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Hedge Accounting and Gross Margin Volatility in Brazilian Agribusiness Companies

Hedge Accounting e a Volatilidade da Margem Bruta em Empresas do Agronegócio Brasileiro

Wesley Carvalho

FECAP

wesley.carvalho@m2msaber.com.br

Elionor Farah Jreige Weffort

FECAP

eweffort@gmail.com

Eric Barreto

INSPER

eric.barreto@m2msaber.com.br

ABSTRACT

This study aimed to verify whether Brazilian agribusiness companies that adopt foreign exchange hedge accounting (HACMB) and commodities hedge accounting (HACDTY) showed lower gross margin volatility (ΔMB) than companies that do not, in the period from 2013 to 2021. The relevance of the research stems from the scarcity of studies that deal with the effect of hedge accounting on operational performance indicators in companies in the sector, particularly in Brazil, where market risk, such as exchange rate and commodity price variations, is highly relevant. The methodology adopted was a quantitative approach, using descriptive statistical analysis and robust multiple regression with panel data. The sample included 29 agribusiness companies, selected from the magazine Exame – Melhores & Maiores do Agronegócio, totaling 263 financial statements analyzed and 205 observations. The results revealed that companies that adopt HACMB and HACDTY had lower ΔMB compared to those that do not. This relationship was statistically significant and consistent between different sectors of agribusiness, with emphasis on animal protein, oils, flours and preservatives, and cotton and grains. The findings are in line with the national and international literature, reinforcing that hedge accounting contributes to greater stability in accounting results related to the performance of operating activities. The practical contribution lies in demonstrating to managers and investors the benefits of adopting hedge accounting for the stability of accounting results related to the performance of operating activities. As for theory, the study expands the understanding of the accounting effects of risk management in the context of Brazilian agribusiness.

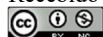
Keywords: Agribusiness, commodities, exchange, hedge accounting.

RESUMO

Este estudo objetivou verificar se as empresas do agronegócio brasileiro que adotam hedge accounting de câmbio (HACMB) e de commodities (HACDTY) apresentaram menor volatilidade da margem bruta (ΔMB) do que empresas que não adotam, entre 2013 e 2021. A relevância da pesquisa decorre da escassez de estudos que tratem do efeito da contabilidade de hedge sobre indicadores operacionais de desempenho em empresas do setor, particularmente no Brasil, onde o risco de mercado, como variações cambiais e de preços de commodities é altamente relevante. A metodologia adotada foi pela abordagem quantitativa, utilizando análise estatística descritiva e regressão múltipla robusta com dados em painel. A amostra abrangeu 29 empresas do agronegócio, selecionadas a partir da revista Exame – Melhores & Maiores do Agronegócio, totalizando 263 demonstrações financeiras e 205 observações. Os resultados revelaram que empresas que adotam HACMB e HACDTY apresentaram menor ΔMB em relação às que não adotam. Essa relação foi estatisticamente significativa e consistente entre diferentes setores do agronegócio, com destaque para proteína animal, óleos, farinhas e conservantes e algodão e grãos. Os achados estão alinhados com a literatura nacional e internacional, reforçando que o hedge accounting contribui para maior estabilidade nos resultados contábeis relativos ao desempenho das atividades operacionais. A contribuição prática está em demonstrar aos gestores e investidores os benefícios da adoção de hedge accounting para estabilidade dos resultados contábeis relativos ao desempenho das atividades operacionais. Já à teoria, o estudo amplia o entendimento sobre os efeitos contábeis da gestão de risco no contexto do agronegócio brasileiro.

Palavras-chave: Agronegócio, commodities, câmbio, hedge accounting.

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1 INTRODUCTION

As stated by Knight (1921), risk refers to future events characterized by a certain degree of uncertainty, but subject to quantification. In the business context, efforts are directed toward quantifying risk, understood as fundamental to the continuity of a business. These risks often relate to operational activities, whose transactions may generate a wide range of risks. Within the scope of this paper, such risks are associated with market risk.

In this regard, one of the sectors most influenced by market risk factors is agribusiness, in which a substantial component of its activities is linked to commodity price fluctuations. Commodity prices are highly volatile, as a result of various factors such as exogenous and uncontrollable events—e.g., climate vulnerability, fiscal and monetary policies, and market dynamics related to product commercialization. These elements directly affect commodity prices, generating volatility (De Zen et al., 2006; Gimenes, 2008; Rosalem et al., 2008; Souza et al., 2011; Andrade & Lima, 2012; Calegari et al., 2012; Silveira et al., 2012; Souza et al., 2012; Middelberg et al., 2013; Barabach & Lobo e Silva, 2015; Rodrigues & Martines, 2016; Oliveira & Santos, 2017). Moreover, exchange rate risk is also present for companies whose functional currency does not match the currency in which the traded commodity is quoted—most commonly the U.S. dollar. Thus, any disparity between a functional currency and the quoted currency of the respective commodity gives rise to exchange rate risk, in addition to the inherent commodity price risk. Accordingly, it is important to emphasize that agribusiness firms trading commodities face, as their primary market risk, the fluctuation in one or more commodity prices, even though their economic environment, financing, and investment decisions may also generate exposure to exchange rate and interest rate risks.

It is noteworthy that unfavorable price fluctuations may impair projected cash flows to the extent that companies may become unable to cover production costs, making investment and financing plans more costly, or even unfeasible, potentially leading to insolvency and business discontinuity (Froot, Scharfstein, & Stein, 1993; Stewart, 1989; De Zen et al., 2006; Saito & Schiozer, 2007; Andrade & Lima, 2012). Therefore, hedging practices emerge as a response to the intolerance of unfavorable market volatilities (Stulz, 1984). To that end, derivative markets were developed, providing financial instruments that enable the transfer or, in some cases, the limitation of risks which, under the lens of risk management and hedging policies, an entity should not remain exposed to (Costa Pinto, 1994).

In Brazil, prior to the adoption of IFRS, derivatives were not subject to accounting recognition throughout the contract's life cycle, which made it more difficult to understand their intended use based on financial statements. Following regulatory changes, derivatives began to be recognized at fair value through profit or loss, thereby increasing earnings volatility, mainly due to accounting mismatches between the treatment of the derivative and the underlying exposure (Chiqueto, 2014). The first accounting standard for derivatives was issued by the FASB, making the release of SFAS 133 a milestone in derivative regulation (Capeletto, Oliveira, & Carvalho, 2007). This applied both to the recognition of derivatives at fair value through profit or loss (Chiqueto, 2014) and to the creation of an optional accounting treatment known as hedge accounting, which seeks to achieve symmetry between the accounting effects of the instrument and those of the hedged exposure, in accordance with the accrual principle (Araujo, Ikuno, Paulo, & Sales, 2011). This treatment represents a more faithful depiction of hedging practices in financial statements.

Accordingly, this study focuses on agribusiness firms whose major market risk exposures stem from commodity prices and foreign exchange fluctuations related to the currencies in which those commodities are traded. Given these circumstances, such firms require consistent risk management practices to reduce the probability of unfavorable events

arising from fluctuations in commodity and foreign currency quotations. A substantial portion of the outcomes of these firms' operating activities is recognized in the income statement as revenue or cost, directly impacting gross profit and gross margin. While isolated hedging practices reduce market risk exposures, they also generate accounting mismatches, since the derivative is recognized at fair value through profit or loss, whereas the hedged item generally remains off-balance sheet and is only recognized in operating results when product or commodity sales occur. For hedging effects to be recognized on a comparable accrual basis—ensuring that the results of the hedging instrument and the hedged item are aligned—hedge accounting (H.A.) designation is required. Fundamentally, this results in lower gross margin volatility (ΔGM) attributable to the hedged risk. It should be noted that, although there is no regulatory requirement mandating that the hedging effect be recognized within operating accounts, evidence suggests that this practice is widespread among companies, a premise reinforced by auditing firms. These auditors often interpret disparities across income statement lines as a form of accounting mismatch (EY, 2019).

Although research has been conducted on hedging practices and hedge accounting across a broad spectrum of firms and countries (DeMarzo & Duffie, 1995; Allayannis & Weston, 2001; De Zen, Yatabe, & Carvalho, 2006; Zhang, 2009; Glaum & Klocker, 2011; Panaretou, Schackleton, & Taylor, 2013; Chiqueto, 2014; Beneda, 2016; Pierce, 2020), there remains a gap concerning the adoption of hedge accounting by agribusiness companies and the accounting effects of this practice on operating results, specifically in relation to its impact on ΔGM . This leads to the guiding research question: Is there evidence that gross margin volatility (ΔGM) was lower among agribusiness companies that adopted hedge accounting between 2013 and 2021?

The relevance of this study lies in both its theoretical and practical contributions, particularly in demonstrating the capacity of hedge accounting to capture the effects of commodity price and exchange rate protection when applied to operational exposures of agribusiness firms. This accounting approach enables a more accurate alignment between risk management strategies and objectives and their financial impacts, thereby ensuring greater faithful representation in financial statements.

In this regard, the presentation of hedging effects in operating accounts should affect performance indicators such as EBITDA, and consequently, may influence firm valuation. Moreover, the cost of debt capital may also be better represented, as recognizing the hedging effect in operating income prevents distortions in financial results. In other words, hedge accounting applied to operational activities of agribusiness firms has the potential to correct key performance indicators, with its impact on gross margin volatility representing the core focus of this study. Therefore, the overall objective of this research is to verify whether there is evidence that ΔGM was lower in agribusiness firms that adopted HACMB or HACDTY between 2013 and 2021, compared with those that did not.

2 THEORETICAL FRAMEWORD

2.1 HEDGING IN AGRIBUSINESS AND HEDGE ACCOUNTING

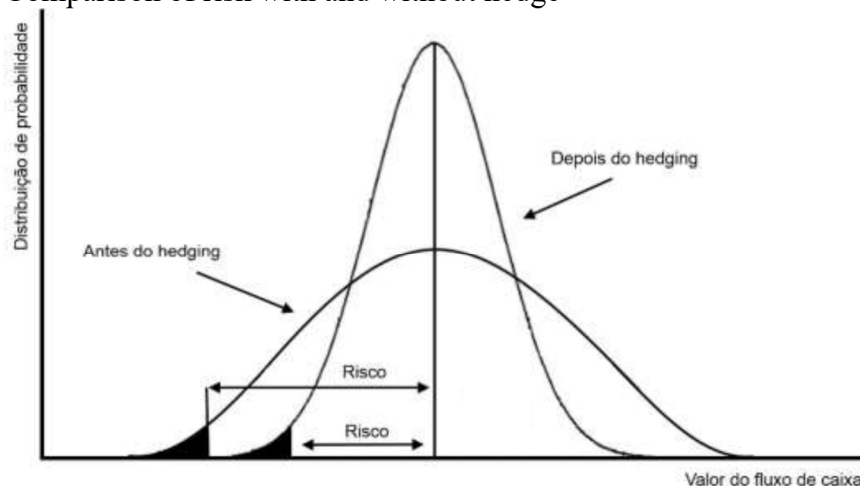
In summary, within agribusiness, the most widely used derivatives for risk management are options, futures, and forward contracts, as they best reflect the economic essence of market risks in the sector. Typically, the hedged exposure in a hedging relationship corresponds to an off-balance sheet component, such as a highly probable forecasted transaction or a firm commitment not yet recognized, usually associated with the sale or purchase of commodities. Over time, such exposures may vary depending on the productive performance of the business.

Through derivatives, companies are able to fix or limit price variations of products

purchased for resale, consumption, or processing, as well as those produced and sold. This practice limits fluctuations in economic profit margins, leading to more accurate cash flow projections (Calegari et al., 2012), which consequently reduces risk (Trindade, Ambrozini, Magnani, & Antônio, 2020). Figure 1 illustrates this through a normal distribution graph that demonstrates the exposure of a given cash flow before and after hedging. Assuming an effective hedge, the figure shows that the probability distribution of cash flows narrows after hedging—thereby evidencing risk reduction:

Figure 1

Comparison of risk with and without hedge



Source: “Teoria do Hedge: Recortes teórico-empíricos aplicados à gestão do risco com derivativos”, C. U. Carmona, J. T. Aquino, B. J. Paredes, & M. L. Torres, 2014. *Revista de Informação Contábil*.

In the context of commodity hedging, one of the key challenges lies in determining the optimal hedge ratio in order to achieve maximum effectiveness in protecting against price fluctuations (Yaganti & Kamaiah, 2012). This challenge is particularly relevant in agribusiness, as certain hedging structures cannot always be designed using tailor-made derivatives, given that appropriate instruments may not exist. In such cases, risk may be hedged with a similar—but not identical—underlying asset, provided there is a genuine economic relationship in price behavior. Only then can the hedge be effective and reduce exposure to the protected risk. Consequently, decisions regarding protection strategy must account for the fact that cross-hedging does not always yield high effectiveness (Santiago & Mattos, 2014).

With respect to hedging the exchange rate component in commodity transactions, coverage may be structured in two ways: (i) separately, focusing exclusively on exchange rate risk, or (ii) jointly with commodity price risk in a single derivative contract, as observed by Salomão (2019). In other words, companies may either use one instrument to hedge both risks simultaneously, or employ two separate instruments, each hedging an individual risk. It should be emphasized that exchange rate hedging is generally easier to achieve, since currency pair quotations are standardized and widely available in derivatives markets. Commodity hedging, in contrast, may be subject to basis risk arising from logistical conditions, quality differences, or geographic variations in reference prices.

Regarding the accounting treatment of hedges, De Zen, Yatabe, and Carvalho (2006) conducted a comparative study between CVM and FASB standards for hedging with futures contracts and CPRs (Rural Product Notes). Their main findings highlighted significant differences in disclosure practices, as Brazilian regulations at that time lacked the clear accounting criteria present in U.S. standards. Moreover, the accounting treatment of a futures

contract differs from that of a CPR with an embedded derivative, even if such a CPR provides effective protection. Similarly, Morais, Christovam, Cicogna, Silva, and Valle (2023) developed a theoretical example of hedging foreign currency assets and liabilities using NDF contracts designated as cash flow hedges. Their findings revealed that hedge accounting reduces earnings volatility by segregating the spot and forward components of the instrument for accounting purposes. They also found that firms applied different exchange rate criteria in their financial statements, which compromises comparability and performance analysis.

Negrisoló and Amorim (2022) analyzed SLC Agrícola's financial statements in a qualitative-exploratory study of exchange rate hedging disclosure. Their results reinforced the relevance of derivative hedging in supporting agribusiness predictability. Without hedge accounting, a company hedging its exposures as part of risk management may record the hedging instrument and the hedged item on different bases, creating timing mismatches that increase reported earnings volatility (KPMG, 2018). Thus, hedge accounting aims primarily to minimize such accounting mismatches. A common example of mismatch in commodity hedging is shown in Table 1.

Table 1
Example of Accounting Mismatch

Hedge Instrument			Hedged Item			Accounting Mismatch
Type of Instrument	Income Statement Line	Measurement Basis	Type of Object	Income Statement Line	Measurement Basis	
NDF	Financial Result	Fair Value	Future Revenues	Operating Result	Off-balance-sheet item	Descasamento entre períodos de reconhecimento e entre linhas de resultado

Source. Adapted from Contabilidade de derivativos e hedge accounting: para empresas e instituições financeiras / coordenação Eric Barreto, Wesley Carvalho. - 1. ed. - Barueri [SP]: Atlas, 2023.

The mismatch across income statement lines illustrated above is not explicitly addressed as a hedging issue under IFRS 9, as the standard does not specify in which accounts hedge-related fair value changes must be recognized. However, many companies record these effects in the same income statement line as the hedged exposure, with ineffective portions typically recognized in financial results, given the financial nature of the hedging instrument. This practice aligns with the matching principle, which requires that revenues and expenses relating to a transaction be recognized in the same periods (Lopes & Santos, 2003). Since hedge accounting is an optional treatment under IFRS rather than a requirement, hedging relationships that are not designated do not receive this accounting treatment (Panaretou, Shackleton, & Taylor, 2013).

Fenn, Post, and Sharpe (1996) examined how non-financial firms use swaps to manage interest rate risk and optimize debt structures. Their findings showed that firms prioritize debt hedging over operational cash flow hedging; larger corporations use derivatives more extensively than smaller ones; and swap users tend to issue 15% more short-term debt. The authors concluded that derivatives enhance financial efficiency, though their use is limited by fixed costs, access to financial markets, and higher risk exposures, making them more prevalent among larger firms. Complementarily, Galdi and Guerra (2009) studied determinants of hedge accounting adoption among NYSE-listed companies in the Mining, Steel/Metallurgy, and Pulp/Paper sectors. Their results indicated a positive and significant relationship between long-term debt and hedge accounting adoption, as well as a positive association with firm size.

Chiqueto (2014) provided strong evidence that hedge accounting adoption reduced

volatility in return proxies such as quarterly and annual ROE and ROA among Brazilian firms listed on the Ibovespa index. Other studies also found that hedge accounting adoption minimized earnings volatility (Zhang, 2009; Glaum & Klocker, 2011; Beneda, 2016; Pierce, 2020).

Zhang (2009) examined the impact of SFAS 133 on corporate risk management. Derivative users were classified as effective hedgers (EH) if their risk exposures decreased after adoption, or as ineffective hedgers/speculators (IS) otherwise. Results showed that cash flow volatility and exposures to interest rate, exchange rate, and commodity risks declined significantly for IS firms, indicating more prudent risk management under SFAS 133. Conversely, Glaum and Klocker (2011) found that the likelihood of hedge accounting adoption was related to derivative usage frequency, IFRS experience, and the perceived importance of earnings volatility reduction. They further noted that earnings volatility reduction was the primary motive for risk management, followed by cash flow volatility reduction. More than half of hedge accounting adopters stated that accounting regulation influenced risk management decisions, aligning with findings by Lins, Servaes, and Tamayo (2011) and Panaretou, Shackleton, and Taylor (2013), who reported strong evidence that accounting regulation significantly affects hedging practices, especially as eligibility for hedge accounting is easier to demonstrate for less complex instruments.

Beneda (2016) also identified a positive association between hedge accounting adoption and lower earnings volatility. Firms adopting hedge accounting exhibited reduced risk exposure and were found to use derivatives mainly for managing cash flows rather than for value creation. The author attributed these findings partly to the relatively small number of firms adopting hedge accounting.

Pierce (2020) showed that companies reduce reported earnings volatility through derivatives subject to hedge accounting, and could further decrease volatility if all derivatives were designated. The study also found evidence that compliance costs influence hedge accounting adoption decisions.

Potin, Bortolon, and Neto (2016) found a positive and significant relationship between accounting information relevance and derivative disclosure among hedge accounting adopters, but a negative and significant relationship with earnings informativeness, as well as statistically significant non-linearity in its effect on information asymmetry. Turra and Santos (2020) analyzed hedge accounting disclosure levels against fourteen firm characteristics and found that Big Four auditing was a significant explanatory factor for higher disclosure levels.

Pereira, Pereira, Silva, and Pinheiro (2017) identified associations between hedge accounting adoption, Novo Mercado listing, and firm-specific economic characteristics. Their evidence confirmed a positive and significant relationship between long-term debt and hedge accounting, while firm size also positively influenced adoption, consistent with Galdi and Guerra (2009).

Borgheti, Silva, and Nardi (2019) analyzed the impact of hedge accounting and reclassification of financial instruments on firm value. Their main findings indicated that hedge accounting adoption did not directly impact firm value, nor did reclassification driven by business model changes. However, in subsequent work, they identified a more consistent increase in value for hedge accounting adopters. Similarly, de Paula, Flores, and Carvalho (2023) found that firms designating more derivatives for hedge accounting engaged less in earnings smoothing, though no evidence was found linking adoption to covenant compliance.

Thus, prior studies examining the relationship between accounting volatility and hedge accounting adoption have not evaluated the specific effects of hedge accounting on gross margin among agribusiness firms. Gross margin is directly affected by hedge accounting adoption, but remains unaffected when hedge accounting is not applied. This supports the

premise that agribusiness companies adopting hedge accounting for operational activities exhibit lower gross margin volatility. Furthermore, the hypothesis is developed by separately analyzing exchange rate and commodity hedge accounting, given that each risk component entails distinct efficiency considerations.

Hypothesis: Agribusiness firms adopting exchange rate or commodity hedge accounting present lower gross margin volatility compared with firms that do not adopt it.

3. METHODOLOGY

This study defines the sample to be analyzed and employs quantitative tools to examine the relationship between a dependent variable, independent variables, and control variables, which allows it to be classified as an empirical study. According to Martins and Théophilo (2016), an empirical study consists of the application of experimental tests and quantitative measurement as criteria of scientific rigor, seeking to reproduce in the applied social sciences conditions approximating those of a laboratory, in order to overcome subjectivities, value judgments, and ideological influences.

The selection of sample firms was based on the theoretical portfolio of Exame magazine's Melhores & Maiores do Agronegócio ranking (2017). Together, these firms achieved USD 220 billion in revenues and nearly USD 3.8 billion in profit in 2016 (Revista Exame, 2017). The analysis covered the period from 2011 to 2021, totaling 11 years. However, as the dependent variable refers to Δ GM on an annual basis, the dataset captures only eight periods. Other observation periods should not significantly influence the results of the study, since the effect of hedge accounting is expected to be perceived in both high and low volatility scenarios in commodity prices and exchange rates.

As most of the companies were privately held, it was not possible to obtain financial statements for all firms selected for analysis. One firm was excluded because it had no exposure to commodity price risk, and others were excluded for not applying IFRS accounting standards. Thus, the final sample comprised 29 companies, all with at least minimal exposure to commodity price risk stemming from operating activities. These companies represent eight agribusiness sectors: wood and pulp; sugar and ethanol; animal protein, cotton, and grains; oils, flour, and preservatives; fertilizers and pesticides; coffee; milk and dairy products. Of these, 16 were publicly traded companies and 13 privately held:

Tabela 2
Amostra da pesquisa

Empresa	Capital	Setor
Biosev	Open	Sugar and Alcohol
Brf	Open	Animal Protein
Jbs	Open	Animal Protein
Mafrig	Open	Animal Protein
Suzano	Open	Wood and Pulp
Klabin	Open	Wood and Pulp
Minerva	Open	Animal Protein
Bayer	Closed	Fertilizer and Pesticides
M dias branco	Open	Oils, Flours, and Preservatives
Fibria	Open	Wood and Pulp
Heringer	Open	Fertilizer and Pesticides
Cooxupé	Closed	Coffee

Camil	Closed	Cotton and Grains
Eldorado brasil	Closed	Wood and Pulp
Castrolanda	Closed	Leite e derivados
São martinho	Open	Sugar and Alcohol
Slc agrícola	Open	Cotton and Grains
J macedo	Closed	Oils, Flours, and Preservatives
Arauco	Closed	Wood and Pulp
Melhoramentos	Closed	Wood and Pulp
Josapar	Open	Cotton and Grains
Tonon	Closed	Sugar and Alcohol
Usina santa adélia	Closed	Sugar and Alcohol
Cerradinho	Closed	Sugar and Alcohol
Eucatex	Open	Wood and Pulp
Jalles machado	Closed	Sugar and Alcohol
Adami	Closed	Wood and Pulp
Duratex	Closed	Wood and Pulp
Conservas oderich	Closed	Animal Protein

Source: Prepared by the authors

The variables used in this research are expected to capture evidence that Brazilian agribusiness companies adopting hedge accounting present lower ΔGM compared with those that do not. Such evidence was identified through statistical testing, focusing on the volatility of gross margin over the observed period. The variables included in the model are described below:

Gross Margin Volatility (ΔMB): Agribusiness companies adopting hedge accounting for operational activities—protecting against commodity price and exchange rate fluctuations—recognize the change in the fair value of the hedging instrument attributable to the effective portion of the relationship in operating results. Therefore, this variable was measured as the annual volatility of gross margin between 2013 and 2021 and defined as the dependent variable of the study. ΔMB was calculated using the standard deviation of gross margin variability (VMB). First, annual historical MB variability was measured as follows:

$$VMB = \ln \frac{MB_{db}}{MB_{db-0}}$$

Where:

$\ln$ = natural logarithm

MB_{db} = gross margin in year n

MB_{db-0} = gross margin in year $n - 0$

With the MB variability vector, dispersion around the mean variability was calculated, i.e., the standard deviation (σ), as follows:

$$\Delta MB = \sqrt{\frac{\sum_{i=1}^n (VMB_i - \bar{VMB})^2}{n - 1}}$$

Where:

VMB_i = annual accumulated variability of gross margin

$\bar{VMB}$ = arithmetic mean of annual accumulated gross margin variability

n = number of observations (years observed)

It is important to note that Zhang (2009) and Beneda (2016) employed the same

metric to measure volatility in their studies.

Commodity Hedge Accounting (HACDTY): A binary variable equal to 1 when the entity adopts hedge accounting for operational commodity exposures. This was determined by observing whether hedge accounting designated commodity risk among the hedged items. This variable was used similarly in Glaum & Klocker (2011), Beneda (2016), and de Paula, Flores, & Carvalho (2023), although without distinguishing the specific risk factor designated.

Exchange Rate Hedge Accounting (HACMB): A binary variable equal to 1 when the entity adopts hedge accounting for operational exchange rate exposures. Determination followed the same logic as HACDTY, but for exchange rate risks. This variable was also used in Glaum & Klocker (2011), Beneda (2016), and de Paula, Flores, & Carvalho (2023).

Size (TAM): Defined as the natural logarithm of total assets, a control variable widely used in prior research (Allayannis & Weston, 2001; Zhang, 2009; Nguyen & Faff, 2010; Bartram, Brown, & Conrad, 2011; Gómez-González, Rincón, & Rodríguez, 2012; Allayannis, Lel, & Miller, 2012; Beneda, 2016).

Functional Currency – USD (MODFC): A binary variable equal to 1 when the entity adopts the U.S. dollar as its functional currency. Commodity-based firms typically face exchange rate risk since most commodities are priced in dollars. Thus, companies using USD as functional currency are expected to exhibit lower Δ GM volatility than those using the BRL, since the former do not face additional FX exposure when their traded commodities are dollar-denominated.

Ownership Control (CTRAC): A categorical variable with values 1 to 4, indicating controlling country: Brazil (1), Germany (2), Chile (3), and France (4).

Big Four Auditing (BIGFOUR): A binary variable equal to 1 when the entity is audited by one of the Big Four firms (Deloitte, KPMG, EY, PwC). This variable has also been used in prior studies (Galdi & Guerra, 2009; Turra & Santos, 2020).

Listed on Stock Exchange (ACBOLSA): A binary variable equal to 1 when the entity's shares are listed on B3.

Sector (SETOR): A categorical variable ranging from 1 to 8, representing different agribusiness markets: sugar and ethanol (1); animal protein (2); wood and pulp (3); oils, flour, and preservatives (4); fertilizers and pesticides (5); coffee (6); cotton and grains (7); milk and dairy products (8). This variable has also been used in empirical studies (Gómez-González, Rincón, & Rodríguez, 2012; Potin, Bortolon, & Neto, 2016).

Table 3
Detailed Variable Description

Variables	Expected Relationship	Measurement	Description	Acronym	Authors
Dependent Variable		Equation (3)	Gross Margin Volatility	Δ MB	(Zhang, 2009; Beneda, 2016)
Independent Variables	-	Binary (1/0)	Commodity Hedge Accounting	HACDTY	(Glaum & Klocker, 2011; Beneda, 2016)
	-	Binary (1/0)	Currency Hedge Accounting	HACMB	(Glaum & Klocker, 2011; Beneda, 2016)
Control Variables					(Allayannis & Weston, 2001; Zhang, 2009; Bartram, Brown, & Conrad, 2011; Allayannis, Lel, & Miller, 2012; Beneda, 2016)
	-	LN of Total Assets	Size	TAM	
	-	Binary (1/0)	Functional Currency: US Dollar	MODFC	
	+/-	Categorical	Ownership Control	CTRAC	

	(1,2,3,4,5...)			
-	Binary (1/0)	Big Four Audit	BIGFOUR	(Galdi & Guerra, 2009; Turra & Santos, 2020)
-	Binary (1/0)	Publicly Traded Shares	ACBOLSA	(Potin, Bortolon, & Neto, 2016)
+/-	Categorical (1,2,3,4,5...)	Sector	SETOR	(Gómez-González, Rincón, & Rodríguez, 2012)

Source: Prepared by the authors

The dataset for the model variables was collected from the selected companies' websites, generally in their investor relations sections. All data used in the analysis were extracted from annual financial statements. A total of 263 financial statements were analyzed. Data were obtained from income statements and explanatory notes on financial instruments, risk management, and hedge accounting. For ΔGM measurement, 205 observations were used.

To describe descriptive statistics, ΔGM was compared across the study period, considering the full sample, firms that never adopted hedge accounting, firms that adopted only HACDTY or HACMB, and firms that adopted both simultaneously, in order to investigate whether evidence could be captured to answer the research question.

To verify whether HACDTY and HACMB negatively affect ΔGM , robust multiple regression was applied using panel data structure processed in R. According to Wooldridge (2010), one estimation method for panel data is Pooled Ordinary Least Squares (POLS), which was employed in this study. Thus, robust regression was specified to address violations of classical assumptions related to heteroskedasticity, positive autocorrelation, and non-normal residuals, as identified by Shapiro-Wilk (normality test) and Breusch-Pagan (homoskedasticity test).

Accordingly, models were re-estimated with heteroskedasticity-robust standard errors (HC1), as proposed by White (1980). This adjustment does not alter estimated coefficients but corrects standard errors used in significance tests, ensuring more reliable t and f inferences even when homoskedasticity and normality assumptions are not met.

Importantly, the model was estimated with interaction terms between the independent variables (HACDTY and HACMB) and the control variable SETOR, in order to assess the impact of hedge accounting adoption while distinguishing the underlying risk factor and sectoral effects on ΔGM . Since SETOR was treated as a factor, the model created dummies for each category. Multiplying HACDTY or HACMB by SETOR generated interaction terms, showing how hedge accounting effects differ across agribusiness sectors. The inclusion of these models also mitigated multicollinearity between HACDTY and HACMB.

Model 1: Commodity hedge accounting and gross margin volatility

$$\Delta MB_{it} = \beta_0 + \beta_1 HACDTY_{1it} \times \beta_k SETOR_{kit} + \beta_k TAM_{kit} + \beta_k MODFC_{kit} + \beta_k CTRAC_{kit} + \beta_k BIGFOUR_{kit} + \beta_k ACBOLSA_{kit} + e_{it} \quad (1)$$

Model 2: Exchange rate hedge accounting and gross margin volatility

$$\Delta MB_{it} = \beta_0 + \beta_1 HACMB_{1it} \times \beta_k SETOR_{kit} + \beta_k TAM_{kit} + \beta_k MODFC_{kit} + \beta_k CTRAC_{kit} + \beta_k BIGFOUR_{kit} + \beta_k ACBOLSA_{kit} + e_{it} \quad (2)$$

Given that classical regression assumes normally distributed errors and homoskedasticity (Gujarati, 2000), robust multiple regression was adopted as an alternative approach. This method yields consistent estimates even in the presence of outliers and

violations of constant variance assumptions.

The identification hypothesis of the model was to evaluate how the estimated coefficients for HACDTY and HACMB affect the dependent variable ΔGM . Since ΔGM was measured as a standard deviation, the resulting values may naturally be very small (Gujarati, 2000). In addition to magnitude, the direction of each coefficient was of primary interest, allowing us to assess whether HACDTY and HACMB have a positive, negative, or null effect on ΔMB .

In addition, other control variables were included, drawing on prior models. According to Allayannis and Weston (2001), Nguyen and Faff (2010), Allayannis, Lel, and Miller (2012), and Ribeiro, Machado, and Rossi (2013), studies of this type require controlling for firm size. For this reason, the natural logarithm of total assets (TAM_kit) was used. Following Gómez-González et al. (2012), a sector control variable ($SETOR_kit$) was included, which—unlike other model variables—does not vary over time. The variable $BIGFOUR$ (Turra & Santos, 2020) was also incorporated.

4 ANALYSIS OF RESULTS

According to the descriptive statistics, it was possible to verify that the adoption of hedge accounting, whether HADTY or HACMB, was lower than that of firms that did not adopt hedge accounting in the period under study. However, the difference was small, considering that in 2013 there were 2 firms and in 2021 there were 5 firms that adopted some hedge accounting model, representing approximately 17% of the sample. The low level of adoption of hedge accounting may reflect a slow maturation process of the standard and knowledge regarding the practice, particularly with respect to the accounting precedent associated with risk management and hedging practices assigned to professionals responsible for financial risk management. This precedent requires professionals to understand the origin and termination of risks, the types of risks to which the firm is exposed, the financial instruments available for management, and the extent of exposure that should be hedged.

The low adoption rate may also be explained by the composition of the sample, which includes 16 publicly traded firms and 13 privately held firms. Among these, 2 privately held firms and 6 publicly traded firms adopted hedge accounting at some point during the period studied. This finding aligns with Calegari, Baigorri, & Freire (2012), who suggest that the use of derivatives is concentrated among large firms, consistent with prior studies (Fenn, Post & Sharpe, 1996; Galdi & Guerra, 2009), which identified a positive relationship between hedge accounting adoption and firm size.

Table 4 reports the volatility of gross margin for the sample: firms that did not adopt hedge accounting, firms that adopted both HACMB and HACDTY simultaneously, those that adopted only HACMB, and those that adopted only HACDTY, over the study period.

Table 4
Average Annual ΔMB

Year	All Companies	Did Not Adopt H.A.	Adopted HACMB and HACDTY	Adopted HACMB Only	Adopted HACDTY Only
2013	14,84%	14,18%	10,22%	31,29%	NULL
2014	15,19%	15,37%	17,71%	6,61%	NULL
2015	25,06%	27,97%	14,11%	NULL	14,93%
2016	25,24%	27,51%	17,56%	NULL	15,68%
2017	25,77%	26,02%	29,54%	NULL	15,40%

2018	22,84%	22,60%	28,19%	NULL	14,74%
2019	22,08%	20,50%	27,62%	NULL	20,44%
2020	23,49%	23,41%	23,68%	NULL	NULL
2021	23,49%	24,54%	21,65%	NULL	20,44%
Total	22,27%	22,64%	22,46%	18,95%	16,24%

Source: Prepared by the authors

It is observed that firms adopting hedge accounting, in any form, presented lower ΔGM compared to non-adopters over the total period analyzed, which is consistent with the literature (Zhang, 2009; Glaum & Klocker, 2011; Chiqueto, 2014; Beneda, 2016; Pierce, 2020; Moraes, Christovam, Cicogna, Silva, & Valle, 2023). Another finding reveals that firms adopting hedge accounting more extensively generally do so for both exchange rate and commodity risks simultaneously. When adopting it for only one risk, HACDTY tends to be more extensively implemented than HACMB.

Arauco was the only firm in the sample with the U.S. dollar as its functional currency and presented an average volatility lower than the overall sample average of 22.27%, recording 19.92% in the period analyzed.

Publicly traded firms adopted hedge accounting more extensively than privately held firms and also showed lower ΔGM . Conversely, firms audited by Big Four auditors presented higher ΔGM than those audited by non-Big Four firms. The sectors with the highest ΔGM were Sugar & Ethanol and Coffee, while the sectors with the lowest ΔGM were Oils, Flours & Preservatives, and Dairy & Derivatives.

Table 4 presents the descriptive statistics of the variables used in the proposed model.

Table 5
Descriptive Statistics

Variable	Coefficient of Variation	Mean	Median	Standard Deviation	Minimum	Maximum
ΔMB	1,067	0,223	0,167	0,209	0,00219	1,59
HACDTY	0,506	0,205	0	0,405	0	1
HACMB	0,445	0,166	0	0,373	0	1
TAM	11,304	15,6	15,7	1,38	12,8	18,9
MODFC	0,187	0,0341	0	0,182	0	1
BIGFOUR	1,300	0,629	1	0,484	0	1
ACBOLSA	1,235	0,605	1	0,49	0	1
SETOR	1,675	3,4	3	2,03	1	8
CTRAC	1,740	1,27	1	0,73	1	4

Source: Prepared by the authors

Table 5 shows the main characteristics of the variables used in the robust multiple regression model, including measures of central tendency, dispersion, and range.

The dependent variable ΔGM has a mean of 0.223 and a median of 0.167, with a standard deviation of 0.209. The coefficient of variation of 106.7% indicates high dispersion relative to the mean, suggesting significant heterogeneity among observations.

The variable HACDTY is binary (0 or 1), with a mean of 0.205, indicating that approximately 20.5% of observations adopted this practice. Its coefficient of variation of 50.6% is consistent with its dichotomous nature. The HACMB variable, also binary, represents another hedge accounting practice, with similar behavior to HACDTY (mean = 0.166; standard deviation = 0.373). Like HACDTY, its distribution is highly asymmetric, with most observations taking a value of zero.

Firm size (TAM), represented by the natural logarithm of total assets, has a mean of 15.6 and a median of 15.7, with a standard deviation of 1.38. The minimum value is 12.8 and the maximum 18.9. The coefficient of variation is 11.3%, indicating low relative dispersion and thus greater homogeneity in firm size across the sample.

Table 6 presents the correlation matrix of the variables analyzed in this study.

Table 6
Correlation Matrix

Variables	Δ MB	HACDTY	HACMB	TAM	MODFC	BIGFOUR	ACBOLSA	SETOR	CTRAC
Δ MB	1								
HACDTY	-0,0313	1							
HACMB	-0,0003	0,8134	1						
TAM	-0,1878	0,2511	0,2054	1					
MODFC	-0,0211	0,2373	-0,0838	0,1151	1				
BIGFOUR	0,1402	0,2895	0,2336	0,1167	0,1443	1			
ACBOLSA	-0,2418	0,1878	0,3604	0,5242	-0,2326	-0,1039	1		
SETOR	-0,2135	-0,0703	-0,0879	-0,1931	-0,0371	0,0617	0,0167	1	
CTRAC	0,0903	0,3407	0,1569	-0,0241	0,4459	-0,1281	-0,2175	-0,1533	1

Source: Prepared by the authors

First, a strong positive correlation (0.8134) is observed between HACDTY and HACMB, suggesting that firms tend to adopt hedge accounting practices for both commodity and exchange rate risks.

A particularly relevant result is the positive correlation between HACDTY and BIGFOUR (0.2895), supporting the expectation that firms audited by Big Four firms are more likely to adopt hedge accounting. This finding contrasts with Galdi & Guerra (2009), who identified a negative relationship between hedge accounting adoption and Big Four audits, arguing that such audit firms impose stricter requirements for qualifying hedge accounting relationships. Complementarily, Turra & Santos (2020) concluded that Big Four audits significantly influence the level of hedge accounting disclosure. Thus, the temporal horizon between the studies suggests that from 2009 to the 2013–2021 period there was a maturation of the standard, as well as increased prominence of hedge accounting in discussions between Big Four firms and their audit clients, leading to greater compliance. Conversely, non-Big Four audit firms may not emphasize hedge accounting in their discussions with clients.

Regarding firm size (TAM), there is a negative correlation with Δ GM (-0.1878), consistent with the hypothesis that larger firms exhibit lower gross margin volatility, corroborating prior studies (Fenn, Post & Sharpe, 1996; Saito & Schiozer, 2005; Galdi & Guerra, 2009). Moreover, the strong correlation between TAM and ACBOLSA (0.5242) confirms that larger firms are typically those accessing capital markets.

The results of Model 1 are presented in Table 7.

Table 7
Model 1 Estimator Results

Variable	Coefficient	Standard Error	t-Statistic	p-Value	Significance
const	0.5117	0.1878	2725	0.0070	**
HACDTY X SETOR 1	-0.4581	0.0694	-6600	< 0.001	***
HACDTY X SETOR 2	-0.4515	0.0646	-6994	< 0.001	***
HACDTY X SETOR 3	-0.3824	0.0512	-7475	< 0.001	***
HACDTY X SETOR 4	-0.5162	0.0576	-8968	< 0.001	***
HACDTY X SETOR 5	-0.2471	0.0724	-3413	0.0008	***
HACDTY X SETOR 6	-0.2599	0.0855	-3039	0.0027	**
HACDTY X SETOR 7	-0.4924	0.0567	-8677	< 0.001	***

HACDTY X SETOR 8	-0.5139	0.0812	-6325	< 0.001	***
TAM	0.0063	0.0142	0.446	0.6501	
MODFC	-0.1320	0.1183	-1642	0.1023	
BIGFOUR	-0.0257	0.0432	-0.596	0.5181	
ACBOLSA	-0.0211	0.0435	-0.486	0.6277	
CTRAC 2	-0.1662	0.1322	-1257	0.2105	
CTRAC 3	-0.2002	0.0682	-2934	0.0038	**
CTRAC 4	-0.1005	0.0862	-1166	0.2452	
HACDTY:SETOR2	0.536066	0.097327	5508	1.21e-07	***
HACDTY:SETOR3	0.420117	0.120258	3493	0.000597	***
HACDTY:SETOR4	0.479761	0.133594	3591	0.000422	***
HACDTY:SETOR5	0.414114	0.150611	2749	0.005564	**
HACDTY:SETOR6	NA	NA	NA	NA	
HACDTY:SETOR7	0.797836	0.093859	8501	6.35e-15	***
HACDTY:SETOR8	NA	NA	NA	NA	
Ajusted R ²	0,4574				
Residual Standard Error	0,154				
F-statistic	9,599 (p < 2.2e-16)				

Source: Prepared by the authors

Model 1 provides relevant findings regarding the impact of HACDTY on Δ GM, controlling for sectoral effects and other variables. The model demonstrates an adequate explanatory power, with an adjusted R² of 0.4574 and a highly significant F-statistic ($p < 2.2e-16$), indicating that the independent variables substantially explain Δ MB.

The main finding of Model 1 reveals a negative and statistically significant relationship between HACDTY and Δ MB ($\beta = -0.4581$; $p < 0.001$), suggesting that the adoption of commodity hedge accounting is associated with reduced gross margin volatility. This result is supported by prior research (Zhang, 2009; Glaum & Klocker, 2011; Chiqueto, 2014; Beneda, 2016; Pierce, 2020; Morais, Christovam, Cicogna, Silva, & Valle, 2023).

The analysis of sectoral effects reveals heterogeneous patterns. All coefficients for HACDTY * Sector variables were negative and statistically significant ($p < 0.01$), ranging from -0.2471 (fertilizers and pesticides) to -0.5162 (oils, flours, and preservatives). This suggests that the negative impact on Δ MB is more pronounced in specific sectors, with greater effects observed in animal protein, wood and pulp, oils/flours/preservatives, fertilizers/pesticides, and cotton/grains. The interaction terms indicate that the impact of hedge accounting varies by industry, being stronger—or even reversed—depending on the sector.

Among the control variables, ownership control in Chile stands out as significant ($\beta = -0.2002$; $p = 0.0038$). Other controls (TAM, MODFC, BIGFOUR, and ACBOLSA) were not statistically significant, suggesting no substantial influence on Δ MB within this model.

Table 8
Model 2 Estimator Results

Variable	Coefficient	Standard Error	t-Statistic	p-Value	Significance
const	0.4982	0.1858	2681	0.0080	**
HACMB X SETOR 1	-0.4549	0.0689	-6606	< 0.001	***
HACMB X SETOR 2	-0.4561	0.0655	-6962	< 0.001	***
HACMB X SETOR 3	-0.3846	0.0507	-7591	< 0.001	***
HACMB X SETOR 4	-0.5140	0.0571	-9008	< 0.001	***
HACMB X SETOR 5	-0.2419	0.0719	-3365	0.0009	***
HACMB X SETOR 6	-0.2615	0.0847	-3087	0.0023	**
HACMB X SETOR 7	-0.5061	0.0569	-8891	< 0.001	***
HACMB X SETOR 8	-0.5209	0.0812	-6414	< 0.001	***
TAM	0.0079	0.0111	0.556	0.5789	ns

MODFC	-0.2049	0.0866	-2367	0.0195	*
BIGFOUR	-0.0335	0.0446	-0.751	0.4534	ns
ACBOLSA	-0.0272	0.0435	-0.625	0.5327	ns
CTRAC 2	-0.2036	0.0990	-2057	0.0411	*
CTRAC 3	-0.1946	0.0684	-2844	0.0050	**
CTRAC 4	-0.0953	0.0857	-1111	0.2680	ns
HACMB:SETOR2	0.521263	0.095036	5485	1.34e-07	***
HACMB:SETOR3	NA	NA	NA	NA	
HACMB:SETOR4	0.477334	0.132343	3607	0.000398	***
HACMB:SETOR5	NA	NA	NA	NA	
HACMB:SETOR6	NA	NA	NA	NA	
HACMB:SETOR7	0.801301	0.091699	8739	1.36e-15	***
HACMB:SETOR8	NA	NA	NA	NA	

Ajusted R ²	0,4677
Residual Standard Error	0,1526
F-statistic	10,96 (p < 2.2e-16)

Source: Prepared by the authors

The results of Model 2 further reveal significant patterns regarding HACMB adoption and ΔGM , also controlling for sectoral and firm-level characteristics. The model demonstrates statistical robustness, with an adjusted R² of 0.4677 and a highly significant F-statistic ($p < 2.2e-16$), indicating that approximately 46.8% of the variation in ΔGM is explained by the independent variables.

The main finding of Model 2 is the negative and statistically significant relationship between HACMB and ΔGM , consistent with previous studies (Zhang, 2009; Glaum & Klocker, 2011; Chiqueto, 2014; Beneda, 2016; Pierce, 2020; Morais, Christovam, Cicogna, Silva, & Valle, 2023). The HACMB coefficients were particularly significant in the animal protein, oils/flours/preservatives, and cotton/grains sectors, suggesting that exchange rate hedge accounting is more effective in reducing gross margin volatility in these industries. The interaction terms (HACMB * Sector) confirm the heterogeneous nature of hedge accounting effects across industries.

Subsequently, diagnostic tests were conducted to evaluate classical regression assumptions: Normality of Residuals (Shapiro-Wilk), Homoscedasticity (Breusch-Pagan), and Independence of Residuals (Durbin-Watson).

Table 9

Assumption Test Results

Assumption	Test Applied	Model 1 - HACDTY	Model 2 - HACMB
Residual Normality	Shapiro-Wilk	W = 0.755, $p < 2.2e-16$	W = 0.755, $p < 2.2e-16$
Homoscedasticity	Breusch-Pagan	BP = 56.05, $p < 0.001$	BP = 56.29, $p < 0.001$
Residual Independence	Durbin-Watson	DW = 0.734, $p < 0.001$	DW = 0.702, $p < 0.001$

Source: Prepared by the authors

The assumption tests revealed significant violations of classical regression assumptions for both models. The Shapiro-Wilk test ($W = 0.755$; $p < 0.001$ in both models) rejected normality, indicating non-normal residuals and raising concerns about the reliability of p-value-based inferences.

The Breusch-Pagan test ($BP \approx 56$; $p < 0.001$ for both models) indicated heteroscedasticity, suggesting non-constant residual variance, which may lead to underestimated standard errors and biased confidence intervals.

The Durbin-Watson test ($DW \approx 0.7$; $p < 0.001$ in both models) revealed positive autocorrelation ($DW < 1$), suggesting dependence among residuals, possibly due to temporal patterns or omitted variables. Accordingly, the regression model was re-estimated using robust standard errors (White, 1980).

Table 10

Results of Models Estimated with Robust Errors

Variable	HACDTY Coefficient	p-value	HACMB Coefficient	p-value
constante	0.5117	< 0.001	0.4982	< 0.001
HA	-0.4581	< 0.001	-0.4549	< 0.001

Source: Prepared by the authors

The robust estimates confirmed statistically significant coefficients for both HACDTY and HACMB. The constant terms were 0.5117 (HACDTY) and 0.4982 (HACMB), both with $p < 0.001$. The coefficients for HACDTY (-0.4581) and HACMB (-0.4549) were also highly significant ($p < 0.001$), independent of sectoral interactions.

These findings are consistent with the extant literature (Zhang, 2009; Glaum & Klocker, 2011; Chiqueto, 2014; Beneda, 2016; Pierce, 2020; Morais, Christovam, Cicogna, Silva, & Valle, 2023).

5 FINAL CONSIDERATIONS

According to the results obtained through descriptive statistics and regression models, there is evidence that companies adopting HACMB and HACDTY exhibit lower ΔMB than those that do not, highlighting that Models 1 and 2 showed high statistical significance through assumption tests and models estimated with robust errors.

Thus, agribusiness companies that adopt HACDTY and HACMB present results aligned with hedge theory, particularly regarding the accounting effect of hedge accounting (Carmona, Aquino, Paredes, & Torres, 2014), and also consistent with the findings of Zhang (2009), Glaum & Klocker (2011), Chiqueto (2014), Beneda (2016), Pierce (2020), and Morais, Christovam, Cicogna, Silva, & Valle (2023), who identified that firms adopting hedge accounting present results with lower volatility.

The results demonstrate that the effect of hedge accounting is heterogeneous, being stronger or even reversed depending on the sector in which the company operates. This heterogeneity suggests that, for certain commodities, the absence of perfect derivatives compels firms to resort to instruments whose underlying assets are not identical to the risks they aim to hedge (Yaganti & Kamaiah, 2012; Santiago & Mattos, 2014). The findings allow us to infer that significant opportunities remain for improving hedging mechanisms, both regarding (i) the expansion of the supply of adequate financial instruments for hedging and (ii) the development of more sophisticated risk management practices and the application of hedge accounting within organizations.

The sectors that presented lower ΔMB when adopting both HACDTY and HACMB were animal protein, oils, flours and preservatives, and cotton and grains, which may indicate that these agribusiness sectors have more efficient hedging instruments.

Another finding of this research is that Arauco, which has the U.S. dollar as its functional currency (MODFC), presented lower ΔMB compared to companies that use the Brazilian real as their functional currency. Therefore, it can be suggested that Brazilian agribusiness firms with the U.S. dollar as their functional currency and engaged in the purchase or sale of commodities are more likely to present less volatile accounting results compared to

those whose functional currency is the Brazilian real.

Hence, the results obtained in this research may be considered a contribution to agribusiness companies, supporting decision-making on whether to adopt hedge accounting, as well as to external users, such as investors, regulators, among others, by evidencing the effect of hedge accounting on firms' results and its underlying mechanisms.

Regarding the limitations of this study, the model did not incorporate variables such as the price behavior of each commodity, exposure volume, and the hedge ratio. As directions for future research, it is recommended to expand this analysis to other markets, allowing international comparisons with the results obtained in Brazil. Additionally, it would be relevant to investigate the different hedging instruments used by companies, analyzing not only their prevalence but also their effectiveness in different economic and sectoral scenarios. Other variables, such as the impact of local regulation and the maturity level of risk management, could also be incorporated, further enriching the understanding of the factors influencing the success of hedging strategies and their accounting effects.

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