through a statement of the then-General-Director Tedros Adhanom, a moment from which all countries started adopting sanitary and restrictive measures.

With the quarterly opening of the results, it can be observed that the explanatory coefficient of the relationship between portfolio returns is, for most of the oil companies analyzed, much higher in the first quarter of 2020 when compared to the last quarter of 2019, which does not occur in the second quarter, after the impact of Covid-19.

Additionally, this research assessed whether the inclusion of other factors in the model would result in an eventual improvement in its explanatory power.

2 Theoretical Foundation

When analyzing the continuous movements of the market and the stock market, as well as its participants, some aspects must be considered, including market efficiency, risk, return and beta.

2.1 Market Efficiency

The modern theory of finance introduced, as one of its main concepts of market efficiency, the study by Fama and Malkiel (1970). They define markets as efficient when asset prices entirely reflect all relevant information as it occurs. This does not imply predictability of the market, but rather an immediate reflection in asset prices.

According to Fama and Malkiel (1970), The assumptions of an efficient market, regarding its participants, are that all of them have either: equal technical knowledge to evaluate stocks; access to all available information about companies; homogeneous expectations regarding the market; and simultaneously track the securities market in a way that they react in the same manner to new information. Fama and Malkiel (1970) also classify market efficiency as weak, semi strong and strong forms.

In a weak form efficiency market, the prices of the assets reflect historical information that is already available to investors, making it impossible to predict future returns. In the semi-strong form, asset prices reflect both historical and current information, which is available to all investors, therefore preventing extraordinary gains. For a strong form efficiency market, asset prices reflect all information, public or not, and even if any investors obtain privileged or strategic information, those would already be priced in the assets, a condition in which it would be impossible for any investor to obtain extraordinary gains.

Thus, it can be affirmed that the market is efficient towards information, since that an investor cannot obtain consistently above-average returns (with a determined level of risk), considering the information publicly available When the investment is made.

2.2 Risk

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Damodaran (2004) mentions that the risk can be understood as the probability of receiving something unexpected as a return on a determined investment, thus, risk does not only include poor results. Independently from the asset pricing model, the adopted premise is to evaluate the relation between risk and return.

2.3 Return

As a third aspect, one can mention the return. According to Ross et al. (2015), it can be considered as the expectation regarding a stock for the next period. Market return is represented by all traded stocks included in a portfolio. Therefore, the return of the market portfolio is equivalent to the compensation for the capital invested by the shareholder, whose value must account for the time of return and the risk relative to the invested amount.

2.4 Beta

Lastly, beta (β), according to Ross et al. (2015), is a measure of a security's response to movements in the market portfolio. Santos (2019) describes beta (β) as a statistical measure of stock price volatility in relation to the benchmark market portfolio - such as Bovespa, Dow Jones, Standard and Poor's 500 (S&P500), among others. According to the author, systematic risk is not eliminated through portfolio diversification. Therefore, the more sensitive the security is to the market portfolio, the higher the investment risk.

Santos (2019), still, mentions that, when evaluating the companies with stocks negotiated in the stock market, the stock's beta is calculated by regressing its returns (daily, weekly, monthly, annual, or other) in relation to the market index selected during previous years from the base date of the evaluation (three to five years prior is recommended). Thus, this relation can be expressed through a Linear Regression equation:

$$y = a + bx + \varepsilon$$

Where:
y = required rate of return on investment.
a = intercept = risk-free rate.
b = slope coefficient or β of the asset.
x = independent variable or required return on market portfolio
ε = random error term reflecting non-systematic risks of the asset.

In Figure 1, a Graphic representation of the relation between the asset return and the market portfolio return is presented:

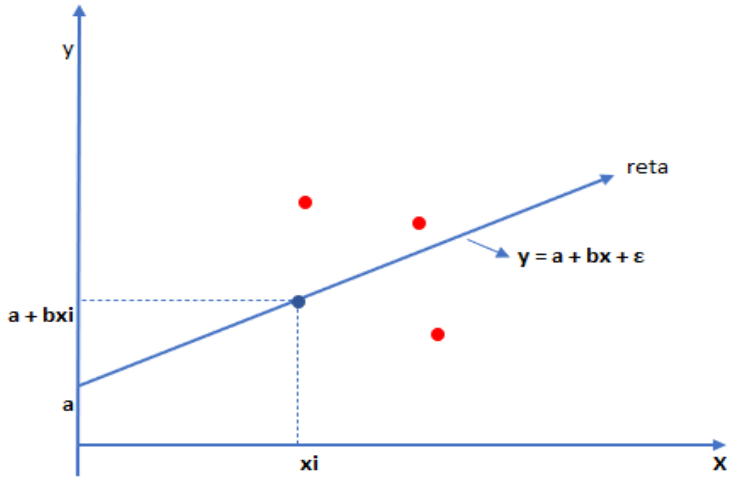

Figure 1 *Graphical Representation of the Linear Equation*.
Source: *Adapted from the author*[1] *of the book "Financial Administration" (Ross et al., 2015, p. 391).*

Ross *et al.* (2015) affirm that the average beta (β) of all securities, when pondered by the proportion of the market value of every security in the market portfolio, is 1. The beta (β) equation, proposed by Ross *et al.* (2015), is:

$$\boldsymbol{\beta i} = \text{Cov}(R_i, R_M) / \sigma 2(R_M)$$

Where:
β_i = beta of asset i.
$\text{Cov}(R_i, R_M)$ = covariance between the returns of asset i and the market portfolio.
$\sigma 2(R_M)$ = market variance.

2.5 CAPM Fundamentals and Assumptions

The model globally know by CAPM (*Capital Asset Pricing Model*), is a one-factor model that explains the behavior of a return on investment considering, exclusively, the return on market portfolio. For Santos (2019), the CAPM offers the opportunity to know the return rate required by the company's owners, thus, the cost of equity. From the works of Markowitz (1952) and Tobin (1958), Sharpe (1964) developed the CAPM model.

The CAPM model is based on the following fundamental assumptions: a) a single investor, by themselves, cannot influence prices; b) the market consists of rational investors who seek to maximize returns given a certain level of risk, or minimize risk given a certain level of return; c) every investor has access to information freely and instantaneously; d) there is no capital rationing, and everyone has access to credit sources; e) assets are traded without transaction costs; f) all investors have homogeneous expectations; g) investors can borrow or lend unlimited amounts of capital at a risk-free rate. Another aspect to consider when evaluating risk is whether it is systematic or non-systematic.

Ross *et al.* (2015) describe a systematic risk as any risk that influences a large number of assets, to a higher or lower level. A non-systematic risk, however, is that which affects a single asset or a small group of assets. From these considerations, it is possible to affirm that a diversified investor should worry about systematic risk and use beta, which is the best risk measurement of an individual asset.

[1] The error terms "ε" are expressed in the dots outside of the line.

The CAPM studies the systematic risk (non-diversifiable) and calculates the minimum return expected by shareholders on their own equity invested in the business. Therefore, the asset pricing model presents the following equation:

$$\mathbf{R_e} = \{R_F + [\beta(R_M - R_F)]\}$$

Where:

R_e = expected return of a security

R_F = Risk-Free Rate (Intercept)

B = beta of the security (measures a security's response to movements in the market portfolio)

R_M = Market Return Rate

$(R_M - R_F)$ = difference between the expected return of the market and the risk-free rate (risk premium)

The Risk-Free rate (R_F) is the one that offers the investor the assurance of knowing, exactly, what he will receive at the end of the investment period (ex.: SELIC). Therefore, it represents the minimum return value for the investment made. Beta coefficient (β) is a statistical measure of stock price volatility in relation to the benchmark market portfolio, representing systematic risk. In this regard, the higher the index, the greater the investment risk. Gitman (2010) provides a facilitator for understanding beta (β) in Table 1:

Table 1

Understanding beta (β)

B	**Comment: Moves in the same direction as the market (positive beta)**
2,0	The sensitivity in the return of the stock is twice as high as that of the market
1,0	The sensitivity in the return of the stock is equal to that of the market
0,5	The sensitivity in the return of the stock is half that of the market
B	**Comment: Moves in the opposite direction of the market (negative beta)**
- 0,5	The sensitivity in the return of the stock is half that of the market
- 1,0	The sensitivity in the return of the stock is equal to that of the market
- 2,0	The sensitivity in the return of the stock is twice as high as that of the market
B	**Comment: There is no movement**
0	There are no changes in the stock returns. It is not affected by market fluctuations.

Source: *Adapted from the table "Selected Beta Coefficients and Their Interpretation" (Gitman, 2010, p. 224).*

The premium on risk ($R_M - R_F$), however, is the difference between the average return rate generated by a reference portfolio and the risk-free rate (R_F). Therefore, it represents the return that the investment generates beyond the minimum return required by the shareholder. Despite the favorable aspects of the CAPM, the model is based on simplifications, which lead to criticisms regarding its ability to accurately reflect the actual performance of the market.

Due to these aspects, it is emphasized that several authors have intensified their studies in order to empirically test the CAPM model presented by Sharpe. Among them, Black, Jensen, and Scholes (1972) and Fama and Macbeth (1973) found evidence that validated it. However, other studies concluded that the CAPM might be deficient, especially after the emergence of evidence that a significant portion of the variation in expected asset returns was not related to the market beta factor (Fama & French, 2004). Among these studies, some identified inefficiencies in the model, leading researchers to conclude that there are other risk factors not captured by beta. Notable among them are Lakonishok and Shapiro (1986) and Fama and French (1992).

In an attempt to improve the explanatory power of the CAPM in capturing market anomalies, Fama and French (1993) developed the three-factor model. According to the authors, the model could significantly explain stock returns by considering three factors: the market, as defined by the CAPM; the company's size, defined by the difference between the returns of portfolios of small and large companies (size factor = SMB => small minus big); and the book-to-market ratio or B/M, defined by the relationship between the book value and the market value of equity. The study by Fama and French (1996; 2004) explained most of the anomalies not accounted for by the market factor, except for the one defined as the momentum effect.

Among the studies and the corresponding identification of the momentum factor risk, the work of Carhart (1997) stands out. By adding it to the three-factor model of Fama and French (1993), he constructed the well-known four-factor model. Carhart's studies (1997) identified empirical evidence that confirmed the superiority of the four-factor model over the three-factor model in explaining returns. Interestingly, the model developed by Sharpe (1964) is widely used by market analysts to evaluate.

2.6 APT Fundamentals and Assumptions.

The APT (*Arbitrage Pricing Theory*) model, developed by Stephen Ross in 1976, sought to explain the return of assets considering that there are several risk sources associated to the return of stocks, not limited to the market factor. Santos and Silva (2009) define arbitrage as the exploration of poor pricing among two or more assets to gain economic profit free of risk. In another way, Bruni and Fama (1998) explain that arbitrage consists in finding two elements equal in their essence, buying the cheaper one and selling the more expensive one, obtaining risk-free return.

Systematic and non-systematic risks, as in the CAPM model, are also addressed in the APT by the inclusion of other factors (beta) that affect a security or an investment portfolio.

The premises of the APT are: the market is perfectly competitive and there are no transaction costs; investors have homogeneous expectations regarding the factors that influence asset prices; the number of assets "n" must be much greater than the number of factors influencing their prices; the uncertainty term represents the unsystematic risk of the asset; the uncertainty terms are independent of the factors and each other. The proposal presented by Ross et al. (2015) for calculating systemic risk through beta is expressed by the following formula:

$$\mathbf{R} = \mathrm{Re} + \mathrm{I}$$

Where:

R = observed return
Re = expected return
I = corresponds to the unexpected part of the return (it is the surprise and constitutes the error)

It is possible to provide a more detailed breakdown of the formula by highlighting the components of systemic risk and non-systemic risk, as follows:

$$\mathbf{R} = \mathrm{Re} + m + \varepsilon$$

Where:
R = observed return

Re = expected return (formed with all available information and knowledge of what can influence the stock)
m = represents systemic risk
ε = represents non-systemic risk

According to Ross et al. (2015), the fact that the non-systematic portions of returns for two companies are unrelated to each other does not imply that the systematic portions are also unrelated. On the contrary, if two companies are influenced by the same market risks, they tend to exhibit relatively similar behavior in terms of the variability of their securities' returns.

An example of systematic risk is inflation, which affects all companies in the market and can impact their stocks either positively or negatively. It will be positive if the stock moves in the same direction as inflation and negative if the stock behaves inversely to inflation. There is also the rare and remote situation where an increase or decrease in inflation has no effects on the stock. In this case, the systematic risk would be null.

Therefore, inflation can be considered as one of the examples of external factors (market risk) that affect the company's operations and also the beta coefficient (β) which indicates the sensitivity of the stock's return to systemic risk. In the APT, the return of an asset stems from various economic and financial factors, such as Gross National Product (GNP) growth, inflation rate (i), interest rate (IR), among other factors. Thus, the combination of the risks mentioned earlier can be expressed by:

If $= \mathbf{R} = Re + I$

Then $= \mathbf{R} = Re + m + \varepsilon$

Therefore $= \mathbf{R} = Re + \beta iFi + \beta_{GNP}F_{GNP} + \beta_{IR}F_{IR} + \varepsilon$

Where:
R = observed return
Re = expected return (formed with all available information and knowledge of what can influence the stock)
β_i = stock beta
F_i = inflation factor
β_{GNP} = gross national product beta
F_{GNP} = gross national product factor
β_{IR} = interest rate beta
F_{IR} = interest rate factor
ε = factors not included in the model

Based on the combination above, it can be stated that in the APT model, the expected return of risky assets results from a linear combination of "k" factors, without specifying how many factors will influence the process of forming the intrinsic prices of assets (Santos & Silva, 2009). In this way, a "k" factors model can be expressed as follows:

$$\mathbf{R} = Re + \beta_1F_1 + \beta_2F_2 + \beta_3F_3 + \ldots\ldots \beta_kF_k + \varepsilon$$

This is a factorial model, as each "F" represents a systemic event that is related to the behavior of the asset's return. On the other hand, "ε" is associated with the unsystematic risk of a specific stock and is not related to the risk of other stocks. When various factors are replaced

by just one market factor that has coverage and relevance, such as the S&P 500, Ibovespa, or another index to measure market returns, the model is referred to as the "market model".

$$\mathbf{R} = Re + \beta(R_M - Re) + \varepsilon$$

Where:

R = observed return
Re = expected return (formed with all available information and knowledge of what can influence the stock)
β = market coefficient
R_M = investment portfolio return
Re = expected return
$(R_M - Re)$ = difference between the return of the investment portfolio and the expected return
ε = factors not included in the model

Ross (1976) does not specify which or how many factors should be used. It is up to each researcher to select systemic events that, in practice, have a significant relationship with price behavior.

The sensitivities to the factors are represented by each of the beta coefficients (βn) associated with each selected systemic event. One of the contributions of the APT model is to allow the inclusion of new variables into the model, aiming to increase the explanatory power of stock return behavior.

3 Methodology

This research considered the major global oil companies, both with state participation and publicly traded, as well as the movement of their stocks and their respective market portfolios during the period from January 2, 2015, to March 31, 2021.

Initially, a simple regression was performed considering one factor using the CAPM metric. Subsequently, additional factors were added (dollar exchange rate and Brent and WTI crude oil prices), aiming to potentially improve the model using the multi-factor metric - APT.

To identify the impacts of Covid-19, the periods were separated into integral, *ex-ante,* and x-*post.* In this format, the *ex-post* period presented "unexpected" results, which led the research to separate it into quarters.

The oil companies were selected based on their market value and revenue in dollars in the year 2018, according to Forbes, Fortune (USA), and Exame (BR) magazines, as presented in Table 2, except for Sinopec and Gazprom, whose market values were not listed in the researched sources.

Table 2
Main oil companies of the world according to Forbes, Fortune e Exame

Main Oil Companies (Forbes - 2018)	Country of Origin	Market Value – US$ (Exame)	Revenue – US$ (2018)
Sinopec	China	Not listed	420,38 billion
Petrochina	China	141,8 billion	342,21 billion
Exxon Mobil	USA	345,98 billion	279,33 billion
Total AS	France	157,57 billion	209,36 billion
Chevron	USA	246,16 billion	158,90 billion

Gazprom	Russia	Not listed	113,38 billion
Petrobras	Brazil	100,90 billion	95,58 billion

Source: *Information extracted from Forbes, Fortune e Exame.*

Among the selected foreign oil companies, five have state participation in their share capital, similar to Petrobras' ownership structure. There are also two American companies, which differ from this criterion (state ownership), selected for their relevance in the oil market.

The type of ownership structure of these companies is displayed in Table 3:

Table 3

Type of ownership of oil companies

Company	**Country**	**Type of Ownership**	
Petrobras	**Brazil**	**Mixed Economy**	**a**
Sinopec	China	Mixed Economy	a
Petrochina	China	Mixed Economy	a
Exxon	USA	Public Limited Company	a
Chevron	USA	Public Limited Company	a
Total	France	Mixed Economy	b
Gazprom	Russia	Mixed Economy	b

Source: *Sites (a) Yahoo Finance and (b) respective companies.*

The historical data of the theoretical market portfolio and the portfolio of oil companies were based on the headquarter country of the respective company, regardless of whether they were traded in other markets. Common stocks were considered for evaluating the results.

The stock exchanges, or market portfolios, and the respective index names are listed in Table 4:

Table4

Main stock exchanges observed and respective indexes of theoretical portfolios.

Exchange	**Country**	**Index Description – Theoretical Portfolio**	**Name**
Hong Kong	China	Hang Seng Index	^HSI
New York	EUA	Dow Jones Industrial Average	^DJI
Paris	France	CAC40	^FCHI
Moscow	Russia	MOEX Russia Index	IMOEX.ME
B3	Brazil	Ibovespa	^BVSP

Source: *Research Data.*

The analyzed period covered the last six years and was divided into *ex-ante* and *ex-post* due to the significant event of Covid-19:

- Integral Period: From January/2015 to March/2021.
- *ex-ante* Period: From January/2015 to December/2019.
- *ex-post* Period: From January/2020 to March/2021.

4 Results and Discussion

Since it is a single-factor model (market risk), the CAPM was used to analyze the historical data of oil companies and measure the results of the research periods through tests conducted by the simple linear regression method. The selection of initial data was made based

on the following stock exchanges, according to the oil company and the theoretical market portfolio of the exchange relative to the home country. Table 5 includes the stock exchanges, the data, and the nomenclature of the mentioned stocks and market portfolios, among other described information.

Table 5
Oil company, exchange, and market portfolios

Company	Origin	Exchange	Stock	Mkt Portfolio
Petrobras	**Brazil**	**São Paulo**	**PETR3**	**^BVSP**
Sinopec	China	Hong Kong	0388.HK	^HSI
Petrochina	China	Hong Kong	0857.HK	^HSI
Exxon Mobil	USA	New York	XOM	^DJI
Chevron	USA	New York	CVX	^DJI
Total S. A.	France	Paris	FP.PA	^FCHI
Gazprom	Russia	Moscow	MCX	IMOEX

Source: *Research Data*

For all analyzed periods, it was identified that maintaining the model was appropriate for analysis through linear regression, as the p-value was found to be lower than the 5% significance level in all calculations. Similarly, the resulting model shows a positive relationship between the return of the market portfolio and the return of the oil companies' stocks.

Based on the observation of the beta (β) interpretation table, the positive sign in the equation indicates that theoretically, in all analyzed scenarios, the stock portfolio tracks the market fluctuations and is either more (> 1) or less (< 1) sensitive to these fluctuations.

The research demonstrated that there is partial similarity to the Brazilian scenario, as the Adjusted Coefficient of Determination (R2) for the oil companies, in part, exceeds the explanatory index of 50%. Table 6 presents the results for the Integral Period.

Table 6
Linear regression Results – integral period

Company	Integral Period	*P-value*	Adjusted R^2	Number of Observations
Petrobras	**y = 0,00009 + 1,5466x**	**0,0**	**62,2%**	**1.551**
Sinopec	y = - 0,000001 + 1,1284x	5,05E-100	25,3%	1.542
Petrochina	y = -0,0007 + 1,1198x	7,34E-202	44,9%	1.542
Exxon	y = -0,0006 + 1,0331x	9,62E-235	49,4%	1.572
Chevron	y = -0,0004 + 1,2147x	8,57E-264	53,5%	1.572
Total	y = -0,0002 + 1,1385x	0,0	61,8%	1.598
Gazprom	y = -0,0001 + 1,0767x	1,32E-276	55,3%	1.568

Source: *Research Data*

Additionally, the data was adjusted for the *ex-ante* and *ex-post* periods, with the goal of investigating its impact in the economic activity of various countries and whether it, in any way, significantly affected the returns of the portfolios. Initially, the data and analyses for the *ex-ante* period are shown in Table 7.

Table 7
Linear regression Results – ex-ante period

Company	*Ex-ante period*	*P-value*	Adjusted R^2	Δ R^2 in relation to the Integral Period	Number of Observations
Petrobras	**y = 0,0002 + 1,6650x**	**3,78E-226**	**56,4%**	**- 5,8%**	**1243**

Sinopec	y = 0,0001 + 1,2247x	4,30E-80	25,3%	0,0%	1233
Petrochina	y = -0,0007 + 1,1056x	3,60E-171	46,8%	+ 1,9%	1233
Exxon	y = -0,0005 + 0,9271x	3,40E-154	42,7%	- 6,7%	1258
Chevron	y = -0,0003 + 1,0082x	1,81E-133	38,2%	- 15,3%	1258
Total	y = -0,0001 + 0,9974x	3,77E-240	57,6%	- 4,2%	1278
Gazprom	y = -0,00003 + 1,1765x	1,52E-214	54,1%	- 1,2%	1258

Source: *Research Data*

By separating the *ex*-ante period, a reduction in the power of explication of the model (adjusted R^2) can be observed. These reductions are related to the high supplies of oil in the United States, with the commercial war between the United States and China and the deceleration of the main global economies in the analyzed period. These factors contributed to the decrease in revenue for some of the researched oil companies, as the barrel price fell in the period. Brazil, in particular, experienced internal issues of political and economic nature influenced by the mentioned systemic events.

In Table 8, the analyses of the results of the *ex-post* period suggest that the Adjusted Explanation Coefficient partially captured the impact of the adverse economic scenario (Covid-19) on the level of activities, revenue, and operational profitability of companies, especially those that have cyclic activities that are very sensitive to the occurrence of systemic adverse events, such as oil companies.

Table 8
Linear regression results – ex-post period

Company	*Ex-post* period	*P-value*	Adjusted R^2	Δ R^2 in relation to the Integral Period	Number of Observations
Petrobras	**y = -0,0004 + 1,4558x**	**5,21E-92**	**74,1%**	**+ 11,9%**	**308**
Sinopec	y = -0,0006 + 0,9066x	8,53E-24	27,9%	+ 2,6%	309
Petrochina	y = -0,0009 + 1,1525x	1,52E-37	41,2%	- 3,7%	309
Exxon	y = -0,0010 + 1,1027x	2,11E-54	53,7%	+ 4,3%	314
Chevron	y = -0,0007 + 1,3500x	1,58E-72	64,6%	+ 11,1%	314
Total	y = -0,0005 + 1,3211x	3,47E-80	67,7%	+ 5,9%	320
Gazprom	y = -0,0008 + 0,9186x	2,91E-67	62,2%	+ 6,9%	310

Source: *Research Data.*

As a result, it is observed that the *ex-post* period showed a reversal in the explanatory power of the model (Adjusted R-squared), with a significant increase for Petrobras, of about 12.0%, and for Chevron, approximately 11.1%.

The model presented in the *ex-post* partially captured the relation between the variability of the returns, which led this research to a quarterly analysis of the referred period, being the final quarter of 2019 and the first two quarters of 2020. In this interval, a notable moment is the period between the communication sent by China to the World Health Organization (WHO) regarding the mysterious pneumonia in Wuhan on December 31, 2019, and its actual recognition as a pandemic by the WHO on March 11, 2020.

Upon observing Table 9, one can note a fluctuation in the explanatory power of the model in relation to the *ex-ante* period. However, it is not possible to make accurate comparisons, as the fourth quarter of 2019 is included in this period.

Table 9
Quarterly results – October to December 2019

Company	*Ex-post* Period	*P-value*	Adjusted R^2	Number of Observations

Petrobras	**y = -0,0008 + 1,3111x**	**1,52E-09**	**45,5%**	**61**
Sinopec	y = -0,0006 + 0,9427x	1,42E-06	31,2%	62
Petrochina	y = -0,0016 + 0,9143x	5,45E-10	46,8%	62
Exxon	y = -0,0013 + 1,2455x	5,12E-07	32,6%	64
Chevron	y = -0,0007 + 1,0694x	2,74E-06	28,9%	64
Total	y = -0,0004 + 1,0058x	2,61E-15	62,6%	65
Gazprom	y = -0,0003 + 1,4691x	5,34E-13	56,4%	64

Source: *Research Data.*

Table 10 presents the model obtained in the linear regression equation for the first quarter of 2020.

Table 10
Quarterly results – January to March 202

Company	*Ex-post* Period	*P-value*	Adjusted R^2 First Quarter	Comparing to the R^2 of the 4th Quarter 2019	Number of Observations
Petrobras	**y = -0,0007 + 1,4835x**	**1,54E-26**	**84,9%**	**+ 39,4%**	**62**
Sinopec	y = -0,0002 + 0,9685x	2,95E-08	39,3%	+ 8,1%	62
Petrochina	y = -0,0009 + 1,4008x	3,04E-17	69,3%	+ 22,5%	62
Exxon	y = -0,0056 + 0,9518x	1,95E-21	77,7%	+ 45,1%	62
Chevron	y = -0,0017 + 1,3242x	1,13E-18	72,5%	+ 43,6%	62
Total	y = 0,0020 + 1,3936x	2,15E-21	76,5%	+ 13,9%	64
Gazprom	y = -0,0030 + 0,8275x	3,66E-19	74,7%	+ 18,3%	60

Source: *Research Data.*

In this period, there is a significant increase in the explanatory power of the adjusted R^2 when compared to the fourth quarter of 2019. The improvement in returns, as shown in Table 10 and presented in the linear regression equation, is due to the improvement in the economy in Brazil and globally, which had not yet fully experienced the magnitude of the imminent crisis.

In Brazil, unemployment rates were on the decline, as indicated by the "Leading Employment Indicator" and the "Coincident Employment Indicator" from FGV (Getulio Vargas Foundation). In terms of the international economy, the signing of the first phase of the trade agreement between the United States and China initially brought a sense of stabilization and reduced risks, leading to a relative recovery of the global economy.

Table 11 shows the results for the second quarter of 2020, which contradicts the findings of better adherence precision of the stock return with the market portfolio return in a scenario of significant decline in economic activity level. A reduction in the predominance of the Explanation Coefficient was observed in the second quarter of 2020.

Table 11
Quarterly results – April to June 2020

Company	*Ex-post* Period	*P-value*	Adjusted R^2 First Quarter	Comparing to the R^2 of the 1st Quarter 2019	Number of Observations
Petrobras	**y = 0,0028 + 1,1644x**	**4,16E-13**	**58,6%**	**- 26,3%**	**61**
Sinopec	y = -0,0009 + 1,0171x	1,66E-08	41,5%	+ 2,2%	60
Petrochina	y = -0,0022 + 1,3693x	2,37E-11	53,2%	- 16,1%	60
Exxon	y = -0,0005 + 1,3198x	5,98E-14	59,9%	- 17,8%	63
Chevron	y = 0,0001 + 1,3224x	2,31E-17	69,0%	- 3,5%	63
Total	y = -0,0027 + 1,1796x	8,39E-16	65,7%	- 10,8%	62

Gazprom	y = -0,0003 + 0,9605x	3,11E-17	69,9%	- 4,8%	61

Source: *Research Data.*

When comparing with the first quarter of 2020, there is a noticeable reduction in the explanation coefficient for Petrobras (-26.3%). This occurred due to the restrictive measures adopted by Brazil and other countries in the fight against the pandemic, which significantly affected economic activity and reduced the consumption of various products and services, including fuel for trucks, aircraft, vehicles, and others.

The reduction in economic activity, with a sharp drop in revenue for oil companies, statistically significantly affects the relationship between the market portfolio return and the stock portfolio return, demonstrated by the decrease in the explanatory power of the model (Adjusted R^2).

To provide a more adequate dimension of the explanatory power of the variability of portfolio returns, it was decided to include three independent variables that intuitively have a relevant relationship with the operational and financial performance of oil sector companies. Thus, the model became multifactorial, operationalized by the methodology of multiple linear regression. The period covered is from January 2010 to March 2021 for the Brazilian company Petrobras and for the American company Exxon.

The factors included were: Brent Crude Oil Price (FOB - IEA) - relevant in the composition of the company's revenue and costs, considering Petrobras' import and export of products (BR); West Texas Intermediate (WTI) Crude Oil Price (FOB - IEA) - relevant in the composition of the company's revenue and costs, considering Exxon's import and export of products (USA); commercial exchange rate for purchasing – Brazilian Real (R$) / US Dollar (US$ - average) - relevant in relation to Petrobras' foreign currency operations.

The extension of the analyzed period and an additional number of about 80.0% of observations (from 1550 to 2787) did not bring statistically significant improvements to the explanatory power of Petrobras' model, as can be observed in the results of the Adjusted R-squared, p-value, and linear regression equation described in Table 12:

Table 12
Results of multifactorial analysis – January 2010 to March 2021

Petrobras	**PETR3 x B3**	**PETR3 x B3 x Brent**	**PETR3 x B3 x Brent x US$**
Model	y = -0,0002 + 1,4515$\mathbf{x_1}$	y = -0,0002 + 1,4239$\mathbf{x_1}$ + 0,0757$\mathbf{x_2}$	y = -0,0002 + 1,4210$\mathbf{x_1}$ + 0,0757$\mathbf{x_2}$ - 0,0139$\mathbf{x_3}$
p-value (B3)	0,00%	0,00%	0,00%
p-value (Brent)	- x -	2,7062E-09	2,800E-09
p-value (US$)	- x -	- x -	0,7438
R^2 - Adjusted	59,1%	59,6%	59,6%

Source: *Research Data.*
Obs.: $\mathbf{x_1}$ = Ibovespa – B3; $\mathbf{x_2}$ = Type Brent Oil Barrel Price and $\mathbf{x_3}$ = Average Dollar Rate.

When comparing the explanatory power of the model's coefficient regarding the relationship between portfolio returns for the Brazilian oil company, it is observed, with little effect, the inclusion of the Brent Crude Oil Price and the dollar exchange rate, with only a 0.5% increase. It is also noted that the dollar variable has a negative sign, which is retained in the model because Petrobras is a major importer of inputs.

The retention of the dollar variable in the model demonstrates that the return of the stock portfolio has an inverse behavior to the market portfolio. It is noticeable that even in different periods, there is little variation (3.1%) in the explanatory power of Petrobras' model coefficient when comparing the Adjusted R^2 of 62.2% for the full period from 2015 to 2021 with 1551 observations, and 59.1% for the period from 2010 to 2021 with 2787 observations.

A similar effect occurs with Exxon, which, even with an additional increase of about 80.0% in the number of observations (from 1572 to 2830), did not show statistically significant improvement in the explanatory power of the company's model coefficient, as shown in Table 13:

Table 13
Results of multifactorial analysis – January 2010 to March 2021

Exxon	XOM x ^DJI	XOM x ^DJI x WTI
Modelo	y = -0,0004 + 1,02662$\mathbf{x_1}$	y = -0,0004 + 1,0200$\mathbf{x_1}$ + 0,0146$\mathbf{x_2}$
p-value (^DJI)	0,00%	0,00%
p-value (WTI)	- x -	7,495E-05
R^2 – Adjusted	53,5%	53,7%

Source: *Research Data.*
Obs.: $\mathbf{x_1}$ = ^DJI – Dow Jones e $\mathbf{x_2}$ = WTI Type Oil Barrel Price

Table 13 shows a variation in explanatory power of only 0.2%, thus no effect after the inclusion of the WTI Crude Oil Price. It is noticeable that there is little variation in the explanatory power of Exxon's model coefficient when comparing the Adjusted R-squared of 49.4% for the period from 2015 to 2021 with 1572 observations, and 53.5% for the period from 2010 to 2021 with 2830 observations.

5 Final Considerations

This research aimed to investigate whether the specificity of the high explanatory power of the variability of Petrobras' common stock returns by the variability of the Ibovespa (B3) market portfolio follows a similar pattern to oil companies in other countries. This is because the analysis of the Brazilian scenario shows a market portfolio return explanation level above 50%.

In this context, due to the variable in question being the market, we initially opted for the CAPM. This single-factor model explains the behavior of the variability of the target stock's return by the variability of the market portfolio return and is represented through a linear regression line equation. The model proved to be suitable for the analysis of oil companies, as it partially captures the impact of representative variables of systemic risks on the return of the selected companies' stock portfolio.

The model exhibited a p-value below five in all scenarios analyzed, ensuring its adequate maintenance and statistical significance. The Adjusted Explanatory Coefficient (R^2) demonstrates, in a statistically significant manner, that the relationship between the returns of the portfolios for the analyzed oil companies occurs partially similarly to the Brazilian scenario. This is because not all companies showed results exceeding the 50% threshold highlighted as the main objective of this research.

The analyses were initially conducted over three periods. The first period considered the range from January 2015 to March 2021 (integral), the second from January 2015 to December 2019 (*ex-ante*), and the third from January 2020 to March 2021 (*ex-post*).

The *ex-ante* period yielded results that reflected a reduction in global economic activity, primarily influenced by the trade war between the United States and China, market competition

through the reduction of prices for Brent crude oil between Russia and Saudi Arabia (OPEC), excess oil inventory due to increased production in the United States (WTI), among other factors.

As for the *ex-post* period, contrary to what might have been intuitively expected, the model showed higher coefficients of explanation (adjusted R^2) for a significant portion of the companies when compared to the ex-ante period. For a more detailed observation, it was necessary to divide the periods into quarters, including the last quarter of 2019 and the first two quarters of 2020. Therefore, the analysis of these relevant quarters was chosen due to the declaration of the Covid-19 pandemic by the World Health Organization (WHO) in March 2020.

The results obtained from the separation show that the relation between the returns of the market portfolio can alter significantly between periods, depending on the systemic risks in economic activity. This fact may be related, in principle, to the crisis generated by the unexpected factor Covid-19. In this sense, the model did not exhibit behavior similar to that of the crisis resulting from an adverse economic scenario, when the market already anticipates the impact of possible changes in the fundamentals of relevant economies, such as the American and the Chinese.

This change can be observed, for example, when analyzing the relationship between the market return of B3 and the return of Petrobras shares, which showed an adjusted R^2 of 45.5% in the 4th quarter of 2019, 84.9% and 58.6% in the first and second quarters of 2020, respectively. These numbers highlight the relevance of the Brazilian oil company and the impact of Covid-19 on the explanatory power of the model in the second quarter of 2020, which experienced a reduction of 26.3%. A similar trend is observed in the other analyzed oil companies, as most of them experienced a reduction in their explanatory coefficients (adjusted R^2).

This reduction resulted from the implementation of restrictive measures in an attempt to contain and eliminate the SARS-CoV-2 virus, which had a significant impact on the global economy by reducing people's mobility, decreasing the consumption of various products and services, and consequently increasing unemployment and affecting the revenue of oil companies. This is because both companies and individuals started consuming less fuel for production, circulation, and transportation.

Another example can be seen with the American company Exxon, which exhibited a similar trend to the Brazilian scenario, with an adjusted R^2 of 32.6% for the 4th quarter of 2019, followed by 77.7% and 59.9% for the first and second quarters of 2020, respectively, indicating a reduction of 17.8% in the second quarter of 2020. The dataset analyzed for all oil companies over the entire period consisted of more than 1,500 observations per company.

Considering the privileged position of the fuel sector in driving the level of economic activity in countries, the results of this research confirmed that the peculiarity of the Brazilian scenario, with a high level of explanation of the market portfolio return exceeding 50%, can also be observed in other countries. This similarity was even more evident in the first quarter of 2020, where it can be observed that the explanatory coefficient of the model (adjusted R2) exceeded 70% (Petrobras at 85%), except for the Chinese oil company Sinopec (39.3%), a country that was in the early stages of economic recovery to meet domestic demands.

Additionally, this research chose to assess the inclusion of other factors that intuitively could contribute to improving the explanatory power of the model, switching from a unifactorial model to a multifactorial model, using the concepts and techniques of the APT. The inclusion was done considering the oil companies Petrobras and Exxon. For Petrobras, the price of a barrel of Brent crude oil and the dollar exchange rate were included, while for the American

company, only the price of a barrel of WTI crude oil was considered. However, in both cases, there was no improvement in the explanatory power.

Thus, it can be concluded that the intuitive expectation that the high explanatory power of the variability of the return of Petrobras' common shares by the variability of the return of the Ibovespa market portfolio occurs similarly in oil companies from other countries.

Regardless of the scenario, there is a statistically significant relationship between the variability of the portfolio return and the variability of the stock return. This research observed that the explanatory coefficient tends to capture the effects of crises arising more significantly from local economic contexts and impacts on the global economy, as seen in potential reductions in the gross domestic product of countries like the United States or China. However, for unexpected events, such as Covid-19, the model, in principle, did not yield the same results, as observed in the quarterly analyses.

As recommendations for future research, to evaluate the predictive power of the model, this research suggests conducting studies in scenarios of crisis and economic growth separately, in order to assess the predictive power of the model and provide further insight into events that may strongly impact the global economy.

Finally, it is important to emphasize that this study should be considered as an initial analysis and the results cannot be taken as a standard for all oil companies worldwide. More comprehensive studies are necessary, including the incorporation of other explanatory factors into the model.

References

Berry, K.; Hasan, T., & O'Bryan, D. (1997). The value-relevance of reserve quantity disclosures conditioned on primary financial statement information. *Journal of Energy Finance & Development, 2, 249-260*.

Black, F.; Jensen, M., & Scholes, M. (1972) The capital asset pricing model: some empirical testes. In: Jensen, M. C. (Org.). *Studies in the Theory of Capital Markets*, New York: Praeger.

Bruni, A. L., & Fama, R. (1998). Eficiência, previsibilidade dos preços e anomalias em mercados de capitais: teoria e evidências. *Caderno de Pesquisas em Administração*, v. 1, n. 7, p. 71-85.

Carhart, M. M. (1997). On persistence in mutual fund performance. *Journal of Finance*, Chicago, American Finance Association, v. 52, n. 1, p.57-82.

Damodaran, A. (2004). *Finanças corporativas: teoria e prática*. 2a. ed. Porto Alegre: Bookman.

Domingues, J. C. A., Ribeiro, E. M. S. (2016). A relevância das informações contábeis e suplementares na avaliação de petrolíferas mundiais. *Revista Base (Administração e Contabilidade) da UNISINOS*, 13, 122-137.

Exame. (2018). *As 15 maiores do setor de petróleo do mundo; Petrobras está na lista.* Recuperado em https://exame.com/mercados/as-15-maiores-do-setor-de-petroleo-do-mundo-petrobras-esta-na-lista/.

Fama, E. F., & Malkiel, B. G. (1970). Efficient capital markets: A review of theory and empirical work. *The journal of Finance*, v. 25, n. 2, p. 383-417.

Fama, E. F., & Macbeth, J. D. (1973). Risk, return and equilibrium: empirical testes. *Journal of Political Economy*, Chicago, The University of Chicago Press, v. 81, n. 3, p. 607- 636.

Fama, E. F., & French, K. (1992). The cross-section of expected stock returns. *Journal of Finance*, Chicago, American Finance Association, v. 47, n. 2, p. 427-465.

Fama, E. F., & French, K. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, v. 33, n. 1, p. 3-56.

Fama, E. F., & French, K. (1996). Multifactor explanation of asset pricing anomalies. *Journal of Finance,* v. 56, n. 1, p. 55-84.

Fama, E. F., & French, K. (2004). The capital asset pricing model: theory and evidence. *Journal of Economic Perspectives,* v. 18, n. 3, p. 25-46.

Fama, E. F., & French, K. R. (2015). A five-factor asset pricing model. *Journal of Financial Economics,* v. 116, n. 1, p. 1-22.

Forbes (2019). *Petrobras é a 10a maior petroleira do mundo em 2018.* (2019). Recuperado em <https://forbes.com.br/negocios/2019/05/petrobras-e-a-10a-maior-petroleira-do-mundo-em-2018/>.

Fortune. (n.d). *Pesquisa por setor*. Recuperado em https://fortune.com/fortune500/2020/search/.

Gitman, L. (2010). *Princípios de Administração Financeira*. 10a. ed. São Paulo: Harbra.

Harris, T. S., Ohlson J. A. (1987). Accounting disclosures and the market's valuation of oil and gas properties. *The Accounting Review*. n. 4, p. 651-670. oct.

Klare, M. T. (2008). *Planeta sediento, recursos menguantes*: La Nueva Geopolítica de la Energía. Ediciones Urano. Barcelona.

Lakonishok, J., & Shapiro, A. (1986). C. Systematic risk, total risk and size as determinants of stock market returns. *Journal of Banking and Finance*, v. 10, n. 1, p. 115-132.

Lintner, J. (1965). The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. *Review of Economics and Statistics*, 47, 1, p. 13-37.

Markowitz, H. M. (1952). Portfolio Selection. *The Journal of Finance*, v. VII, n. 1, mar.

Mossin, J.(1966). Equilibrium in a capital asset market. *Econometrica*, 34, 4, p.768-783. 1966.

Organización Mundial del Comercio (OMC). Estadísticas: Estadísticas del Comercio Internacional, 2014. *El comercio y las cadenas de valor mundiales*. Recuperado em <https://www.wto.org/spanish/res_s/statis_s/its2014_s/its14_trade_value_s.htm>.

Reuters (31/12/2019). *Como se desenrolou a pandemia global de coronavirus*. Compilado por Tiffany Wu e Leela de Kretser; Edição de Daniel Wallis em set., 2020. Recuperado em <https://www.reuters.com/article/health-coronavirus-timeline-idINKBN26K09Z>.

Ross, S. A. (1976). The Arbitrage Theory of Capital Asset Pricing. *Journal of Economic Theory* n. 13, p. 341-360.

Ross, S. A., Westerfiled, R. W., Jaffe, J., & Lamb, R. (2015). *Administração Financeira* (Version Corporate Finance – 10th edition). MC.

Santos, J. O. (2019). *Valuation* – Um Guia Prático. 2a. ed. São Paulo: Ed. Saraiva.

Santos, M. I. C.; & Silva, M. S. (2009). Teoria de precificação por arbitragem: um estudo empírico no setor bancário brasileiro. *Enfoque: Reflexão Contábil*. v. 28, n. 1, p. 70-82.

Sharpe, W. F. (1964). Capital asset prices: a theory of market equilibrium under conditions of risk. *Journal of Finance*, Oxford, UK, v.19, n.3, p. 425-442, sept.

Silva, R. C., & Santos, O. M. (2019). Influência das oscilações do preço do barril de petróleo nas informações contábeis das empresas petrolíferas. *Revista Contabilidade Vista & Revista, ISSN 0103-734X*, Universidade Federal de Minas Gerais, Belo Horizonte, v. 30, n. 3, p. 1-17, set./dez.

Tobin, J. (1958). Liquidity preference as behavior toward risk. *The Review of Economic Studies*, Stockholm. Oxford University Press. v. 25, n. 2, p. 65-86.