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DETERMINANTS OF AUDIT FEES IN THE BASIC MATERIAL SECTOR ON THE BRAZILIAN STOCK EXCHANGE: THE ROLE OF ASSET SIZE AND CORPORATE GOVERNANCE

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Abstract

This study analyzes the determinants of audit fees in the basic materials sector on the Brazilian Stock Exchange (B3), focusing on the impact of company size and corporate governance practices. The research uses data from 288 observations of 24 companies listed on B3, covering the period from 2011 to 2022. Through a descriptive methodology and the application of quantile regression, the study explores how variables such as affiliation with Big Four audit firms, asset size (LTA), corporate governance (CG), and other factors such as the market-to-book ratio (MTB) influence the fees paid to auditors. The results reveal that asset size is the most relevant factor, exerting a significant positive impact on audit fees. Corporate governance also plays an important role, especially among smaller companies, where robust governance practices amplify audit costs. Additionally, affiliation with Big Four audit firms is identified as a factor justifying higher fees, reflecting the search for credibility and rigor in auditing. Based on the findings, it is concluded that asset size is the primary determinant of audit fees in the Basic Materials sector, as evidenced by its positive and statistically significant association. Additionally, corporate governance proved particularly relevant for smaller companies, suggesting that the pursuit of robust practices can increase audit costs. The Big Four audit firms affiliation further reinforces the trend of higher fees, reflecting the premium placed on the quality and technical rigor provided by these firms.

Keywords: Accounting Regulation; Audit Fees; Corporate Governance.

Resumo

Este estudo analisa os determinantes dos honorários de auditoria no setor de Materiais Básicos da Bolsa de Valores do Brasil (B3), com foco no impacto do tamanho da empresa e das práticas de governança corporativa. A pesquisa utiliza dados de 288 observações de 24 empresas listadas na B3, abrangendo o período de 2011 a 2022. Por meio de uma metodologia descritiva e da aplicação de regressão quantílica, o estudo investiga como variáveis como afiliação a firmas de auditoria Big Four, tamanho dos ativos (LTA), governança corporativa (GC) e outros fatores, como a razão mercado-valor contábil (MTB), influenciam os honorários pagos aos auditores.Os resultados indicam que o tamanho dos ativos é o fator mais relevante, exercendo um impacto positivo significativo sobre os honorários de auditoria. A governança corporativa também desempenha um papel importante, especialmente entre empresas menores, onde práticas de governança mais robustas elevam os custos de auditoria. Além disso, a afiliação a firmas da Big Four é identificada como um fator que justifica honorários mais elevados, refletindo a busca por maior credibilidade e rigor no processo de auditoria.Com base nos achados, conclui-se que o tamanho dos ativos é o principal determinante dos honorários de auditoria no setor de Materiais Básicos, conforme evidenciado por sua associação positiva e estatisticamente significativa. Além disso, a governança corporativa mostrou-se particularmente relevante para empresas menores, sugerindo que a adoção de práticas mais estruturadas pode aumentar os custos de auditoria. A afiliação a firmas da Big Four reforça a tendência de honorários mais elevados, refletindo o prêmio atribuído à qualidade e ao rigor técnico oferecidos por essas firmas.

Palavras-chave: Governança Corporativa; Honorários de Auditoria; Regulação Contábil.

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INTRODUCTION

Auditors' remuneration plays a crucial role in the quality and credibility of the financial information disclosed by companies. The way audit fees are determined can reflect various aspects of corporate governance, company size, and the complexity of operations. This study aims to explore the determinants of audit fees in the Basic Materials sector on the Brazilian Stock Exchange (B3), focusing on how factors such as the adoption of good corporate governance practices and asset size influence auditors' remuneration.

The audit market in Brazil, especially among companies listed on B3, is characterized by a wide variety of practices and policies related to auditors' remuneration. Companies often face challenges defining audit fees, which should reflect not only the complexity and scope of the services provided but also aspects related to governance and financial transparency. The existing literature suggests that factors such as being audited by the Big Four audit firms, asset size, the market-to-book ratio (MTB), and the timing of financial statement releases can have significant impacts on the fees paid to audit firms.

Given this scenario, the following research question arises: What are the effects of asset size and corporate governance practices on auditors' remuneration in the Basic Materials sector of the Brazilian Stock Exchange? This question guides the central analysis of this study.

This study analyzes 24 companies in the sector listed on B3 between 2011 and 2022, aiming to identify the determinants of auditors' remuneration and how they influence corporate transparency and accountability. Additionally, special relevance is given to the analysis of regulatory changes that impact the disclosure of audit fees in Brazil, with the implementation of CVM Resolution 80. By examining this aspect, our work seeks to understand how changes in the regulatory environment influence companies' willingness and ability to disclose critical information, a vital component for investor confidence and the improvement of corporate governance.

The central motivation of this study lies in exploring how auditors' remuneration is influenced by the size of client companies and corporate governance practices in the basic materials sector. The main objective is to test whether audit fees are significantly associated with the size of companies' assets, in addition to examining the impact of good corporate governance practices on these costs. The study seeks to provide valuable insights into audit policies and practices that can promote greater transparency and strengthen corporate governance in the sector.

The structure of this paper is organized as follows: Section 2 presents a review of the relevant literature, highlighting the main theories and studies on auditors' remuneration, corporate governance,

and operational complexity. Section 3 describes the methodology used, focusing on the data analysis procedures and the application of the quantile regression econometric model. Section 4 discusses the results obtained, emphasizing how asset size, corporate governance, and other factors, such as affiliation with the Big Four audit firms, influence audit fees. Finally, Section 5 offers conclusions and recommendations based on the research findings, highlighting their implications for companies, auditors, and regulators in the Brazilian market.

AUDIT FEES AND ITS DETERMINANTS

This section explores the theoretical foundations that support the determinants of independent auditors' remuneration, specifically focusing on audit fees. The objective is to gain a deeper understanding of the factors that impact audit fees, considering the interaction between company size, corporate governance, and market valuation.

Audit Fees: Concept And Determinants

Audit fees represent the cost incurred by companies for external audit services, typically influenced by multiple factors such as audit complexity, risk exposure, corporate governance, and firm characteristics (SIMUNIC, 1980). Studies suggest that audit fees are driven by both demand-side factors (financial reporting complexity, regulatory requirements, and governance practices) and factors such as market competition and firm-specific risks) (DEFOND; ZHANG, 2014).

The seminal model of Simunic (1980) postulated that audit fees are determined by the auditor’s expected cost of conducting the audit, which is directly linked to the firm's size, complexity, and risk profile. Subsequent research has refined this model, showing that firms with greater financial opacity, aggressive earnings management, and high litigation risk tend to pay higher audit fees (HAY *et al*., 2006; FRANCIS; WANG, 2008).

International studies have also highlighted the role of corporate governance in determining audit fees. Firms with strong governance mechanisms tend to demand more rigorous external audits, leading to increased audit fees (LARBI, 2024). Conversely, companies with weak governance structures may face higher fees due to greater financial misstatement risks (XUE; O’SULLIVAN, 2023; SOYEMI, 2021).

Big Four Audit Firms and Audit Fees

The Big Four audit firms refer to the four largest international auditing firms: Deloitte, Ernst and Young (EY), KPMG, and PricewaterhouseCoopers (PwC). These firms dominate the global audit market and are known for their rigorous audit procedures, extensive client portfolios, and adherence to high professional standards (DEANGELO, 1981; SIMUNIC, 1980). Hiring a Big Four audit firm is often seen as a signal of higher financial credibility and reliability in corporate financial statements (BEATTY, 1989).

From a theoretical standpoint, the selection of a Big Four audit firm has implications for audit quality, audit fees, and corporate governance. The literature suggests that Big Four auditors charge premium fees compared to non-Big Four firms due to their brand reputation, expertise, and ability to handle complex audits (FRANCIS; WANG, 2008; LARBI *et al*., 2024). The premium fees reflect the higher demand for their services, the extensive resources allocated to audits, and the enhanced credibility associated with their reports. Prior studies have found a strong positive association between Big Four affiliation and audit fees (LAWAL; IBRAHIM, 2022; MARTINEZ; MORAES, 2014), reinforcing the argument that these firms bring added value in terms of risk mitigation, transparency, and corporate accountability.

Company Size (LTA) and Audit Fees

The logarithm of total assets (LTA) is widely used as a proxy for company size in empirical accounting and auditing research (SIMUNIC, 1980; DEFOND *et al*., 2000). Larger companies tend to have more complex financial transactions, greater regulatory oversight, and a broader scope of operations, all of which require additional audit effort (HALLAK; SILVA, 2012). Consequently, larger firms generally incur higher audit fees, as their financial statements demand more detailed verification and risk assessment (LARBI, 2024).

Corporate Governance (CG) and Audit Fees

Corporate governance (CG) refers to the mechanisms, principles, and processes by which companies are controlled and directed. Strong governance structures ensure greater transparency, accountability, and adherence to regulatory standards, all of which can influence audit fees (BORTOLON *et al*., 2013). The literature suggests that companies with robust governance practices

face increased audit scrutiny, which can lead to higher fees due to more extensive testing and compliance measures (MORAES; MARTINEZ, 2014).

Market-to-Book Ratio (MTB) and Audit Fees

The market-to-book ratio (MTB) is a financial metric used to assess a company's valuation relative to its book value of equity. It is calculated as:

$$MTB = \frac{\text{Market Value of Equity}}{\text{Book Value of Equity}}$$

MTB values above 1 indicate that investors assign a higher market value to the company compared to its book equity, suggesting strong growth prospects or intangible asset contributions. Conversely, MTB values below 1 suggest that the company may be undervalued, facing financial distress, or operating inefficiently (NIKKINEN; SAHLSTRÖM, 2004).

Empirical research has shown that firms with higher MTB ratios tend to pay higher audit fees. This can be attributed to:

1. **Higher investor scrutiny**: Companies with high MTB ratios often attract more institutional investors, who demand rigorous financial reporting, leading to **more intensive audits** (SCOTT, 2024).
2. **Increased complexity**: High MTB firms may rely heavily on **intangible assets**, **goodwill**, or **financial instruments**, requiring additional audit procedures to verify valuation accuracy (AMBA, 2014).
3. **Regulatory oversight**: Companies with strong market valuations are often subject to **greater regulatory attention**, necessitating detailed audit testing (LARBI, 2024).

However, MTB may also act as a risk indicator for auditors, particularly when there are significant discrepancies between market value and book value. In such cases, auditors may charge higher fees to compensate for the additional risk associated with potential overvaluation, goodwill impairments, or financial statement adjustments (MARTINEZ; MORAES, 2014; ZHANG *et al*., 2022).

Summary and Theoretical Implications

The literature review highlights that audit fees are influenced by a combination of factors, including firm size (LTA), corporate governance (CG), Big Four audit firms affiliation, and market

valuation (MTB). Each of these factors interacts with audit complexity, regulatory requirements, and risk assessment procedures, shaping the cost structure of audit engagements.

Expanding the discussion on these topics reinforces the theoretical foundation of this study and aligns with prior research that emphasizes the multidimensional nature of audit pricing. This review also underscores the relevance of these factors in the Brazilian context, where governance standards and financial reporting requirements continue to evolve. The empirical analysis in subsequent sections will further investigate these relationships to provide insights into audit fee determinants in the basic materials sector.

METHODOLOGY

This study adopts a descriptive quantitative method to investigate the determinants of audit fees in the Basic Materials sector of the Brazilian Stock Exchange (B3). The data collection procedures were conducted using information provided by the Brazilian Securities Commission (CVM) and the Comdinheiro platform, resulting in a sample of 288 observations from 24 companies, spanning the period from 2011 to 2022. Regarding the data analysis procedures, the study employed descriptive statistics, correlations, and multiple and quantile regression models to explore the relationships between audit fees and factors such as asset size, corporate governance, and Big Four affiliation. Additionally, Variance Inflation Factor (VIF) analysis was carried out to assess multicollinearity among the variables, ensuring the robustness of the econometric models presented in the subsections.

Method

The study adopts a descriptive quantitative method, as described by Barros and Lehfeld (2000, p. 70), complemented by panel data analysis. Quantitative research is appropriate for testing hypotheses and examining causal relationships between variables using numerical data and statistics. In this study, panel data analysis and descriptive quantitative methodology are used to investigate and understand the relationship between audit fees and their determining variables over time and across different companies in the basic materials sector of the Brazilian stock market.

Additionally, to theoretically support the study and justify the choice of method and procedures adopted, a comprehensive literature review on the topic was conducted, as also performed by Putri and Bergmans (2021). The literature review aimed to identify relevant studies that address the relationship between independent auditor remuneration and the financial and operational variables of companies.

Based on this review, the main concepts, theoretical model, and statistical methods used in this work were outlined.

Data Collection Procedures

The sample selection focused on 31 companies in the basic materials sector of the Brazilian stock market, based on the market value of the aforementioned companies from 2011 to 2022. Thus, it was possible to compile a quantitative description of historical financial data, as per Soyemi (2021), resulting in 288 observations detailed in Table 1. The data were collected from two main sources: the website of the "Comissão de Valores Mobiliários (CVM)" and the "Comdinheiro" platform. It is noteworthy that this data is considered secondary, as it was originally compiled for purposes other than this specific research.

Table 1 - Sample Selection Process of Companies Listed on B3

Selection Criteria	Number of Companies
Companies Initially Listed on B3	31
Exclusions (Incomplete Data)	-7
Final Sample	**24**
Total Observations	**288**

Source: Self elaboration.

The **"Comissão de Valores Mobiliários (CVM)"** website provides information about the remuneration of independent auditors, obtained from reference forms available on the CVM website. These forms detail the fees paid for accounting audit services, classified by type of service

Data on auditor remuneration were collected with a focus on fees related to accounting audit services performed by independent auditors. This information was extracted through a documentary analysis of the reference form (FR), specifically based on section 2 (dedicated to independent auditors). This form specifies the total remuneration paid to independent auditors, categorized by type of service. A continuous effort was made to ensure the consistency and reliability of the information collected.

In turn, the **"Comdinheiro"** platform provides a database that offers access to detailed financial information about companies, including market value, assets, liabilities, profits, among others. Using this database, we obtained a variety of relevant information, such as companies' market value, accounts receivable, inventory, non-current assets, total assets, equity, operating cash flow, EBITDA, net revenue, net profit, operating cycle, return on assets, and return on equity. This data was then used to structure the variable framework of the study.

We collected data from 24 companies over 12 years, covering the period from 2011 to 2022, as

shown in Table 2. With the completion of the data collection and transformation stages, the variables were organized into a panel format, facilitating the longitudinal tracking of information for each company.

Table 2 - Basic Materials Sector of the Brazilian Stock Exchange - B3

Subsector	Company	Observations
Mining	Companhia Brasileira de Alumínio (CBA) S.A	
	CSN Mineração S.A	
	Vale S.A.	
Steel and Metallurgy	Ferbasa - Companhia de Ferro Ligas da Bahia S.A	12
	Gerdau S.A.	12
	Metalurgica Gerdau Sa	12
	CSN - Companhia Siderúrgica Nacional S.A.	12
	Usinas Siderúrgicas de Minas Gerais S.A. - Usiminas	12
	Mangels Indústria e Comércio S.A	12
	Panatlantica Indústrias S.A	12
	Tekno S.A - Indústria e Comércio	12
	Paranapanema S.A	12
Chemicals	Braskem S.A	12
	Dexxos Participações S.A.	12
	Nutriplant Indústria e Comércio SA	12
	Vittia Fertilizantes e Biológicos S.A.	12
	Unipar Carbocloro SA	12
	Dexco S/A	12
Wood and Paper	Eucatex S/A Indústria e Comércio	12
	Klabin S/A	12
	Suzano Holding S.A.	12
	Suzano S.A.	12
Packaging	Irani S.A.	12
Diverse Materials	Sansuy S.A. Indústria de Plásticos	12
Total	**24 Companies**	**288 Observations**

Source: B3
Note: This form is available on the CVM website.

Data Analysis Procedures

To analyze the collected data, the study adopted a quantitative approach. First, the data were tabulated and organized into an electronic database using statistical software. Descriptive analyses were then conducted to examine the basic characteristics of the data, such as means, medians, and standard deviations, as proposed by Deyganto (2021). Additionally, correlation analyses were performed to investigate the relationships between the variables of interest. Multiple linear regression models were applied to identify the main factors associated with the dependent variable. All statistical procedures were carried out with a significance level of 5%.

Variables

This section provides the definitions of the variables, most of which are derived from the financial information obtained from the Comdinheiro database. In order to address the research

hypotheses and understand the determinants of audit fees in the basic materials sector of the Brazilian Stock Exchange (B3), a set of variables that will be used for analysis is presented, as shown in Table 3:

Table 3 - Variables Used in the Research and Bibliographic References

Variable	Definition	Bibliography
AFEE	(Natural logarithm of audit fees)	Simunic (1980); Vasconcelos, Alves, Oliveira (2018)
LTA	(Company Size) represents the natural logarithm of total assets at the end of the fiscal year;	Simunic, (1980); DeFond, Francis, Wong, (2000)
GC	(Corporate Governance) is a dummy variable that takes the value of 1 for companies listed in one of the corporate governance segments of B3, and 0 for others.	Moraes, Martinez (2014); Bortolon *et al.* (2013)
BIG4	(Big Four) is a dummy variable that takes the value of 1 for companies audited by one of the four largest audit firms in the world (PricewaterhouseCoopers, Deloitte, Ernst and Young, and KPMG), and 0 for others.	Beatty (1989); Lawal, Ibrahim (2022)
MTB	(Market-to-Book Ratio) is the market-to-book (MTB) ratio, calculated as the market value of equity divided by the book value of equity.	Nikkinen and Sahlström (2004)
REPLAG	(REP - Results Announcement Period) is the number of days between the end of the fiscal year and the announcement of the company's financial results.	Kim (2024); Scott (2024)
AGE	(Company Age) represents the natural logarithm of the company's age.	Larbi (2024); Shakhatreh, Alsmadi (2021)
SGROWTH	(Sales Growth Rate) represents the sales growth rate compared to the previous fiscal year.	Penman, (2007)

Source: Self elaboration.

Econometric Model

Relationship between Audit Fees and Their Determinants

To test the hypothesis, the following equation was estimated using panel data:

$$AFEE = \beta 0 + \beta 1 LTA_{it} + \beta 2 GC_{it}) + \beta 3 BIG4_{it} + \beta 4 MTB_{(i\square)} + \beta 5 REP_{(i\square)} + \beta 6 AGE_{(i\square)} + \beta 7 SGROWTH_{(i\square)} + \epsilon_{(i\square)} \quad \text{.....(1)}$$

Where β_0 indicates the intercept, ε_{it} represents the error term, and the remaining variables are defined in the previous section. The estimation method is é *LS* (*Least Squares*), the same used by Cărăușu (2022). This model encompasses a broad set of variables potentially related to audit fees, aiming to investigate the influence of various factors on the aforementioned dependent variable. Additionally, the total assets variable is transformed using the natural logarithm for better alignment with the model's assumptions.

The hypothesis of interest is confirmed when the results of the statistical analysis reveal a statistically significant relationship between the dependent variable (audit fees) and at least one of the independent variables included in the model, such as the natural logarithm of total assets at the end of

the fiscal year (LTA) and its interaction with corporate governance (LTA×GC). In other words, if at least one of the independent variables shows statistical significance in explaining audit fees (a statistic indicating whether a result is real, usually a p-value below 0.05, rather than just a coincidence), then the hypothesis that these variables influence audit fees is considered confirmed.

Hypothesis Formulation

Auditor remuneration is a crucial factor in the context of financial auditing, reflecting not only the work performed but also the complexity and magnitude of the operations of the audited companies in the basic materials sector of the Brazilian stock market.

The size of a company's total assets is often considered an important indicator of the scale and complexity of its operations, which can impact the value of the fees paid to auditors. In this scenario, it is essential to investigate how the size of total assets influences auditor remuneration in order to better understand the dynamics between corporate size and the associated auditing costs.

Thus, in the specific context of basic materials companies on the Brazilian stock exchange, we have the following research hypotheses:

- Research Hypothesis 1 (H1): The larger the total assets of a basic materials company, the higher the remuneration demanded by auditors.

This hypothesis seeks to explore the relationship between the size of total assets and the fees paid to auditors. Companies with larger assets generally have more complex and extensive operations, which may require detailed and extensive audits. The complexity and scale of the operations of a large basic materials company can increase the time and resources needed to conduct the audit, justifying higher remuneration for the auditors.

- Research Hypothesis 2 (H2): Basic materials companies that implement effective corporate governance (CG) practices tend to pay higher audit fees.

This hypothesis examines the impact of corporate governance on the determination of audit fees. Companies with large assets not only face more complex operational challenges but may also adopt more robust governance practices.

The implementation of effective governance can influence these companies' willingness to pay higher fees to ensure the quality and integrity of the audit. Well-governed companies view high-quality auditing as an essential investment to maintain transparency and trust among stakeholders, resulting in a

greater willingness to pay for superior audit services.

In summary, analyzing these hypotheses in the basic materials sector of the Brazilian stock exchange can provide valuable insights into how companies manage audit costs based on their size and governance practices, contributing to the enhancement of audit and corporate governance policies.

RESULTS ANALYSIS

The results of this study are presented in an organized manner throughout this section. First, the data were analyzed using descriptive statistics and the correlation matrix of the variables, which are available in Tables 4 and 7, respectively. Table 4 provides a comprehensive overview of the central characteristics of the data, while Table 7 presents the correlations between the variables, highlighting the relationships and possible interdependencies among them.

Subsequently, the results of the econometric model estimation are presented, examining the relationship between audit fees and their determinants. These results are detailed in Table 9, highlighting the significant relationships identified throughout the analysis. To ensure the robustness of the regression models, the variance inflation factors (VIF) were calculated and reported in Table 8 to assess potential multicollinearity issues among the independent variables.

Finally, Table 10 presents the results of the quantile regression, which deepens the analysis by investigating how the determinants of audit fees behave at different points of the dependent variable's distribution, providing a more detailed view of the studied relationships.

Results

Descriptive Statistics

To conduct the econometric analysis, 288 observations were collected, and the descriptive statistics are summarized in Table 4. The variable AFEE, which represents the natural logarithm of audit fees, has a mean of 2.962, a median of 2.888, and a standard deviation of 0.715. These figures indicate that the audit fees paid exhibit little variation among the companies, with a range of values from 1.748 to 4.574. These numbers suggest a relative consistency in audit costs across the analyzed companies.

The size of the companies, represented by LTA (natural logarithm of total assets), has a mean of 8.677 and a standard deviation of 2.186, ranging from 4.067 to 13.120. This reflects a diversity in company sizes, encompassing both smaller firms and large corporations. The presence of companies of

different sizes is a relevant factor in determining audit fees, as larger companies tend to pay more for more complex audit services.

Table 4 - Descriptive Statistics

Variables	Mean	Median	Standard Deviation	Min	Max
AFEE	2.962	2.888	0.715	1.748	4.574
LTA	8.677	8.783	2.186	4.067	13.120
MTB	1.306	0.954	1.915	-5.035	14.501
REPLAG	74.427	67.500	36.532	32.000	322.000
AGE	42.708	46.000	14.548	2.000	81.000
SGROWTH	16.373	10.520	31.862	-57.454	314.546

Source: Self elaboration.
Note: AFEE represents the natural logarithm of audit fees; LTA represents the natural logarithm of total assets at the end of the fiscal year; LTA×GC: The interaction between LTA and GC helps to understand how the impact of asset size (LTA) on auditor remuneration may vary depending on whether the company adopts good corporate governance practices; MTB is the market-to-book (MTB) ratio, calculated as the market value of shares divided by the book value of equity; REPLAG is the number of days between the end of the fiscal year and the announcement of the company's financial results; AGE represents the company's age; SGROWTH represents the sales growth rate compared to the previous fiscal year.

The MTB variable (market-to-book ratio), with a mean of 1.306 and a standard deviation of 1.915, shows significant variation, ranging from -5.035 to 14.501. This indicator reflects the differences in market valuations compared to the companies' book values, suggesting that some companies are being traded at a significant premium, while others have market values below their book value.

The variable REPLAG, which measures the number of days between the fiscal year-end and the disclosure of financial results, has an average of 74.427 days, with a standard deviation of 36.532. The range, from 32 to 322 days, shows that some companies can report their results quickly, while others experience longer delays, potentially due to more complex internal processes or inefficiencies.

The average age of the companies (AGE) is 42.708 years, with a standard deviation of 14.548, ranging from 2 to 81 years. The presence of both newer and well-established companies suggests that the basic materials sector has a broad spectrum of firms, where maturity may influence the quality of governance and internal processes, thereby impacting audit fees.

Finally, the sales growth rate (SGROWTH) shows an average of 16.373% with a standard deviation of 31.862%. The extreme variation, ranging from -57.454% to 314.546%, indicates that company performance is highly heterogeneous, reflecting volatile market conditions and the impact of varying growth strategies.

These descriptive statistics provide a clear overview of the characteristics of companies in the basic materials sector and serve as a foundation for the econometric analysis of the determinants of audit fees.

Frequencies of Dummy Variables

Dummy variables are essential for capturing relevant qualitative aspects in the context of companies in the basic materials sector. Table 5 presents the frequencies of the BIG4 and GC variables, providing a clear view of how these variables are distributed.

The BIG4 variable indicates that 72.92% of the companies in the sample are audited by one of the four largest audit firms in the world (PricewaterhouseCoopers, Deloitte, Ernst and Young, and KPMG). This predominance reflects the confidence of the basic materials sector in the ability of these large firms to handle the complexity of operations for companies of this size. Choosing one of these audit firms is generally associated with the superior quality of the services offered, which may justify the payment of higher fees compared to smaller audit firms.

Table 5 - Frequencies of Dummy Variables

Variables	Category	Frequency	Percentage (%)
BIG4	0	78	27,08
	1	210	72,92
GC	0	84	29,17
	1	204	70,83

Source: Self elaboration.
Note: Big4 is a dummy variable that takes the value of 1 for companies audited by one of the four largest audit firms in the world (PricewaterhouseCoopers, Deloitte, Ernst and Young, and KPMG) and 0 for others; GC (Corporate Governance) is a dummy variable that takes the value of 1 for companies listed in one of the corporate governance segments of B3 and 0 for others.

Regarding Corporate Governance (GC), it is observed that 70.83% of the companies are listed in corporate governance segments of B3. This demonstrates that the majority of companies in the sector adhere to good governance practices, which enhances transparency and investor confidence. The adoption of these practices can directly influence the level of audit fees, as companies with robust governance tend to require more rigorous and detailed audits.

These results indicate that both the presence of the Big Four and adherence to corporate governance practices are common characteristics among companies in the basic materials sector, significantly impacting audit fees. The use of reputable audit firms and the adoption of good governance practices increase the rigor of audit processes, resulting in higher costs and greater quality and confidence in financial statements.

Univariate Analysis of Mean Differences

The univariate analysis of mean differences between the quartiles (Q1 and Q4) was conducted for the variables audit fees and LTA, aiming to identify patterns or trends in the distribution of these variables across different quartiles. Table 6 presents the average values of these variables for each quartile, providing a clear view of how the values vary among the groups.

Table 6 - Univariate Mean Difference Test

Variables	Q1 (25%)	Q2 (50%)	Q3 (75%)	Q4 (100%)
Audit Fees	2,461	2,889	3,368	4,574
LTA - Mean	6,804	7,288	9,484	11,133

Source: Self elaboration

In the case of audit fees, it is observed that companies in the upper quartile (Q4) pay significantly higher fees, with an average of 4.574, compared to the lower quartile (Q1), which has an average of 2.461. This pronounced increase suggests a positive relationship between the level of audit fees and quartile position, indicating that larger companies or those with more complex operations incur higher costs for auditors. This result can be explained by the greater need for detailed audits and the level of regulatory scrutiny that larger companies face.

The LTA variable, which represents the natural logarithm of total assets, also exhibits an increasing trend across the quartiles. Companies in the upper quartile (Q4) have an average of 11.133, while those in the lower quartile (Q1) show an average of 6.804. This reinforces the positive correlation between company size and audit fees, suggesting that companies with larger asset volumes require more rigorous audits, which is reflected in the associated costs.

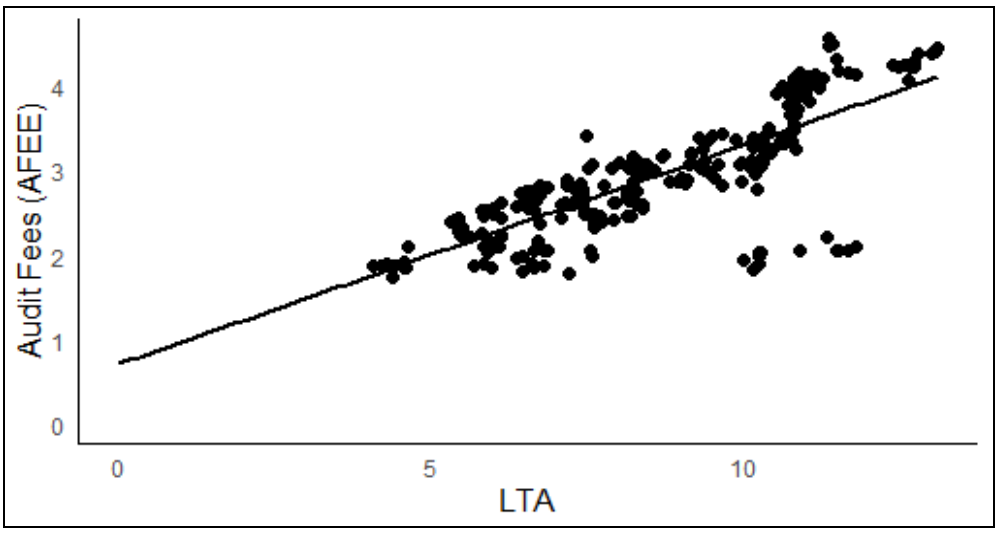
The Welch t-test, conducted to compare groups Q1 and Q4, confirms that the differences observed between the quartiles are statistically significant. In particular, the estimated difference of -2.113 for audit fees between the two groups indicates that companies in the upper quartile pay significantly more for audit services compared to companies in the lower quartile.

These results highlight that the size of the company and operational complexity have a direct impact on audit fees. Larger companies with more complex operations tend to incur higher costs for audits due to the need for greater scrutiny and detail in the auditing processes. The quartile analysis provides an important perspective on how financial and auditing management needs to be adjusted to address the specific demands of each group, particularly regarding the allocation of resources for detailed audits and the management of corporate risks.

Scatter Plot

The scatter plot above illustrates the relationship between audit fees (AFEE) and the natural logarithm of total assets (LTA). The goal is to demonstrate how the size of the assets directly influences the fees paid to auditors.

Graph 1 - Scatter Plot of Audit Fees Distribution (2011–2022)



Source: Self elaboration

There is a clear positive correlation between audit fees (AFEE) and the natural logarithm of total assets (LTA). As the size of the assets increases, audit fees also tend to rise. This behavior is represented by the trend line, which has an upward slope. This pattern reinforces the idea that larger companies, with greater asset volumes, require more detailed and complex audits, resulting in higher fees. The scatter points are mostly concentrated around the trend line, suggesting a strong correlation between company size and audit costs. However, there are some outliers, indicating that some companies, regardless of size, may pay lower or higher audit fees due to other factors not directly represented by LTA. In summary, the graph illustrates that asset size (LTA) is one of the primary factors influencing audit fees. Companies with larger assets tend to incur higher audit costs, which can be explained by the increased complexity of their operations and the need for more rigorous audits. The linear relationship between the two variables highlights that company size is a crucial determinant in the context of auditing.

Correlation Matrix of Variables

The analysis of the Spearman correlation matrix, presented in Table 7, reveals significant relationships between the analyzed variables, without the need for data normality, as confirmed by the Shapiro-Wilk test. The Spearman correlation is suitable when the assumptions of linearity and normality of the data are not guaranteed, as may be the case with the data in this study.

The strongest correlation observed was between audit fees (AFEE) and the size of total assets (LTA), with a coefficient of 0.790. This result indicates that larger companies, with a higher volume of assets, tend to pay higher audit fees. This is consistent with the expectation that larger companies have more complex operations and require more detailed audits, which justifies the higher costs.

Table 7 - Correlation Matrix

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	
(1)	AFEE		0.790	0.473	-0.471	0.062	0.037	Spearman
(2)	LTA	0.792		0.345	-0.401	0.059	0.074	
(3)	MTB	0.289	0.228		-0.260	-0.050	0.174	
(4)	REPLAG	-0.321	-0.221	-0.009		0.133	0.052	
(5)	AGE	0.041	0.062	-0.048	0.185		0.074	
(6)	SGROWTH	-0.014	0.043	0.061	0.054	0.091		
				Pearson				

Source: Self Elaboration.

Note: Where: AFEE represents the natural logarithm of audit fees; LTA represents the natural logarithm of total assets at the end of the fiscal year; LTA×GC: The interaction LTA×GC helps to understand how the impact of asset size (LTA) on auditor remuneration may vary as the company adopts good corporate governance practices; MTB is the market-to-book (MTB) ratio, calculated as the market value of shares divided by the book value of equity; REPLAG is the number of days elapsed between the end of the fiscal year and the announcement of the company's financial results; AGE represents the age of the company; SGROWTH represents the sales growth rate compared to the previous fiscal year.

Another relevant result is the positive correlation between AFEE and MTB (0.473), suggesting that companies with higher market valuation relative to book value tend to pay higher audit fees. This can be explained by the fact that more valued companies may be under greater scrutiny and, therefore, require more robust audits to ensure the transparency and accuracy of their financial statements.

The negative correlation between AFEE and REPLAG (-0.471) indicates that companies that take longer to disclose their financial results tend to pay less for audit services. This result may be related to the lower complexity of these companies or to a lesser degree of rigor required in the audit process.

Variables such as AGE (age of the company) and SGROWTH (sales growth) showed weak correlations with AFEE, with coefficients of 0.062 and 0.037, respectively. This suggests that the age of the company and sales growth have a minimal impact on audit fees in the basic materials sector.

It is important to highlight that the BIG4 and GC variables are dummies, and therefore, they were excluded from the correlation analysis and examined separately through frequency analysis.

These results reinforce the relevance of company size, measured by LTA, and market valuation (MTB) as crucial factors in determining audit fees. The Spearman correlation analysis also shows that variables such as company age and sales growth have a much lesser influence in this context.

Multicollinearity Analysis (VIF)

Table 8 presents the Variance Inflation Factors (VIF) of the independent variables used in the regression models, along with their respective inverses (1/VIF). The VIF is an essential metric for assessing the presence of multicollinearity among the explanatory variables, meaning it checks for significant correlation among the independent variables, which could affect the accuracy of the estimated coefficients in the regression model.

Table 8 - Variance Inflation Factors (VIF) of the Independent Variables in the Regression Models

Variable	VIF	1/VIF
LTA	1.354	0.738
GC	1.212	0.824
BIG4	1.313	0.761
MTB	1.084	0.921
REPLAG	1.150	0.868
AGE	1.150	0.869
SGROWTH	1.017	0.982

Source: Self Elaboration.

The results indicate that all variables have VIF values below 2, suggesting low multicollinearity in the models. VIF values below 10 are generally considered acceptable, and in this case, the variables are well within this limit, indicating that multicollinearity should not be a significant issue in the coefficient estimates.

Among the analyzed variables, the size of the company (LTA) showed the highest VIF (1.354), which is expected given its prominent role in explaining audit fees. Although it is the highest value in the table, it is still well below the critical limit of 10, suggesting that there are no significant multicollinearity issues.

The corporate governance (GC) variable, with a VIF of 1.212, and the BIG4 variable, with a VIF of 1.313, show low VIF values, indicating that these variables have minimal correlation with the others. This means that their estimates in the regression model will be reliable.

Other variables, such as MTB (1.084), REPLAG (1.150), AGE (1.150), and SGROWTH (1.017), also show very low VIF values, further reinforcing that there is no excessive correlation between these variables and the others. These results ensure the robustness of the model and the accuracy of the coefficient estimates.

The values of 1/VIF, which are the inverses of the variance inflation factors, range from 0.738 (for LTA) to 0.982 (for SGROWTH), confirming that the variables are within an acceptable range of correlation. These results indicate that the regression model has low multicollinearity, reinforcing the reliability of the estimates and the robustness of the model.

The low correlation among the explanatory variables ensures that the coefficients are not distorted, guaranteeing the validity of the conclusions.

Therefore, the multicollinearity analysis demonstrates that the model used is suitable for investigating the determinants of audit fees in the basic materials sector.

Discussion

The results presented in Table 9 provide a detailed view of the factors that affect audit fees in companies from the basic materials sector listed on the Brazilian stock exchange. With an R-squared of 0.727, it is evident that most of the variation in fees can be explained by the selected independent variables, indicating the robustness of the model in identifying the main determinants of these costs. Additionally, an F-statistic of 106.918 confirms the significance of at least one independent variable in explaining the dependent variable, with a p-value indicating a significance level of 0.05.

Table 9 - Relationship Between Audit Fees and Their Determinants

Variables	AFEE
C	0.879***
LTA	0.204***
GC	0.327***
BIG4	0.223***
MTB	0.035**
REPLAG	-0.002***
AGE	0.002
SCROWTH	-0.000
R-Squared	0.727
Adjusted R-Squared	0.720
Standard Error	0.377
F-Statistic	106.918
Observations	288

Source: Self elaboration.
Note: AFEE represents the natural logarithm of audit fees; LTA represents the natural logarithm of total assets at the end of the fiscal year; GC is a dummy variable that takes the value of 1 for cases listed in one of the corporate governance segments of B3 and the value of 0 for others; Big4 is a dummy variable that takes the value of 1 for companies belonging to the four largest auditing firms in the world, known as the Big Four (PricewaterhouseCoopers, Deloitte, Ernst and Young, and KPMG), and the value of 0 for other companies; MTB is the market-to-book ratio (MTB), calculated as the market value of shares divided by the book value of equity; REPLAG is the number of days elapsed between the end of the fiscal year and the announcement of the company's financial results; AGE represents the age of the company; SGROWTH represents the growth rate in sales compared to the previous fiscal year. ***, ** and * indicate significance at the 1%, 5% and 10%.

Among the findings, the intercept (C) has a coefficient of 0.879 and statistical significance ($p < 0.01$), suggesting that there are intrinsic costs associated with audit fees, regardless of other variables. This result reinforces the idea that certain baseline costs are necessary to ensure the quality and compliance of audits (KAJOLA *et al*. 2022).

The Natural Logarithm of Total Assets (LTA), with a coefficient of 0.204 and significance ($p < 0.01$), highlights the strong influence of asset size on audit fees. This result confirms **Research Hypothesis 1 (H1), which proposes that the larger the total assets of a basic materials company, the higher the remuneration demanded by auditors**. Larger companies with more assets require more detailed audits, as stated by Kajola *et al*. (2022) and corroborated by Lawal and Ibrahim (2022). These more complex audits reflect the greater diversity of transactions and the more robust governance structure of these companies, as suggested by Tania and Tarmizi (2023). Therefore, asset size is one of the most influential factors in audit fees.

Corporate governance (GC), with a coefficient of 0.327 and statistical significance ($p < 0.01$),

has also proven to be an important factor in determining audit fees. This result confirms **Research Hypothesis 2 (H2), which suggests that basic materials companies that implement effective corporate governance practices tend to pay higher audit fees. Companies with better governance practices require more rigorous audits, resulting in higher costs.** This finding is consistent with Xue and O'Sullivan (2023) and Shakhatreh (2021), who highlight the relevance of governance in enhancing the transparency and reliability of financial information.

The positive and significant association between audit fees and the hiring of the Big Four (coefficient of 0.223) indicates that companies pay a premium for engaging these large audit firms, as suggested by Larbi (2024). This reflects the pursuit of credibility and greater rigor in audit processes, ensuring the mitigation of financial and operational risks.

The coefficient of the MTB variable (0.035, $p < 0.05$) suggests that companies with a higher market valuation relative to their book value also pay higher audit fees. This result can be interpreted as a reflection of the greater scrutiny that more highly valued companies face in the market.

The REPLAG variable, with a negative coefficient of -0.002 and statistical significance ($p < 0.01$), suggests that companies that take longer to disclose their financial results tend to pay less for audit services, possibly due to a lower complexity or less rigor required in the audit process.

On the other hand, variables such as AGE and SGROWTH were not statistically significant in the model, suggesting that, in this specific context, these variables have a lesser impact on audit fees. This underscores the need for future studies to explore these variables in different scenarios or with alternative methodological approaches. In summary, this detailed analysis not only provides valuable insights into the determinants of audit fees in the basic materials sector but also raises questions about the relationship between corporate governance, choice of audit firms, and the complexity of companies' operations, outlining a fertile ground for future investigations.

Interpretation of Quantile Regression Results

To ensure the robustness of the results, Table 10 was created, presenting the quantile regression results on the relationship between audit fees (LAF) and their determinants. This approach provides a more detailed analysis of the effects of the explanatory variables at different points in the distribution of audit fees, allowing for the identification of how these factors impact companies with varying risk characteristics and capital structures—something that a conventional linear regression, focused solely on average effects, would not be able to capture.

Table 10 - Quantile Regression on the relationship between Audit Fees and their Determinants

Variables	AFEE		
	Q1	Q2	Q3
C	1.271***	0.848***	0.683***
LTA	0.139***	0.220***	0.277***
GC	0.364***	0.084	0.077
BIG4	0.262***	0.339***	0.133**
MTB	0.054**	0.026**	0.012
REPLAG	-0.004	0.000	0.000
AGE	0.000	-0.002**	-0.000
SCROWTH	0.000	-0.001***	-0.001***
Pseudo R-squared	0.481	0.540	0.609
Adjusted R-squared	0.468	0.529	0.600
Standard error	0.484	0.412	0.495
Prob(Quasi-LR stat)	0.000	0.000	0.000
Observations	288	288	288

Source: Self elaboration.

Note: AFEE represents the natural logarithm of audit fees; LTA represents the natural logarithm of total assets at the end of the fiscal year; GC is a dummy variable that takes the value of 1 for companies listed in one of the corporate governance segments of B3 and the value of 0 for others; Big4 is a dummy variable that takes the value of 1 for companies belonging to the four largest auditing firms in the world, known as the Big Four (PricewaterhouseCoopers, Deloitte, Ernst and Young, and KPMG), and the value of 0 for other companies; MTB is the market-to-book (MTB) ratio, calculated as the market value of equity divided by the book value of equity; REPLAG is the number of days between the end of the fiscal year and the announcement of the company's financial results; AGE represents the age of the company; and SGROWTH represents the growth rate in sales compared to the previous fiscal year. ***, ** and * indicate significance at the 1%, 5% and 10%.

When analyzing the results, it can be observed that LTA (Natural Logarithm of Total Assets) shows positive and significant coefficients across all quantiles, indicating that company size is a fundamental factor in determining audit fees, regardless of the level at which the company falls within the distribution. In the first quartile (Q1), the coefficient for LTA is 0.139, while in the third quartile (Q3), it increases to 0.277, highlighting that as the size of assets grows, audit fees also rise, reinforcing the increasing complexity of operations in larger companies.

The variable BIG4, which indicates whether the company is audited by one of the Big Four accounting firms, is also significant across all quantiles, with coefficients ranging from 0.262 in Q1 to 0.133 in Q3. This demonstrates that, regardless of the size of the company, the Big Four firms charge a premium for their services, which can be interpreted as a reflection of the quality and reputation these audit firms bring to the market. This perception of greater credibility and rigor in audit processes remains a relevant factor in justifying the higher fees.

Corporate Governance (GC) has a more significant impact on companies with lower audit fees, with a coefficient of 0.364 in Q1. However, its significance diminishes in the higher quartiles, losing strength in the second (Q2) and third (Q3) quantiles, where its coefficients are not significant. This may suggest that, in smaller companies, good governance practices serve as a differentiating factor that justifies higher audit fees. In larger companies, which are likely to have a more established governance structure, the impact of governance on audit costs becomes less pronounced.

Other determinants of audit fees include the Market-to-Book (MTB) ratio, which is positive and significant in the first two quartiles, with coefficients of 0.054 in Q1 and 0.026 in Q2, but loses significance in the third quartile. This suggests that companies with a higher market valuation relative to

their book value tend to pay higher audit fees in the lower levels of cost distribution, possibly reflecting a need for more detailed audits to ensure the accuracy of these market assessments.

On the other hand, the timing of financial results disclosure (REPLAG) showed a negative, albeit significant, correlation only in the first quartile, indicating that companies that take longer to disclose their results tend to pay less for audit services. This may be related to the fact that these companies might face less complexity or rigor in the audit process, especially among smaller firms. Regarding the variable AGE (age of the company), negative and significant coefficients were observed in the second quartile, but without statistical relevance in the other quantiles, suggesting that the age of the company does not have a consistent impact on audit fees. Growth in sales (SGROWTH), in turn, presented negative and significant coefficients in the upper quantiles, which may indicate that rapidly growing companies might be investing more in other areas than in auditing.

These results provide important insights for the market, showing that, in addition to the size of the company and the choice of a Big Four firm, corporate governance and other factors such as market valuation and the timing of results disclosure also play crucial roles in determining audit fees. The impact of corporate governance is more pronounced in smaller companies, while the size of the company and the presence of a Big Four firm are consistent determinants throughout the distribution. The quantile analysis highlights that these factors affect companies in different ways, providing a more comprehensive view of the impact of governance and operational complexity on audit costs in the basic materials sector of B3.

Contribution Obtained from the Results

The results of this study provide three main contributions that enhance the understanding of the relationship between audit fees and their determinants in Brazil, focusing on the basic materials sector. First, it was confirmed that the size of assets (LTA) is a significant determinant of audit fees, regardless of the company's position in the distribution of audit costs. Larger companies pay higher fees, reflecting the increasing complexity of their operations, in line with the need for more robust audits. These findings are consistent with those of Simunic (1980) and Vasconcelos *et al*. (2018), who also demonstrated the importance of asset size in determining audit fees in various contexts. However, while Simunic (1980) focused primarily on developed markets, the results of this study extend the understanding of this relationship to an emerging market context, showcasing the similarities and differences between these environments. This comparison reveals that in both developed and emerging markets, larger companies necessitate more complex and extensive audits, justifying higher audit fees.

Second, corporate governance (GC) was identified as a relevant factor, particularly in smaller companies, where good governance practices amplify audit costs due to higher demands for transparency and compliance. This highlights that companies with stronger governance practices require more rigorous audits and consequently incur higher costs. These findings corroborate the studies by Moraes e Martinez (2014) and Bortolon *et al*. (2013), which also observed that robust governance structures are associated with higher audit fees. Additionally, unlike Moraes and Martinez (2014), this study identifies that the impact of corporate governance is more pronounced among smaller firms, suggesting that smaller companies face proportionally greater pressure to demonstrate transparency and accountability when adopting stronger governance practices.

Finally, the results of this study provide new empirical evidence regarding the influence of the Big Four on audit fees. Companies audited by one of the four major firms tend to pay a premium for higher quality services, reflecting the pursuit of credibility in the market. These findings align with those of Lawal and Ibrahim (2022), who noted that Big Four auditors consistently charge higher fees due to their reputation and expertise. However, in contrast to Lawal and Ibrahim (2022), who argued that the Big Four's influence is weaker in emerging markets, this study demonstrates that their impact on audit fees in Brazil remains significant, suggesting a growing demand for high-quality auditing services even in developing economies.

In summary, the triangulation of these findings with prior research enriches the understanding of audit fees' determinants in both developed and emerging markets, highlighting unique aspects of the Brazilian context. This study's contributions emphasize the interplay between asset size, governance practices, and auditor choice in shaping audit costs, offering valuable insights for future research and practical applications.

CONCLUSION

The analysis of the results reveals crucial information about the determinants of audit fees in the basic materials sector of the Brazilian stock market. Using a robust regression model and analyzing a detailed sample of 288 observations covering the period from 2011 to 2022, it was found that both the size of the company and corporate governance practices have a significant influence on the determination of audit fees.

First, Research Hypothesis 1 (H1) is confirmed, highlighting that the total assets size (LTA) has a significant influence on audit fees. The positive and highly significant coefficient of LTA underscores that companies with larger assets pay higher audit fees. This is due to the greater complexity and

expanded scope of their operations, requiring more detailed and rigorous audits, as suggested by existing literature. Larger companies have a diversity of transactions and processes that increase the need for thorough audits, thus reflecting in higher costs.

Additionally, Research Hypothesis 2 (H2) is also confirmed, highlighting the fundamental role of corporate governance (GC) in the relationship between asset size and audit fees. The results show that companies with effective corporate governance practices tend to pay higher audit fees, especially those with a larger volume of assets. This finding suggests that solid governance intensifies the impact of company size on audit costs, reflecting the need to ensure the quality and integrity of the audit process in well-managed companies. This aligns with what the literature suggests regarding the relevance of governance practices in the audit context.

Furthermore, the analysis shows that hiring renowned audit firms, such as the Big Four, is associated with higher fees. Companies that choose these large audit firms seek greater credibility and rigor in the audit processes, which justifies paying a premium for these services. The MTB (Market-to-Book) variable also proved significant, highlighting that companies with higher market valuations tend to pay higher audit fees. On the other hand, variables such as REPLAG, AGE, and SGROWTH did not exhibit statistical significance in this study, suggesting that these factors may not have a direct impact on audit fees in the basic materials sector, or that their influence may depend on other specific contexts.

In summary, this study provides an in-depth understanding of the key factors that determine audit fees in the basic materials sector. The confirmation of the hypotheses regarding the impact of asset size and corporate governance highlights the importance of considering these variables when analyzing audit costs. These insights offer a solid foundation for future research in the fields of accounting and auditing, as well as contributing to professional practice by helping managers and auditors make more informed decisions about the costs associated with auditing in companies with different profiles and governance structures.

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