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DIVIDEND YIELD AS A PREDICTOR FOR STOCK PRICING IN THE ELECTRICITY SECTOR: APPLICATION OF ARIMA AND VAR MODELS

DIVIDEND YIELD COMO PREDITOR PARA PRECIFIÇÃO DE AÇÕES DO SETOR ELÉTRICO: APLICAÇÃO DOS MODELOS ARIMA E VAR

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SUMMARY:
Companies in the Brazilian electricity sector, unlike other sectors, have their own characteristics that place them in a different group from conventional economic theory. One of the main financial decisions taken by companies refers to the definition of a dividend distribution policy. It is up to the company to decide on net income: retain it, to reinvest in its own activity; or distribute it to its shareholders. The objective of this work is 1) to verify if the use of ARIMA and VAR models can predict the prices of shares in the electricity sector from the payment of dividends and 2) if dividends have a causal relationship on the price of assets in the electricity sector. Results and conclusions: Dividend-based VAR and ARIMA models were not able to predict asset prices. The Granger test showed a causal relationship between the dividend yield on the variation of asset prices in ELET3 and CMIG4, but not in TRPL4. One of the reasons why the Granger test had different results between TRPL4 and the others may be related to the former acting only in the transmission sector, unlike ELET3 and CMIG4, which operate in different segments of generation, transmission and distribution. In addition, ELET3 and CMIG4 are companies with strong state influence, which would explain the need to pay dividends as a way of managing agency conflicts, signaling and even protecting minority shareholders.

Keywords: dividends; electricity sector; econometrics

RESUMO:
As empresas do setor elétrico brasileiro, diferentemente de outros setores, possuem características próprias que as colocam em um grupo distinto da teoria econômica convencional. Uma das principais decisões financeiras tomadas pelas empresas refere-se á definição de uma política de distribuição de dividendos. À empresa cabe a decisão sobre o lucro líquido: retê-lo, para reinvestir em sua própria atividade; ou distribuí-lo aos seus acionistas. O objetivo deste trabalho é 1) verificar se o uso de modelos ARIMA e VAR conseguem prever os preços de ações do setor elétrico a partir do pagamento de dividendos e 2) se os dividendos têm uma relação de causalidade sobre o preço dos ativos do setor elétrico. Resultados e conclusões: Os modelos VAR e ARIMA baseados em dividendos não foram capazes de prever o preços dos ativos. O teste de Granger mostrou relação de causalidade do *dividend yield* sobre a variação de preços de ativos

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em ELET3 e CMIG4, mas não em TRPL4. Um dos motivos pelos quais o teste de Granger teve resultado diferente entre TRPL4 e as demais pode estar relacionado à primeira atuar apenas no setor de transmissão, diferente de ELET3 e CMIG4, que atuam nos diferentes segmentos de geração, transmissão e distribuição. Além disso, ELET3 e CMIG4 são empresas com forte influência estatal, o que explicaria a necessidade do pagamento de dividendos como forma de gerir conflitos de agência, sinalização e mesmo proteção aos acionistas minoritários.

Palavras-chave: dividendos; setor elétrico; econometria

1 INTRODUCTION:

The Brazilian electricity sector is characterized by the presence of the State, which regulates the price of energy and promotes other forms of intervention that can affect the market balance (DIVINO; BRANDÃO, 2020). Companies in the Brazilian electricity sector, unlike other sectors, have their own characteristics that place them in a different group from conventional economic theory (SILVA; KIRCH, 2020). The studies by Costa e Oliveira (2004) and Tolmasquim (2012) show the importance of the energy sector for the economic and social development of the country, where they mention the regulatory changes that occurred in the sector that attracted greater investments to the electric energy sector, resulting in in greater competitiveness.

The importance of dividend policy for Deshmukh (2005) is based on three main theoretical focuses: information asymmetry, transaction costs and agency costs. According to Almeida (2017), one of the main financial decisions taken by companies refers to the definition of a dividend distribution policy. It is up to the company to decide on net income: retain it, to reinvest in its own activity; or distribute it to its shareholders.

Time series try to predict the future behavior of a variable from its past behavior, that is, it aims to predict future values of a given variable using historical data, instead of building cause and effect models (MARGARIDO, 2020). Thus, according to Gomes (2021), after modeling a time series in a given database, it is possible to compare the predictions made with the actual values of the series and, thus, identify possible exceptions, or even anticipate future exceptions.

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2 THEORETICAL REFERENCE

The Brazilian electricity sector is characterized by the presence of the State, which regulates the price of energy and promotes other forms of intervention that can affect the market balance (DIVINO; BRANDÃO, 2020). Companies in the Brazilian electricity sector, unlike other sectors, have their own characteristics that place them in a different group from conventional economic theory (SILVA; KIRCH, 2020), which Castro (2018) describes: natural monopoly, greater regulation of this sector, the remuneration, tariff model, would make financial operations more stable with greater predictability of income and expenses. As they are public service concessionaires, they operate from public concessions (hence the term “concessionaire”). Despite the way it operates, which ranges from electricity generation to transmission and distribution, its service is subject to regulatory bodies that, in addition to monitoring the quality of service provision, define the pricing of the fees charged.

The studies by Costa e Oliveira (2004) and Tolmasquim (2012) show the importance of the energy sector for the economic and social development of the country, where they mention the regulatory changes that occurred in the sector that attracted greater investments to the electric energy sector, resulting in in greater competitiveness and placing Brazil as one of the references in the segment.

Vieira and Alberton (2020) analyzed the return provided by publicly traded companies in the electricity sector to the individual investor over an 11-year period, comparing it to other types of investments. In view of the conservatism of most Brazilian savers, we sought to analyze companies in the electricity sector with greater liquidity, as the sector has a volatility below the market average, in addition to being a segment of vital importance for society. The return provided by companies, according to Vieira and Alberton (2020), followed a good average operating performance of the sector in the years of analysis, shown by the behavior of profitability indicators and EBIT evolution. The sector proved to be a viable option for Brazilians interested in joining the stock exchange, given the good performance combined with the lowest risk in the sector. For each variation of 1 percentage point in the Brazilian market, the electric energy sector tends to vary, on

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average, 0.85 percentage points, proving to be less volatile than the Brazilian market average and providing greater security for investors seeking less risk.

This article is divided as follows: this introduction, followed by the theoretical framework where a review of the literature on the electricity sector, dividend policy and the application of prediction and causality models is shown. In this same section, the hypotheses under test are presented. The following section, methodology, explains how the sample was selected and collected, in addition to the means of analysis. The results are presented in the section of the same name, where they are discussed in the light of the literature. The article ends in the conclusions, where the inferences obtained are resumed and future perspectives are demonstrated.

Silva et al (2009) analyzed, through a study with five companies in the electricity sector, which operate on the São Paulo stock exchange and have good liquidity in this market, the following question: the EVA® (Economic Value Added) indicators - added economic value) corresponds to the resulting value after remuneration of creditors (third parties) and partners (shareholders), that is, it is the value that the company added to shareholders. In addition to EVA®, the authors also evaluated how Net Income, Cash Flow and EBITDA influenced the share price. In order to achieve the objectives, an exploratory study was chosen, in which five companies in the electric energy sector with shares traded on the BMF&Bovespa, from 2007 to 2008 were randomly selected. correlation analysis, in which we sought to verify to what extent the independent variables interfered in the composition of the dependent variable, that is, stock price fluctuation. According to the results presented, it was not possible to identify a uniform correlation between the independent variables and the stock price fluctuation.

Modigliani and Miller (1961), in their classic article, suggested that dividend policy is irrelevant in relation to firm value. Under the assumption of perfect markets, when separating investment and financing decisions, the authors concluded that the company's value was determined solely and exclusively by the return on investments made. However, when considering market imperfections or frictions, the hypothesis of irrelevance of the dividend policy ends up being frequently refuted. For Deshmukh (2005), three main theoretical focuses are considered as possible explanations for the importance of dividend policy: information asymmetry, transaction costs and agency costs. According

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to Almeida (2017), one of the main financial decisions taken by companies refers to the definition of a dividend distribution policy. It is up to the company to decide on net income: retain it, to reinvest in its own activity; or distribute it to its shareholders.

Martins and Fama (2012), in addition, carried out a review of the literature, between the years 1990 and 2010, on dividend policies in Brazil and highlighted that the study on the topic of dividends is even more controversial in Brazil due to some existing particularities. , also highlighting the need to study the Brazilian reality of Interest on Equity (JCP) and its differentiated tax treatment.

KALUARACHCHI and FERNANDO (2016) examined the relationship between the stock exchange price and the interest rate using daily data for the period from July 2012 to December 2015. Two variables were considered in the price of shares used on the Colombo Stock Exchange and at SLIBOR (Sri Lanka Interbank Offered Rate). The All Share Price Index (ASPI) and the Standard and Poor Price Index (S&P) were used to evaluate the Srock price as dependent variables. The study had two dependent variables that are evaluating the individual with the consideration of independent variables. The results, regression and correlation showed that the interest rate is a significant negative relationship with ASPI and S&P.

Almeida (2017) analyzed the relationship between the share return and the distribution of dividends of companies listed on the BM&FBOVESPA in 2015. The most relevant result found in this research is that there is no relationship between the distribution of the additional dividend and the share return , that is, for companies that choose to distribute amounts above the minimum legal and contractual value, companies that have created their own dividend policy not based on legal or contractual impositions, it is observed that they do not signal to the market a positive action, therefore do not add value to the share price, being irrelevant.

Considering that on the date of announcement of the payment of dividends, information is transmitted to the market, enabling the reaction of interested parties and the consequent impact on stock prices, Marchi (2019) verified the behavior of stock prices in relation to the announcement of the distribution of dividends. of companies listed on the Brazilian stock exchange (B3), which distributed dividends in 2016 and 2017. Quantitative analysis of the impact of dividend announcements, dividend yield, sector of activity and

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level of governance of companies on share prices was carried out using the methodology of studying events, explanatory analysis and a proposed mixed linear regression model. The research findings indicated that the higher the percentage of the share price distributed in the form of dividends (dividend yield), the greater the abnormal cumulative returns of the shares. Furthermore, it was verified the existence of differences between the average accumulated abnormal returns in shares of companies classified in different sectors of activity and levels of governance. However, according to Marchi (2019), such differences were characterized as statistically insignificant, indicating the non-influence of the operating sectors and corporate governance levels on the abnormal cumulative returns of the shares, in the periods close to the announcement of dividend payment. Silva and Kirch (2019), in turn, when comparing the shares of the electricity system with those belonging to the Bovespa index, through the CAPM model, showed that the shares of the electricity system are more likely to generate increases in the price of shares above 2% than companies belonging to the Bovespa index after the payment of dividends. According to the authors, the actions of the electricity sector showed their own behavior, different from other sectors.

Basu (1983) studied the relationship between earnings yield, company size, and returns on common stocks of New York Stock Exchange (NYSE) companies. The results confirm that common stock of high E/P companies earn, on average, higher risk-adjusted returns than common stock of low E/P companies. This E/P effect is clearly significant even if experimental control is exercised over differences in firm size, that is, the size effect, as measured by the market value of common stock, is random. These empirical anomalies are consistent with the hypothesis that either the capital asset pricing model for a period is incorrectly specified due to the omission of other relevant factors and therefore does not adequately represent market equilibrium or that the NYSE is not completely efficient. , or both. To the extent that the first interpretation is believed to be appropriate because of the longevity of the E/P anomaly, then the reported results imply that, as a minimum, E/P ratios are correlated with the set of missing factors that are relevant to NYSE cormnon stock pricing.

Dunis and Reilly (2004), using daily data from December 31, 2000 to December 31, 2002 and 5 variables to categorize a panel of 689 stocks from the London FTSE All-

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Share stock index along a value dimension -growth, analyzed the investment returns obtained from the best decile portfolios of "growth" stocks and "value" stocks. The results suggest that a “value growth” factor is significant in the UK stock market, regardless of which of the five relative valuation techniques are used. Value stocks outperformed growth stocks, on average, for all five relative valuation techniques used during the study period, both absolutely and after adjusting for risk. Value stocks also outperformed the market, on average, for all five relative valuation techniques, both absolutely and after adjusting for risk. Furthermore, the results also showed that the high dividend yield decile portfolio produced a significant cumulative performance of the low dividend yield decile portfolio over the period under review. Possible reasons include the “customer effect” of the dividend and/or dividends acting as a signal to financial markets about a company's future prospects.

Keppler (1991) examined the relationship between dividend yield and return on investment for companies around the world. The study covered the 20-year period between December 31, 1969 and December 31, 1989 and assumed an equally weighted investment each quarter in the MSCI national equity indices of 18 countries. Each quarter, country indices were ranked according to dividend yield and ranked into four quartiles. Total return on investment was measured for each of the four quartile groups over the subsequent 3 months. The most profitable strategy was to invest in the highest dividend yielding quartile. The compound annual investment return for the highest yielding stocks was 18.49% in local currencies and 19.08% in US dollars over the 20-year period. The least profitable strategy was to invest in the lowest dividend yield quartile, which produced a compound annual return of 5.74% in local currency (and 10.31% in US dollars). The Morgan Stanley Capital International World Index returned 12.14% in local currency and 13.26% in US dollars, showing that the value quartile (comprised of the stocks with the highest dividend yield) outperformed the market. , in the studied period.

Levis (1989) examined the association between dividend yield and investment returns from January 1955 to December 1988. Using a sample of 4,413 companies listed on the London Stock Exchange, all companies listed each year were ranked according to dividend yield and classified into deciles. The highest dividend yield decile had an annual investment return of 19.3%, while the lowest dividend yield decile had an annual

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investment return of 13.8%. Both were higher than the FTSE All Share Index's annual return on investment (13.0%) over the same thirty-four year period.

Nagel and Amaral (2013) analyzed the relationship between the dividend yield and the abnormal return accumulated in the post-dividend payment period, considering economic instability. The sample consisted of the events in which there was payment of dividends or interest on the capital of shares of non-financial companies traded on the São Paulo Stock Exchange during the period from May 2009 to December 31, 2011. For the analysis of data, the event study method was used, based more specifically on the work of MacKinlay (1997). The results found indicate that the difference in abnormal returns between groups with high and low dividend yield is statistically insignificant for all tests performed, which contradicted the results of other authors, such as Novis Neto and Saito (2003), who reached results that pointed to a direct relationship between the dividend yield and the accumulated abnormal return in the post-dividend payout period. A similar study was carried out one year later by Kuronuma et al. (2004), with similar results.

Antônio et al (2018), through event studies based on the use of the Bootstrap statistical tool, whose main benefit is the adjustment for small samples, for a minimum period of analysis was ten years (January 2006 to December 2015) showed that distributions of dividends and interest on equity positively influenced the market, since the average abnormal return on shares was 0.70% on the day of the event. Stock splits were also able to influence the market, as on the day of the event the average abnormal return on stocks was 1.96%. In turn, the stock groups did not present statistically significant abnormal returns, but it could be graphically inferred that the stock return around this event follows a downward trend.

Cavalcante Cruz (2019) analyzed the actions of the electricity sector to observe its resilience to crises during the period between 2012 and 2020, as well as the profit distribution policy in this sector. Electric power companies, by virtue of the concession contracts, tend to have a forecast of revenue and expenses. This financial stability generates, as a consequence, a possibility of a stable dividend policy. It was shown that in the researched period, companies tend to continue generating profit and maintain their dividend distribution policy (CAVALCANTE CRUZ, 2019). Also according to the author, the analysis of risk versus return showed a positive assessment for the sector, compared

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to the Ibovespa, which as a rule maintained its growth trajectory, especially for private energy transmission companies. It also concludes that private companies in the electricity sector in the electrical transmission subsector tend to fulfill the hedging function in variable income, and that this subsector tends to be companies with a better risk-return ratio and more resilient in their dividend payment policy.

Silva and Kirch (2020), researched the unfolding of actions in Brazil on the electricity sector. Despite the small sample, some conclusions were reached: 1) the split/grouping was related to an increase in the volume traded on the first day after its occurrence, which could demonstrate the informational content; 2) the share turnover by split/regroup was higher on the first day and on the third month after the split; 3) the price of the split shares increased relative to the control group in the first week after the split/regroup. Fourth: no significant relationship was found in the linear regression between the share price and its respective volume and the share turnover in any of the groups. Fifth: the split did not influence yield in the first 3 years after the split. The yield level between the groups (split and split) was not statistically different. Sixth: linear regression showed no statistical correlation between yield and stock prices.

According to Wang (2004), stock markets have different behaviors in the short and long term. Dividend investing sees fewer years with losses, adding significant utility to the investor (CLEMENS, 2012). Silva and Kirch (2021) showed that there was a positive variation in the value of the shares of companies in the Brazilian electricity sector one year after their acquisition in that group that had a positive variation in dividends in the previous year, compatible with the “Dogs of Dow” strategy, not being This relationship was found for longer periods of time, both for dividends and for quotes. Thus, the authors suggest that the strategy of seeking appreciation of assets based on their prior payment of dividends should stick to the period of a previous year of dividend payment, aiming at a horizon limited to one year after the purchase of the shares of the respective company.

Silva (2022), in order to demonstrate the influence of shareholding concentration and company size on the dividend policy of companies in the Brazilian electricity sector, collected data on shareholding control of companies in the electricity sector and other sectors listed in B3 during 2019. Based on the results, the following conclusions were reached: 1) companies in the electricity sector pay lower payout than companies in other

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sectors; 2) there was no difference between companies in the electricity sector and the others in terms of payout in relation to shareholding concentration, both between companies considered large and those of smaller size; 3) regarding the size of the companies, there was no statistically significant difference between the payout paid by the electricity sector and the other companies; 4) smaller company size was related to greater occurrence of losses both in the electricity sector and in the group of other companies.

Silva (2019), using the chi-square test, found an inverse relationship between the variation in GDP above 3% with investment in companies in the electricity sector listed on Bovespa during the period from 1994 to 2007. In addition, in periods growth (GDP variation greater than 3%), external financing tends to be negative, while dividend payout tends to increase in these periods. These results, according to the author, point to a management model dependent on credit for its expansion. Companies in the electricity sector may be, therefore, despite the large formation of cash, making use of external credit for their investment. In other words, the expansion of GDP is in direct proportion to the distribution of dividends. The fact that companies in the electricity sector can easily obtain resources in the market, with no need to retain profits, could explain these results. Companies, especially larger ones, by having greater access to credit, often subsidized, can afford this higher payment of dividends. This higher payment of dividends, in turn, could be used as a sign of the good functioning of the company (Signaling Effect).

Silva and Kirch (2022), in order to seek a correlation between non-operating profits and the dividend distribution policy by companies in the Brazilian electricity sector through their respective payouts, analyzed using Student's t test and ordinary least squares and demonstrated that the electricity sector stood out from the other sectors for having lower non-operating profit, higher yield and lower annual appreciation than the other sectors, with no difference in payout. The intrasectoral analysis showed an inverse relationship between non-operating profit and payout as well as non-operating profit and dividend yield. Companies in the electricity sector with high non-operating profits are related to low valuation, yield and payout, and this factor may be a poor prognosis metric for the asset. According to the authors, these findings showed how the electricity sector differs from other sectors, requiring different strategies for investors who wish to obtain greater profits,

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such as considering high non-operating income as a factor of lower profitability and asset valuation.

Time series try to predict the future behavior of a variable from its past behavior, that is, it aims to predict future values of a given variable using historical data, instead of building cause and effect models (MARGARIDO, 2020). Thus, according to Gomes (2021), after modeling a time series in a given database, it is possible to compare the predictions made with the actual values of the series and, thus, identify possible exceptions, or even anticipate future exceptions.

According to Gomes (2021), the best-known time series model, the Autoregressive Integrated Moving Average Model - ARIMA, according to Margarido (2020), seeks to explain the present and future behavior of a variable based on its own past values, also called of autoregressive parameters (AR) and its own present and past error, called moving average (MA) parameters.

Using an autocorrelation model, Leal (2013) states that in Brazil, as well as in the United States, low liquidity induces a delay in the adjustment of the prices of small and medium-sized companies capable of generating predictability of the returns of these shares, suggesting some inefficiency of the Marketplace.

From the classic article by Sims (1980), the use of vector autoregressive models (VAR) spread rapidly among economists, and today these models are among the most used instruments in empirical investigations in the area of macroeconomics. The popularity of VAR models derives, to a large extent, from the perception that such models allow the analysis of the interrelationships between multiple variables from a minimum set of identification restrictions – that is, restrictions that allow the identification of the "exogenous" component of each variable, making it possible to estimate the effect of a "shock" in this variable on the others.

According to Cavalcanti (2010), in addition to the obvious limitation that the possibility of simultaneity between the variables is ruled out a priori, one of the main difficulties of this method lies in the fact that all possible orderings of the VAR variables are observationally equivalent, so that it is not possible to differentiate between them based on statistical criteria. Thus, the option for a certain ordering requires justifications

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based on theoretical arguments or prior knowledge about the nature of contemporary relationships between variables.

Thus, Cavalcanti (2010) warns of a common error in applied macroeconomic literature, associated with the identification of VAR models based on the results of Granger causality tests. Initially, it is shown that the fact that a certain variable X does not cause another variable Z in the Granger sense is neither a necessary nor a sufficient condition for the absence of a contemporary effect of X on Z and that, therefore, the identification method based on tests of Granger causality is based on a false premise. This conclusion strongly speaks against the identification method in question, but by itself does not totally invalidate it. In the same vein, Kendall and Stuart (1961) state that pure and simple regression analysis does not imply causality. The identification of a statistical relationship between two or more variables, however strong, can never establish a causal relationship between them; our convictions about any causal relationship must originate from outside statistics, based fundamentally on some established theory or even common sense.

Doornik (2007) developed and estimated an econometric model based on Auto-Regressive Vectors (VAR) representing the financial statements of Petrobrás S.A. The methodology used makes use of correlation analysis, unit root tests, cointegration analysis, VAR modeling, Granger causality tests, in addition to impulse response and variance decomposition methods. In addition to the endogenous variables belonging to the financial statements, a vector of exogenous variables was used, including the Brazilian GDP, national and international interest rates, the international price of oil, the exchange rate and country risk. The final version of the model is a Vector Error Correction (VEC) model, which takes into account the cointegration relationships between the endogenous variables. After estimation and validation, the model is used to generate projections of the financial statements of the company under study.

According to Carneiro (2012), the causality test that has become more popular in the literature is due to the econometrician Clive Granger and assumes that the future cannot cause the past or the present. For example, if event A occurs after event B, we know that A cannot cause B. At the same time, if A occurs before B, this does not mean that A necessarily causes B.

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After the estimation, four different cases can be distinguished:

1. One-sided causality from Y to X:

2. One-sided causality from X to Y:

3. Bicausality or simultaneity: when the lagged coefficient sets of X and Y are statistically different from zero in both regressions.

4. Independence:

According to Louzano et al (2019), the causality test proposed by Granger (1969) aims to overcome the limitations of using simple correlations between variables. This distinction is of fundamental importance, since, by itself, correlation does not imply causality (relationship of cause and effect).

In the causality test developed by Granger (1969) there is sometimes a difficulty in deciding the direction of causality between two related variables and also whether or not there is feedback between them. Gujarati (2006, p. 559, 560) complements by stating that “although regression analysis deals with the dependence of one variable on others, this does not necessarily imply causality”. That is, “the existence of a relationship between variables does not prove causality or direction of influence”. According to Pindyck and Rubinfeld (2004) this test is based on a simple idea. If X causes Y, then changes in X must precede changes in Y. To say that "X causes Y" it is necessary to fulfill two conditions: a) X must help predict Y. That is, in a regression of Y against its lagged values, the addition of lagged values of X as an independent variable should contribute significantly to increase the explanatory power of the regression. b) Y should not help predict X, because if X helps predict Y and Y helps predict X, it is likely that one or more variables are actually “causing” the observed changes in these two variables.

O'Hanlon (1991) investigated the question of whether accounting returns lead to stock market returns or vice versa. For that, a Granger causality test is applied to the series of stock returns and accounting returns. The evidence that can be drawn from these results suggest that accounting returns lead equity returns more strongly than equity returns lead accounting returns. .

Ritta et al (2015) sought to identify the relationship between EBITDA and the stock return of Brazilian companies listed on the BM&FBovespa in the period between 2008 and

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2014, through the application of the Granger Causality Test. The results showed that the EBITDA Margin over Net Revenue was, on average, 30.43% in the investigated period. In 26 companies there were causal relationships between the variables EBITDA Return and Share Return. According to the authors, the research results did not allow a definitive conclusion on the influence of the EBITDA indicator on the stock return and vice versa, since there was a balance in the results according to the econometric test. It is inferred that the results of the research and of previous studies are related to the fact that the accounting information represents the past performance of the organizations and, therefore, they are used in a complementary way by the capital market. Another important point, according to Ritta et al (2015) is that accounting indicators, especially EBITDA, represent organizational performance in a short-term and operational management view. This contrasts with the capital market, which in turn is more interested in the long-term performance and perpetuity of the business.

Campos et al (2012) verified, through the Granger causality test, the relationship between the quarterly series of accounting earnings and the market returns (RET) of Brazilian companies with shares on the stock exchange that present different levels of disclosure requirements. The analyzed sample consisted of 75 companies listed on the BM&FBOVESPA, during the period from 1995 to 2010. The variables analyzed were accounting returns (ROE) and market returns (RET). In the analysis of the results, it was found, at the level of 5% of statistical significance, that most companies had at least some sense of causality, either from ROE to RET, or from RET to ROE. By analyzing at an aggregate level the causality between ROE and RET, it can be concluded that there is causality, in the Granger sense, in both directions. It was also verified, through the aggregated analysis of the P-values of the Granger test, that there is bi-causality between ROE and RET, concluding that the Brazilian stock market does not have market efficiency in the analyzed sample.

The cointegration method is based on the Error Correction Mechanism (ECM) which examines whether lagged values of one variable X can help explain changes in the current values of another variable Y, even if changes passed in Y are not relevant, assuming, however, that both variables X and Y are stationary (MARGARITO;

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ANEFALOS, 2001). The concept of co-integration seeks to identify whether two or more integrated variables of the same order have an equilibrium relationship in the long run. According to Margarido (2004), co-integration tests have assumed great relevance in the field of economics and econometrics. The importance of co-integration tests lies in the fact that they allow us to verify whether there is a long-term balance, or relationship, between economic variables.

In the line of investigating the relevance of accounting information for capital markets in emerging countries, Galdi et al (2008) analyzed whether there is a long-term and causal relationship between accounting earnings and the stock price of Latin American companies. For this, co-integration tests were used. In essence, if they are co-integrated, the variables maintain a long-term relationship. In addition to the co-integration test, the Granger causality between earnings and stock prices was investigated. Evidence points to a long-term relationship between earnings and stock prices. However, a clear causal relationship between these two variables cannot be established.

According to Gomes (2021), the application of time series models to identify behaviors in electricity consumption data is one of the ways that electric power companies use to identify irregularities. Divino and Brandão (2020) combined panel data from national electricity submarkets with time series of the Brazilian economy in the estimation of panel VAR models (PVAR) and impulse-response functions. The results revealed that fiscal and monetary shocks affect the dynamics of the electricity sector, albeit indirectly, as in inputs for energy generation, such as diesel oil, as well as restrictive fiscal policies that reduce consumption. There is high rigidity in the electricity tariff, which is explained by state regulation.

Brugni et al (2015) evaluated 36 firms in the Brazilian capital market in the period from 2003 to 2013, seeking to investigate whether there are incentives for the accounting information disclosed to follow the share price and not the other way around. The authors explored the time relationship between the earnings surprise component and the stock price by applying the Granger causality test. Subsequently, the logistic regression technique was used to identify possible incentives that could increase the probability of occurrence of the causality vector, in the Granger sense, from price to profit. The results indicated that, of the companies analyzed, 11 have the surprise component of the Granger

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profit-causing price and 10 whose market can anticipate, in the short term, the surprise component of future earnings. Brugni et al. (2015) also suggest that the size of the firm contributes to the increase in the probability of prices anticipating the surprise component of profits in the market, providing support for the study of the phenomenon in large firms. Among the companies surveyed, 5 companies in the electricity sector were part of the sample; only 1 test did not show causality; in another 3 the causality was both bilateral and unilateral, with profit causing price. In one it was only bilateral.

The use of cointegration models in dividend theory is quite recent. Seminal works such as those by Lintner (1956) and Fama and Babiak (1968) modeled the relationship between dividends and earnings using Ordinary Least Squares, assuming a short-term relationship between the variables. According to Colombo (2011), more recently, with the advancement of econometric tools, other approaches have been used to verify the long-term relationship between variables, such as the Engle-Granger and Johansen models (for cointegration analysis) and Granger (2011). for causality analysis).

Colombo (2011) found evidence that favorable (unfavorable) expectations regarding the future of the national economy are linked to reductions (increases) in the distribution of dividends. According to the author, this result suggests that the effects of the scarcity of capital and the increase in the opportunity cost play a dominant role in the influence of the softer perspectives about the future of the economy.

With the objective of building an index that could be used as a proxy for the distribution of dividends in the Brazilian stock market that would present a smoother behavior and use it to verify the presence of rational bubbles in this market, Ribeiro (2016) used the cointegration tests Engle-Granger and Johansen methods to verify the existence of a long-term equilibrium relationship between stock prices and dividends. The null hypothesis of absence of cointegration was not rejected in any of the tests. Therefore, there is no long-run equilibrium relationship between the series. The author concludes that the absence of this equilibrium does not allow the presence of explosive bubbles to be ruled out.

Fernandes and Medeiros (2009) analyzed the presence of bubbles in the Brazilian stock market between 1994 and 2007 using ADF unit root tests (Augmented Dickey - Fuller test), Engle-Granger and Johansen cointegration tests and a causality test.

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Granger. The authors used the Ibovespa as a price proxy and built a monthly dividend index based on the theoretical portfolios and the Ibovespa methodology. The ADF unit root test, performed using Eviews, rejected the null hypothesis of unit root, indicating that the series was stationary. The same test was performed for the Ibovespa and indicated the presence of a unit root. Based on this result, the authors concluded that there is no cointegration between the Ibovespa and the dividend index. The absence of cointegration was considered evidence of the presence of bubbles in the Brazilian stock market in this period. The Granger causality test indicated that dividends do not cause prices, which reinforced the hypothesis of the presence of bubbles, according to the authors.

Mahmood and Fatah (2007), on the other hand, when examining the relationship between the return of stocks in the Malaysian market, dividend yields and price gains, found results contrary to those of Fernandes and Medeiros (2009). Specifically, the authors explored the existence of long-term and short-term relationships and also their predictive power (causality) between and between stock market returns, dividend yields, and price gains. Using monthly data from 1989-2005, the study found that all these fundamental variables have a strong long-term relationship. As for the short-term relationship, the results showed a significant positive predictive power of the dividend yield for stock returns and a significant negative relationship between stock returns and earnings indices. Furthermore, applying the multivariate causality test, the results showed that both the dividend yield and the Granger price gain index cause (predict) stock returns. Similar results are found for stock returns and P/E ratio for dividend yield, as well as for dividend yields and stock returns for P/E ratio, but to a lesser extent.

From the Present Value Model, which states that the current price of securities is equal to the discounted value plus future dividends, where the discount rate is equivalent to the required rate of return and using a sample of companies belonging or that belonged to the index Ibovespa during the period from 1986 to 2009, Martin et al. (2012) analyzed the relationship between prices and dividends of these companies through panel cointegration and first-generation panel unit root estimation methods to test the long-term relationship between share prices and dividends for the Brazilian stock market. The results do not reject the hypothesis of non-cointegration between real prices and real dividends, considering the different sample companies examined, thus validating the Present Value

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Model between prices and dividends with Constant Expected Returns. There were 2 companies in the electricity sector in the sample, but there was no sectoral analysis.

Based on the above, the following hypotheses are formulated:

> Hypothesis 1: the use of ARIMA and VAR models can predict the prices of shares in the electricity sector based on the payment of dividends.
>
> Hypothesis 2: dividends have a causal relationship on the price of assets in the electricity sector.

3 METHODOLOGY

From the Yahoo Finance website, companies in the electricity sector were selected from the first day of the year in which dividend payment records begin, until December 31, 2021. Share price data were collected on the last day of each year, from which the annual variation was calculated. Each dividend payment was divided by the respective share price on the payment day to obtain the dividend yield. The sum of the dividend yields during the year generated the dividend yield used in the analysis.

According to Doornik (2007), the methodology used makes use of correlation analysis, unit root tests, cointegration analysis, VAR modeling, Granger causality tests, in addition to impulse-response methods. Data analysis was performed using Eviews software. The level of statistical significance was set at 0.1.

4 RESULTS

Three companies were selected: Eletrobras, Cemig and Transmissão Paulista. In this section, each company is presented individually, followed by the analysis of their respective time series. The stock codes were adopted as identification: ELET3, CMIG4, TRPL4.

4.1 ELET3

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According to the Yahoo Finance website (2022), Centrais Elétricas Brasileiras S.A. (Eletrobras), through its subsidiaries, operates in the generation, transmission and distribution of electricity in Brazil. The company generates electricity through hydroelectric, thermal, nuclear, wind and solar plants. As of December 31, 2021, it owned and operated 32 hydroelectric plants with a total installed capacity of 46,295.75 megawatts; nine thermal plants, including coal, oil and gas power generation units, with a total installed capacity of 1,505 megawatts; and two nuclear plants comprising Angra I with an installed capacity of 640 megawatts and Angra II with an installed capacity of 1,350 megawatts. It also operates 66,556 kilometers of transmission lines. The company was incorporated in 1962 and is headquartered in Rio de Janeiro, Brazil. Its shares traded under the code ELET3 on the B3 are part of the IEE electricity index, the IDIV dividend index and the main stock index, the IBOV (B3, 2022).

The analysis of ELET3 is shown in table 1. On average, the shares experienced a positive variation of 19%, while the dividend yield, on average, was 4.6%. The Johansen cointegration test could not be performed due to low sampling. When performing the unit root test, in turn, non-stationarity was detected in the dividend yield, which was corrected by applying the first difference (level 1).

The ordinary least squares equation using the asset price variation as the dependent variable and the dividend yield as the independent variable in the first difference, did not show any element with statistical significance, as shown in table 1. The ARIMA model, when applied, had the its best model (lower Akaike and Schwarcz values) in the form of an AR(4) and MA(4) model, without the inclusion of any dividend yield element. When tested as a model for predicting the price variation of ELET3 shares, it predicted that the asset would not change, while, in fact, there was a positive variation of 14.8%.

The unstructured VAR model was applied, with the most suitable equation having a number of lags equal to three. The forecast for 2021 indicated a negative variation of ELET3 of 11.7%, different, therefore, from the actual value. Thus, both ARIMA and VAR models were unable to make correct predictions of the variation in the value of ELET3 shares from a model based on dividend yield, thus accepting the null hypothesis.

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When applying the Granger test, a unidirectional causality relationship was found between the dividend yield and the stock price, which is in agreement with Mahmood and Fatah (2007), Dunis and Reilly (2004), Keppler (1991), Levis (1989), Antônio et al (2018), Silva and Kirch (2019, 2021) and Marchi (2019) and contradicts the results of Fernandes and Medeiros (2009), Nagel and Amaral (2013) and Almeida (2017). Therefore, the null hypothesis is rejected. The Choleski impulse-response method was applied and is shown in Figure 1. In it, the maximum response of the dividend yield effect on the asset value in a period of four years is evident.

Table 1 – Asset analysis ELET3 (n = 14)

Descriptive statistics				
	Mean ± Standard error			
Dcot	0.194±0.23			
Yield	0.046±0.018			
Unit Root Test *				
	level	p-value		
Dcot	0	0.018		
Yield	1	0.021		
Ordinary Least Square (dependent variable: Dcot)				
Variable	Standard error	coefficient	t-value	p-value
C	0.209	0.26	0.8	0.43
Yield**	-0.88	3.35	-0.26	0.79
Arima Model (dependent variable**: Dcot)**				
Variable	Standard error	coefficient	t-value	p-value
C	0.63	0.33	1.89	0.1
AR (4)	0.05	0.31	0.17	0.86
MA (4)	-0.92	0.09	-10	< 0.001
Dcot forecast for 2021: 0.0027[1]				

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Unstructured VAR

Number of lags: 3

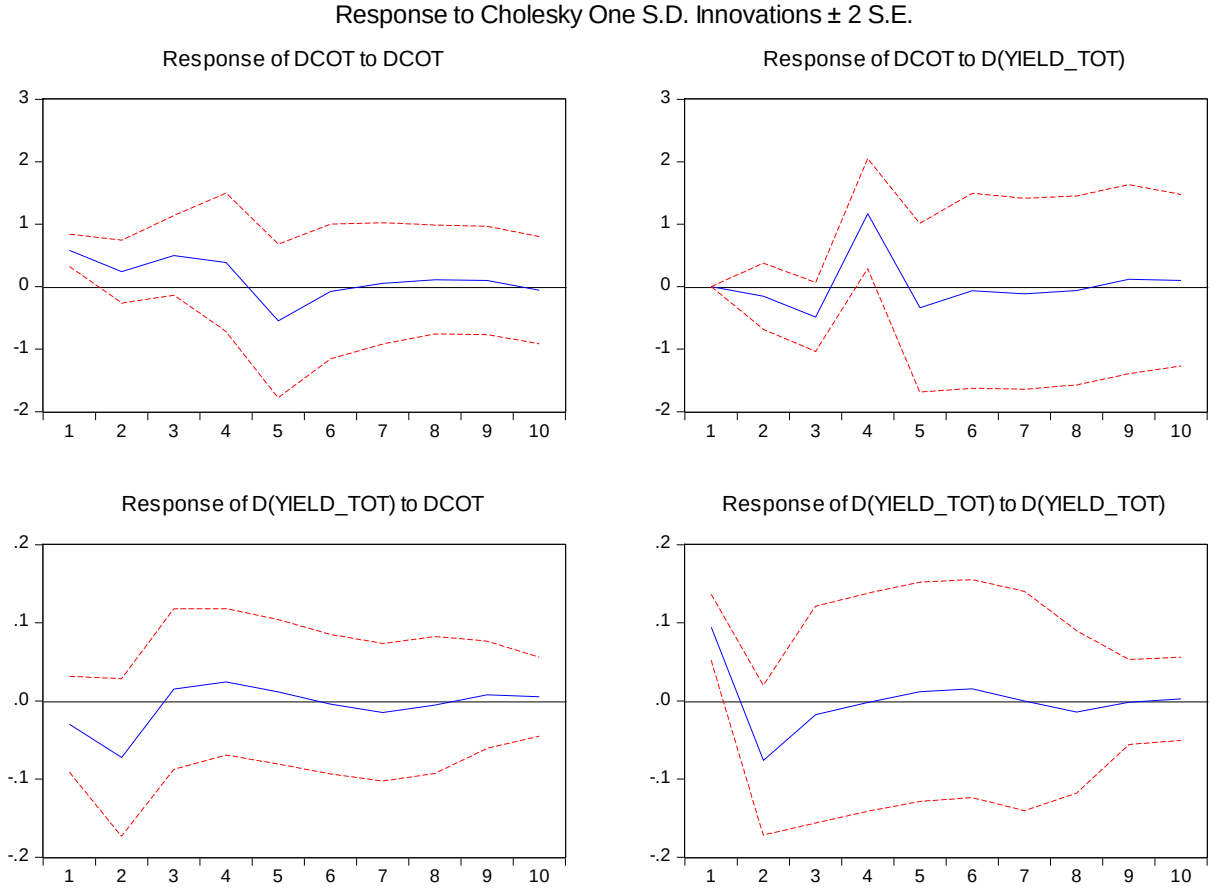
Dcot forecast for 2021: -0.117[1]

Granger Test

dependent variable	independent variable	p-value
Dcot	Yield**	< 0.001
Yield**	Dcot	0.26

*Dick-Fuller test. **in first difference. Abbreviations: Dcot: annual change in share price; [1]Actual value: 0.148

Figure 1 – Choleski impulse-response for ELET3



4.2 CMIG4

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Companhia Energética de Minas Gerais, through its subsidiaries, operates in the generation, transmission, distribution and commercialization of energy in Brazil. As of December 31, 2021, the company operated 70 hydroelectric, wind and solar plants with an installed capacity of 5,700 MW; 339,086 miles of distribution lines; and 4,449 miles of transmission lines. It also works in the acquisition, transport and distribution of gas and its by-products and derivatives; cloud solution delivery, IT infrastructure, IT management and cybersecurity services; provision of technological systems and operational management systems for public service concessions; sale and commercialization of energy; provision of telecommunications services; and distributed generation, account services, cogeneration, energy efficiency and supply and storage management activities. The company was incorporated in 1952 and is headquartered in Belo Horizonte, Brazil (YAHOO FINANÇAS, 2022). Its shares traded under the code CMIG4 on B3 are part of the IEE electricity index, the IDIV dividend index and the main stock index, the IBOV (B3, 2022).

The analysis of CMIG4 is shown in table 2. On average, the shares suffered a positive variation of 5%, while the dividend yield, on average, was 8%. The Johansen cointegration test could not be performed due to low sampling. When performing the unit root test, in turn, non-stationarity was not detected, and all variables were, therefore, tested in level.

The ordinary least squares equation using the asset price variation as the dependent variable and the dividend yield as the independent variable, did not show any element with statistical significance, as shown in table 2. The ARIMA model, when applied, had its best model (lower Akaike and Schwarcz values) in the form of an AR(6) and MA(4) model, with the inclusion of the dividend yield without producing significantly statistical results. When tested as a CMIG4 stock price change prediction model, it predicted that the asset would experience a positive change of 65%, while, in fact, there was a much smaller positive change (0.5%).

The unstructured VAR model was applied, with the most suitable equation having a number of lags equal to two. The forecast for 2021 indicated a positive variation of CMIG4 of 34.3%, different, therefore, from the actual value. Thus, both ARIMA and VAR

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models were unable to make correct predictions of variation in the value of CMIG4 shares from a model based on dividend yield, thus accepting the null hypothesis.

When applying the Granger test, a unidirectional causality relationship was found between the dividend yield and the stock price, which is in agreement with Mahmood and Fatah (2007), Dunis and Reilly (2004), Keppler (1991), Levis (1989), Antônio et al (2018), Silva and Kirch (2019, 2021) and Marchi (2019) and contradicts the results of Fernandes and Medeiros (2009), Nagel and Amaral (2013) and Almeida (2017). Therefore, the null hypothesis is rejected. The Choleski impulse-response method was applied and is shown in Figure 2. In it, the statistically significant response of the dividend yield effect on the asset value over a two-year period is evident. In this case, different from what was seen in ELET3, the answer in this case was a fall in the price of the asset within 2 years.

Table 2 – Asset analysis CMIG4 (n = 12)

Descriptive statistics				
	Mean ± Standard error			
Dcot	0.05±0.014			
Yield	0.08±0.023			
Unit Root Test *				
	level	p-value		
Dcot	0	0.03		
Yield	0	0.02		
Ordinary Least Square (dependent variable: Dcot)				
Variable	Standard error	coefficient	t-value	p-value
C	0.02	0.19	0.116	0.9
Yield**	0.34	2.04	0.166	0.87
Arima Model (dependent variable**: Dcot)**				
Variable	Standard error	coefficient	t-value	p-value
C	0.127656	0.031267	4.082725	0.0551

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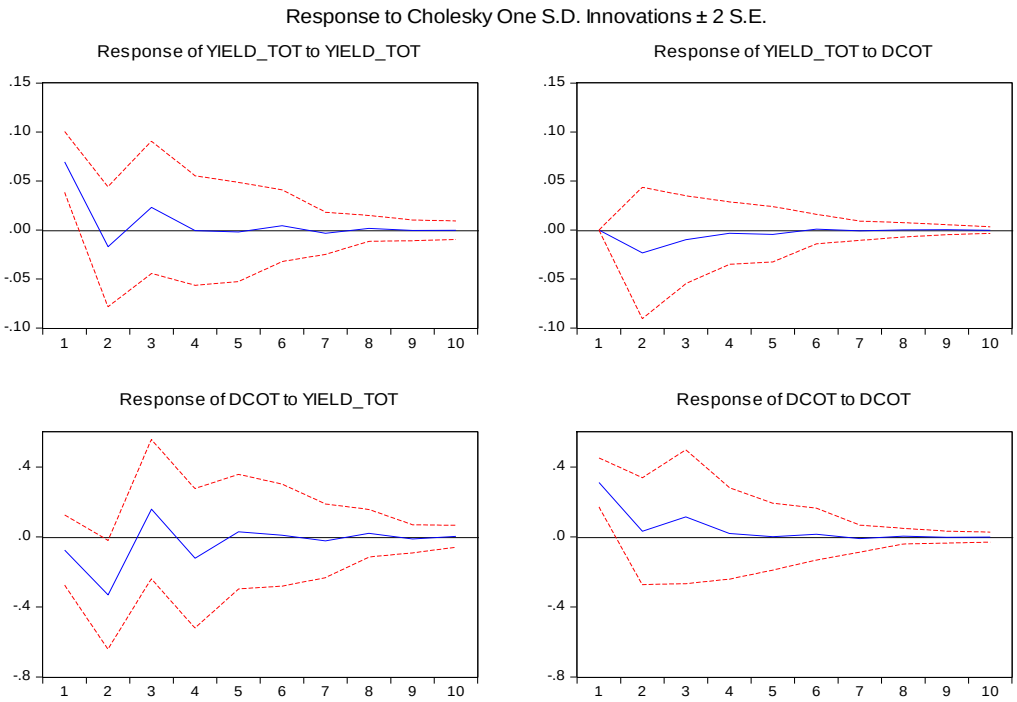
Yield	-0.598138	6.553423	-0.091271	0.9356
AR (6)	0.092455	1.105274	0.083649	0.9410
MA (4)	0.999986	1.84E-10	5.45E+09	0.0000
Dcot forecast for 2021: 0.65[1]				
Unstructured VAR				
Number of lags: 2				
Dcot forecast for 2021: 0.343[1]				
Granger Test				

dependent variable	independent variable	p-value
Dcot	Yield**	0.03
Yield**	Dcot	0.64

*Dick-Fuller test. Abbreviations: Dcot: annual change in share price; [1]Actual value: 0.005

Figure 2 – Choleski impulse-response for CMIG4



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4.3 TRPL4

CTEEP - Companhia de Transmissão de Energia Elétrica Paulista S.A. operates in the field of electric power transmission in Brazil. As of December 31, 2021, it had a total installed transformation capacity of 71.7 thousand MVA along with transmission lines of 19 thousand kilometers; 26.1 thousand kilometers of circuits; and 131 substations. It operates in the states of Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Minas Gerais, Rondônia, Mato Grosso, Mato Grosso do Sul, Goiás, Tocantins, Maranhão, Piauí, Paraíba, Pernambuco, Alagoas, Espírito Santo and Bahia. The company was incorporated in 1999 and is headquartered in São Paulo, Brazil (YAHOO FINANÇAS, 2022). Its shares, traded on B3 under the code TRPL4, are part of the IEE electricity index and the IDIV dividend index (B3, 2022).

The analysis of TRPL4 is shown in table 3. On average, the shares experienced a positive variation of 11.2%, while the dividend yield, on average, was 6.3%. The Johansen cointegration test was performed and no cointegration vectors were found. When performing the unit root test, in turn, non-stationarity was not detected, and all variables were, therefore, tested in level. The ordinary least squares equation using asset price variation as a dependent variable and dividend yield as an independent variable, did not show any element with statistical significance, as shown in table 3. The ARIMA model, when applied, had its best model (lower Akaike and Schwarcz values) in the form of an AR(3) and MA(3) model, with the inclusion of the dividend yield without producing significantly statistical results. When tested as a model for predicting the price variation of TRPL4 shares, it predicted that the asset would experience a positive variation of 22.8%, while, in fact, there was a negative variation of 14.4%.

The unstructured VAR model was applied, with the most suitable equation having a number of lags equal to one. The forecast for 2021 indicated a positive variation of TRPL4 of 17.8%, different, therefore, from the actual value. Thus, both ARIMA and VAR models were unable to make correct predictions of variation in the value of CMIG4 shares from a model based on dividend yield, thus accepting the null hypothesis.

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When applying the Granger test, no causal relationship was found between dividend yield on stock price, which is in agreement with the results of Fernandes and Medeiros (2009), Nagel and Amaral (2013) and Almeida (2017) and contradicts the works of Mahmood and Fatah (2007), Dunis and Reilly (2004), Keppler (1991), Levis (1989), Antônio et al (2018), Silva and Kirch (2019, 2021), and Marchi (2019) . and it is also different from the results of the other companies studied. Therefore, the null hypothesis is accepted. Choleski's impulse-response method was applied and is shown in Figure 3. In it, no statistically significant findings were found regarding the response of the variation of TRPL4 stock prices to the dividend yield.

Table 3 – Asset analysis TRPL4 (n = 15)

Descriptive statistics				
	Mean ± Standard error			
Dcot	0.112±0,028			
Yield	0.063±0,016			
Unit Root Test *				
	level	p-value		
Dcot	0	0.026		
Yield	0	0.076		
Ordinary Least Square (dependent variable: Dcot)				
Variable	Standard error	coefficient	t-value	p-value
C	0.193869	0.113927	1.701685	0.1126
Yield**	-1.300776	1.468120	-0.886015	0.3917
Arima Model (dependent variable**: Dcot)**				
Variable	Standard error	coefficient	t-value	p-value
C	0.216954	0.168750	1.285653	0.2345
Yield	-1.587539	1.995214	-0.795674	0.4492
AR (6)	-0.352886	0.284681	-1.239583	0.2503

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MA (4)	0.904962	0.091241	9.918317	0.0000

Dcot forecast for 2021: 0.228[1]

Unstructured VAR

Number of lags: 1

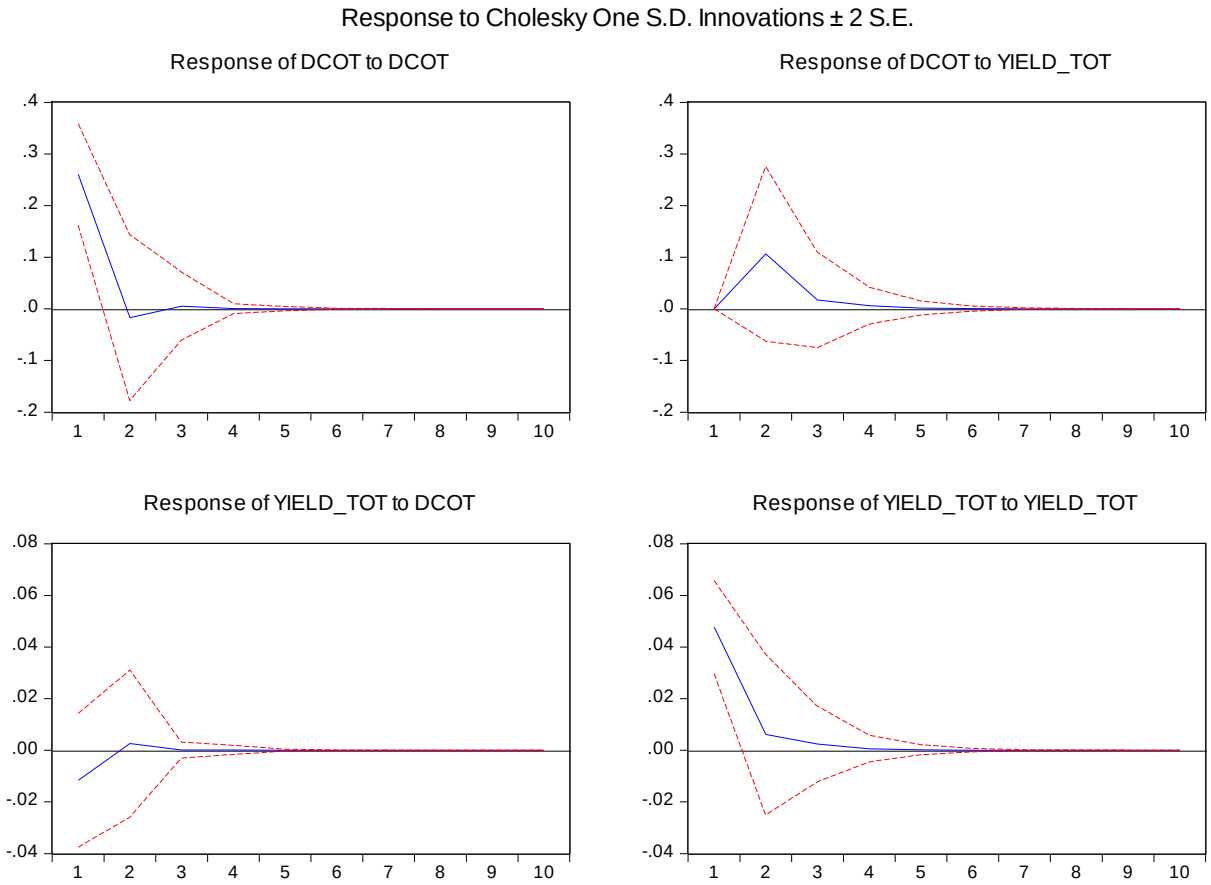
Dcot forecast for 2021: 0.178[1]

Granger Test

dependent variable	independent variable	p-value
Dcot	Yield**	0.19
Yield**	Dcot	0.77

*Dick-Fuller test. Abbreviations: Dcot: annual change in share price; [1]Actual value: : -0.144

Figure 3 – Choleski impulse-response for TRPL4



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Resuming, each company behaved differently despite being in the same sector. One of the reasons why the Granger test had different results between TRPL4 and the others may be related to the former acting only in the transmission sector, unlike ELET3 and CMIG4 that operate in different segments of generation, transmission and distribution. In addition, ELET3 and CMIG4 are companies with strong state influence, which would explain the need to pay dividends as a way of managing agency conflicts, signaling and even protecting minority shareholders. Another aspect to be better clarified is the "negative" effect of the dividend yield on prices that occurred in the asset CMIG4 and which appeared in the ARIMA model and in the impulse-response of Choleski. An effect like this, where the increase in the payment of dividends leads to a lower valuation of the stock, would return to the theory of the irrelevance of dividends by Modigliani and Miller (1961).

5 CONCLUSIONS:

The use of econometric models for a better understanding of the dividend policy in the electricity sector opens the door to multiple discussions and reassessments of conclusions from other works on the subject, but with different methodologies (SILVA et al, 2009, SILVA, 2019, SILVA; KIRCH, 2019, SILVA; KIRCH, 2020, SILVA, 2022, SILVA; KIRCH, 2022).

The use of dividend yield to forecast asset prices did not work for any of the models used. In the three companies studied, the best ARIMA model was obtained without the inclusion of dividends and only with the residuals of asset price variations, it proved incapable of making a correct forecast for the year 2021. The VAR model was not able to predict the variation in stock prices, despite the fact that a causal relationship between dividends and changes in asset prices was found.

Each company behaved differently despite being in the same sector when testing causal relationships between dividends and asset price changes. One of the reasons why the Granger test had different results between TRPL4 and the others may be related to

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the former acting only in the transmission sector, unlike ELET3 and CMIG4 that operate in different segments of generation, transmission and distribution. In addition, ELET3 and CMIG4 are companies with strong state influence, which would explain the need to pay dividends as a way of managing agency conflicts, signaling and even protecting minority shareholders.

The Granger test showed a causal relationship between the dividend yield and the variation in asset prices. Choleski's impulse-response method showed different responses between companies, being null in TRPL4 and significant in the others. However, the effect was maximum in different periods: four years in ELET3 and two years in CMIG4.

Within the research perspectives, for a better forecasting model, a larger sample and other variables must be considered.

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