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Golden Ratio-based Leverage Targeting and the ESG Performance of US and European Listed Firms

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Golden ratio-based leverage targeting and the ESG performance of US and European listed firms

Abstract

Our paper aims to assess whether golden ratio-based leverage targeting is linked to better ESG performance. To answer this research question, we study how ESG performance affects the distance between the leverage targets and the levels defined by the golden ratio and examine the temporal dynamics of leverage in relation to the distance between leverage targets and the golden ratio levels. Our main findings show that when firms in the European manufacturing sector have better ESG performance, they choose to have leverage targets closer to the levels defined by the golden ratio. In this case, firms adjust their book leverage considering the distance between the leverage targets and the golden ratio levels. Our results highlight that prudential sustainability reporting regulation and higher ESG exposure can guide firms toward a more harmonized capital structure.

Keywords: capital structure, golden ratio, target leverage, ESG performance
JEL classification code: G32, Q56, M14

Highlights

- When firms in the European manufacturing sector have better ESG performance, they choose to have leverage targets closer to the levels defined by the golden ratio.
- In this case, firms adjust their book leverage considering the distance between the leverage targets and the golden ratio levels.
- Our results highlight that prudential sustainability reporting regulation and higher ESG exposure can guide firms toward a more harmonized capital structure.

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Introduction

The current evolution of business is often described as a shift from the long-dominant concept of shareholder value maximization to a more stakeholder-centric model, where the needs of multiple stakeholders, including employees, consumers, investors, communities, and our environment, are considered. Pursuing stakeholder value creation can benefit firms in various ways, including lowering the cost of capital and mitigating the information asymmetry, which allows firms to raise capital more efficiently (Adeneye et al., 2022).

Corporate social responsibility, ESG, sustainability, purpose marketing, diversity, and inclusion aim to make companies and organizations more ethical, socially responsible, and sustainable. In today's purpose-driven world, aligning these areas around a powerful and inspiring goal has a greater impact than focusing on many different goals and issues. Thus, they become part of a whole, pointing toward a harmonious, unified goal rather than scattered units in a suboptimal arrangement. The ESG frameworks and metrics aim to capture this higher purpose and efficiently measure stakeholder value creation and sustainability of investments. Firms with higher ESG exposure are incentivized to improve ESG performance, reduce ESG risks, and define a clear strategy concerning sustainability matters, as ESG becomes a crucial driver of competitiveness and market valuation. A strict prudential sustainability reporting regulation guides European firms, while the United States adopted a more market-driven approach.

In this article, we aim to assess how ESG performance is linked to leverage targeting from the perspective of the Divine Proportion or 'golden ratio', the irrational number that connected mathematicians, biologists, artists, musicians, historians, architects, psychologists, and even mystics throughout the centuries, who have investigated and discussed its unexpected presence in the most diverse fields including the stock markets.

Our research question posits that firms with better ESG performance choose leverage targets closer to levels defined by the golden ratio. We argue that in the presence of superior ESG performance, firms unwittingly adjust their leverage targets towards golden ratio levels to reach a more harmonized capital structure, and this behavior is strongly present in those sectors and regions where firms put more emphasis on sustainability matters. Our findings show that in the presence of superior ESG performance, firms in the European manufacturing sector choose to have leverage targets closer to golden ratio levels. Furthermore, these firms adjust their book leverage considering the distance between leverage targets and golden ratio levels.

According to the paper's main finding, we argue that prudential regulation in Europe and higher ESG exposure in the manufacturing sector guide firms toward a more harmonized capital structure. This argument complements Adeneye et al.'s (2022) findings in ASEAN countries, which state that better ESG performance allows firms to have higher leverage by mitigating financial constraints. In addition, Ulbert et al. (2022) found that a golden ratio-based capital structure improves firms' financial performance and market acceptance. To justify the paper's originality, we extend that literature by showing that better ESG performance is linked to golden ratio-based leverage targeting.

Our paper proceeds as follows: After introducing the relevant research areas (ESG, capital structure, golden ratio) and developing our hypotheses, we present our empirical results on ESG performance and golden ratio-based leverage targeting. We conclude the paper by analyzing the practical and theoretical implications of the results.

Related literature and hypothesis development

Golden ratio-based leverage targeting

The term "proportion" usually refers to the equilibrium or symmetry between group elements or between a specific element and the group (Haylock, 2006). Proportionality can be mathematical, geometric, or harmonic (Kotliar, 2016). Notably, all these proportionality types incorporate 1.618, the golden ratio. In 1815, German mathematician Martin Ohm coined the term to describe the divine proportion, the 'Goldener Schnitt'. The golden ratio is irrational due to its non-recurring decimal representation. It is the only number whose decimal component, which follows the decimal point, equals its square and inverse. See $\varphi^2 = 2.61803398874$ and $1/\varphi = 0.61803398874$ (Ulbert et al., 2022). For centuries, it has connected mathematicians, biologists, artists, musicians, historians, architects, psychologists, and even mystics, who have studied and discussed its unexpected presence in many fields (Urmantsev, 2009).

Previous literature emphasizes management, marketing, operations management, finance, and accounting applications of the golden ratio. A comprehensive literature review by Kulis and Hodzic (2020) addresses the interdisciplinary nature of these applications. Findings relevant to our study can be found in the works of Rehwinkel (2016), Ulbert et al. (2022), and Amin and Cek (2023). Rehwinkel (2016) combined the constructal law, golden ratio, and second law of thermodynamics. The author found that firms in the basic material and consumer goods sector arrange their capital structures according to the constructal law. Symmetry has a fundamental role in corporate financial reporting and financial risk analysis since it is inherent

in the foundational accounting equation. Thus, it dramatically affects corporate capital structure formulation and comprehension.

In their study, Ulbert et al. (2022) examined golden ratio-based capital structure in relation to financial performance and market acceptance. The authors compared the equity ratio to the golden ratio level of 38.2% and found a positive relationship with financial performance and market acceptance, especially in the service sector of the United States. Amin and Cek (2023) compared leverage to the 61.8% golden ratio level and found conflicting results concerning the relationship between golden ratio-based capital structure examining firms from the United Kingdom and France.

Many studies examined capital structure and leverage targeting. Choosing a leverage target is a crucial consideration in a firm's financing policy. As a significant driver of weighted average cost of capital (WACC) calculations, it affects corporate financial performance and value creation. Mainstream capital structure theories define cross-sectional optimal capital structures. While leverage targeting literature focuses on leverage adjustment speed to capture how firms reach their optimal capital structure over time. Before reviewing the literature on ESG performance and capital structure, summarizing capital structure theories, in general, helps to explain how golden ratio-based leverage targeting relates to the existing capital structure theories.

The classic trade-off theory aims to maximize the firm's value with the most beneficial leverage level (Kraus and Litzenberger, 1973). Companies decide about a mix of equity and debt financing by applying trade-offs for the highest benefits. Trade-off theory states that leverage is optimal if the firm value is maximized. Thus, it argues that firms can define their leverage targets based on these trade-offs.

Agency theory examines the interests of shareholders, management, and other agents (Jensen and Meckling, 1976). It deals with the problem of maximizing the company's value, considering the different interests, information problems, and conflicts between control and ownership. Firms can maximize their value if they minimize the agency costs of debt and equity. (Grabinska et al., 2021; Khatib, 2021; Dawar, 2014; Albers and Guenther, 2010; Zamil et al., 2021). Capital transfers from debt holders to shareholders increase agency costs for highly leveraged firms (Khatib et al., 2021).

The pecking-order theory introduces a hierarchy of how companies handle capital (Myers, 1984). Managers do not set the target leverage but use capital sources in a particular

order: internal funds, debt, and equity. According to pecking-order theory, firms use debt to cover their deficits before using equity.

Many studies examined sector-specific capital structure. Ross et al. (2008) argue that the optimal level of leverage differs significantly across industries. Frank and Goyal (2009) explain the sector-specific capital structure with management's decisions, which consider the sector's median leverage as the leverage target. On the other hand, Hovakimian et al. (2001) pointed out that firms actively adjust their leverage towards the sector average.

Companies strive to achieve the optimal capital structure, which maximizes firm value at the lowest cost. By testing the empirical validity of capital structure theories, Dang (2011) finds that listed firms tend to define leverage targets, but they cannot reach their targets immediately due to market frictions like asymmetric information. However, their leverage converges towards the target dynamically. Adeneye et al. (2022) also find that the firms' leverage converges towards their leverage targets. The speed of adjustment usually varies due to market frictions. Morais et al. (2022) point out that the speed of adjustment can change due to different financial systems, macroeconomic conditions, financial constraints, and financial flexibility levels, and both zero-leverage and leveraged firms actively adjust their leverage to a target debt ratio. Oino and Ukaegbu (2015) disclose evidence about leverage targeting in the context of Nigerian firms. These findings empirically support the assumptions behind the trade-off theory against the other capital structure theories pursuing the optimal capital structure. In contrast to these findings, Moradi and Paulet (2019) present empirical evidence that validates the assumptions of pecking-order theory and agency cost theory and emphasize that the Euro Crisis significantly affected leverage upon examining the firm-specific characteristics of capital structure. Vo (2017) also provides evidence consistent with the agency cost theory in the context of Vietnamese firms and argues that determinants of capital structure differ for long-term and short-term indicators.

This research argues that firms define time-varying and firm-specific leverage targets, which differ across sectors and regions. However, these targets unwittingly converge towards the important levels defined by the golden ratio. In addition, firms adjust their leverage to minimize the distance between leverage targets and levels defined by the golden ratio to reach a more harmonized capital structure. Thus, the distance between the leverage targets and the golden ratio levels has a positive relationship with leverage adjustments. Golden ratio-based leverage targeting can complement optimal and dynamic capital structure theories, assuming that firms strive for harmonic symmetry in their capital structure. Utilizing the golden ratio for

leverage targets can effectively balance risk and reward by tapping into its historical and natural symbolism of equilibrium and unity.

H1: Firms adjust their leverage considering the distance between leverage targets and the important levels defined by the golden ratio.

H1a: Firms adjust their market leverage considering the distance between leverage targets and the important levels defined by the golden ratio.

H1b: Firms adjust their book leverage considering the distance between leverage targets and the important levels defined by the golden ratio.

ESG and the capital structure

Disclosing information on sustainability matters is inevitable as the ESG performance of firms has become a crucial driver of competitiveness and market valuation. Previous literature argued that the relationship between firm value and ESG performance is positive since better ESG performance can result in higher market valuation and lower cost of capital as shareholders accept lower returns, and debtholders can mitigate the problems of asymmetric information. Due to this fact, firms with higher ESG performance can have higher target leverage and a higher speed of adjustment (Adeneye et al., 2022). Table 1. presents a summary of the relationship between ESG performance and the determinants of capital structure in the existing empirical literature.

The indisputable observation of good outcomes resulting from engagement in ESG activities is evident in the published papers regarding the cost of equity. The findings demonstrate a distinct inverse correlation between ESG performance and the cost of equity due to asymmetric information (Matthiesen and Salzmann, 2015; Ng and Rezaee, 2015). Additionally, according to a survey conducted by PriceWaterhouseCoopers (2014), it was observed that the utilization of Environmental, Social, and Governance (ESG) standards is associated with a reduction in company risk, leading to a fall in the cost of equity. According to a separate poll by Armitage and Marston (2008), there was a notable emphasis on the importance of improved transparency. According to the research conducted by Sharfam and Fernando (2008), it was seen that the management of environmental risk led to a decrease in beta and stock volatility. Ferris et al. (2017) found a correlation between management social capital and sharing information with stakeholders in a company.

In relation to the domain of bonds, Weber et al. (2008), Chen et al. (2011), Weber et al. (2012), Ge and Lui (2015), and Al Amosh et al. (2022) observed that the inclusion and transparency of ESG activities led to a favorable outcome, namely the ability to issue bonds at a reduced cost. Focusing on Nordic countries, Kjerstensson and Nygren (2019) showed that the required risk premium did not decrease concerning higher ESG ratings. So, for them, a higher ESG score did not provide a lower cost of debt. Gracia and Siregar (2021) argue that better sustainability disclosure, enables firms to achieve lower costs of debt.

Table 1.: ESG performance and the determinants of capital structure in the existing empirical literature

	ESG performance		
	+	-	0
Cost of equity		Matthiesen and Salzmann (2015) Ng and Rezaee (2015) PriceWaterhouseCoopers (2014) Armitage and Marston (2008) Sharfam and Fernando (2008) Ferris et al. (2017) Cantino et al. (2017)	
Cost of debt	Li et al. (2020) **(E)** Goss and Roberts (2011)	Li et al. (2020) **(S, G)** Arora and Sharma (2022) **(S)** Chen et al. (2011) Ge and Lui (2015) Cooper and Uzur (2015) Hoepner (2016) Weber et al. (2008) Weber et al. (2012) Gracia and Siregar (2021)	Kjerstensson and Nygren (2019) Gracia and Siregar (2021)
Book leverage	Adeneye et al. (2022) Al Amosh et al. (2022) Krištofík et al. (2022)		
Market leverage		Adeneye et al. (2022)	
Speed of adjustment	Adeneye et al. (2022)		

Table 1. summarizes the relationship between ESG performance and capital structure in the existing literature. +\-\0 denotes positive\negative\non-significant relationships between ESG performance and the determinants of capital structure, such as cost of equity, cost of debt, market and book leverage, and the speed of adjustment.

When considering loans obtained from financial institutions, the presence of a disagreement remained evident. Goss and Roberts (2011) observed that ESG activities and CSR initiatives were not perceived as factors that mitigate risk by the banks. However, Cooper and Uzur (2015) and Hoepner (2016) obtained contrasting findings while analyzing commercial banks as stakeholders. Individually concentrating on the ESG pillars, Li et al. (2020) discovered a positive correlation between bond default rate and energy consumption and use but a negative

correlation with social responsibility and governance. While emphasizing the significance of stakeholder theory, Arora and Sharma (2022) discovered the possibility of reducing the cost of debt through ESG activities in countries such as India.

The study conducted by Al Amosh et al. (2022) indicates a clear preference among Jordanian enterprises for debt financing over equity financing in ESG activities. In contrast, equity financing did not affect ESG performance noticeably. Krištofík et al. (2022) targeted top European companies with their research and found that companies involved in sustainability are more leveraged than those who did not have such incentives and investments. Khan (2022) also highlights the positive relationship between ESG performance and leverage. Cantino et al. (2017) pointed out that firms with CSR initiatives have a lower cost of equity than that of firms without CSR. Benlemlih (2017) observed a reverse pecking order theory for firms with CSR initiatives. These studies clearly emphasize equity utilization. Concerning the speed of adjustment (SOA) to target leverage, no matter which pillars of ESG scores are investigated, the speed of adjustment is faster in the presence of superior ESG performance than without it (Adeneye et al., 2022).

The cited papers demonstrate that conducting research on a given subject with almost identical factors can provide convergent and controversial findings. Determining how ESG performance influences capital structure resulted in contradictory results. In addition, we can find contradictory results on whether to include more equity or debt in the financing mix. Identifying an optimal capital structure allocation is important to address a wide range of interests effectively. What does the optimal capital structure consist of, and what is the optimal ratio between equity and debt when considering ESG performance?

We argue that firms incentivized to put more emphasis on sustainability unknowingly adjust their leverage targets towards golden ratio levels. Our research question posits that firms with better ESG performance choose to have leverage targets closer to the important levels defined by the golden ratio. Thus, we anticipate a positive significant relationship between ESG performance and the distance between the leverage targets and the levels defined by the golden ratio.

H2: When firms have better ESG performance, they choose to have leverage targets closer to the important levels defined by the golden ratio.

H2a: When firms have better ESG performance, they choose to have a market leverage target closer to the important levels defined by the golden ratio.

H2b: When firms have better ESG performance, they choose to have a book leverage target closer to the important levels defined by the golden ratio.

Research design

Estimated models and variable descriptions

To analyze whether better ESG performance is connected to golden ratio-based leverage targeting, we examine whether firms with superior ESG performance adjust their leverage targets towards the important levels defined by the golden ratio. First, we estimate the time-varying, firm-specific leverage targets. Next, we regress the distance between leverage targets and golden ratio levels on the leverage adjustments. Last, we investigate the relationship between ESG performance and the distance of leverage targets from the golden ratio levels.

Table 2: Description of the variables

Variables	Description
$ESG_{i,t}$	ESG Score of firm i in the financial year t
$ENV_{i,t}$	Environmental Pillar Score of firm i in the financial year t
$SOC_{i,t}$	Social Pillar Score of firm i in the financial year t
$GOV_{i,t}$	Governance Pillar Score of firm i in the financial year t
$MLEV_{i,t} = \frac{Total\ Debt_{i,t}}{Total\ Debt_{i,t} + Market\ Cap._{i,t}}$	Market leverage of firm i in the financial year t.
$BLEV_{i,t} = \frac{Total\ Debt_{i,t}}{Total\ Debt_{i,t} + Total\ Equity_{i,t}}$	Book leverage of firm i in the financial year t.
$PROF_{i,t} = \frac{EBIT_{i,t}}{Total\ Assets_{i,t}}$	Profitability of the firms, measured by the ratio of earnings before interest and taxes and total assets
$MTB_{i,t} = \frac{Price_{i,t}}{BVPS_{i,t}}$	Market to book ratio, measured by the ratio of market price and the book value per share
$TANG_{i,t} = \frac{PPE_{i,t}}{Total\ Assets_{i,t}}$	Tangibility of the firms, measured by the ratio of property, plant, and equipment, and total assets
$NDTS_{i,t} = \frac{D\&A_{i,t}}{Total\ Assets_{i,t}}$	Non-debt tax shield of the firms, measured by the ratio of depreciation and amortization and the total assets
$SIZE_{i,t} = LN(Total\ Assets_{i,t})$	Size of the firms, measured by the logarithm of the total assets

Table 2. presents the description of the variables used in our analysis. ESG denotes the ESG score, ENV the environmental pillar score, SOC the social pillar score, and GOV the governance pillar score measured on a 0 to 100 scale. MLEV denotes the market leverage, and BLEV is the book leverage. PROF stands for profitability, MTB for the market-to-book ratio, TANG for tangibility, NDTS for the non-debt tax shields, and SIZE for the size of the firms. i and t denote the firms and financial years, respectively.

Table 2. presents the conceptualization and operationalization of the variables encompassed in our analytical framework. Our variables describe the ESG performance, market and book leverage, and other firm characteristics, which we use to estimate the target leverage of the firms. The ESG score and ESG pillar scores are quantified using a numerical scale ranging from 0 to 100. Market leverage was computed by dividing the total debt by the sum of the total debt and market capitalization. The book leverage equals the total debt divided by the sum of the total debt and total equity. Profitability is measured by the ratio of earnings before interest and taxes and total assets. The market-to-book ratio is calculated as the ratio of the market price and the book value per share. Tangibility equals the ratio of property, plant, and equipment, and total assets. Non-debt tax shield is measured by the ratio of depreciation and amortization and the total assets. Size equals the logarithm of the total assets.

To estimate the market\book leverage targets (TARGET), we regress the actual market\book leverage on profitability, the market-to-book ratio, tangibility, non-debt tax shields, and size. We assume that market\book leverage targets of the firms differ across financial years, sectors, and regions. Thus, we include dummies for the financial years (YEAR), regions (REGION), and sectors (SECTOR) to examine the cross-sectional heterogeneity of the market\book leverage in equation (1). This model uses similar specification to Adeneye et al. (2022) and Dang (2011) to estimate the market\book leverage targets of the firms. Estimated targets are bounded between 0 and 1.

$$LEV_{i,t} = \alpha + \beta_1 \cdot PROF_{i,t} + \beta_2 \cdot MTB_{i,t} + \beta_3 \cdot TANG_{i,t} + \beta_4 \cdot NDTS_{i,t} + \beta_5 \cdot SIZE_{i,t} + \sum_{t=1}^{T-1} \tau_t \cdot YEAR_t + \sum_{r=1}^{R-1} \gamma_r \cdot REGION_r + \sum_{s=1}^{S-1} \delta_s \cdot SECTOR_s + \varepsilon_{i,t} \quad (1)$$

In equation (2), we regress the first difference of the market\book leverage on the absolute deviation of the previous market\book leverage targets (TARGET) from the chosen golden ratio level (GRL) and the deviation of the previous market\book leverage targets from the previous market\book leverage (TDIF). This model provides insights into whether the distance of the market \book leverage targets from the golden ratio-based levels explains how firms adjust their market\book leverage. If firms adjust their leverage towards their leverage targets and consider the distance between leverage targets and golden ratio levels, we anticipate positive coefficients for β_1 and β_2.

$$\Delta LEV_{i,t} = \alpha_i + \beta_1 \cdot LEVDIF_{i,t-1} + \beta_2 \cdot TDIF_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

where

$$LEVDIF_{i,t} = \left|TARGET_{i,t} - \text{GRL}\right|$$

$$TDIF_{i,t} = TARGET_{i,t} - LEV_{i,t}$$

$$TARGET_{i,t} = \widehat{LEV_{i,t}}$$

Next, we examine the relationship between the absolute deviation of the environmental, social, and governance (ESG) performance compared to its highest value in the investigated 12-year span and the absolute deviation of the leverage targets from the golden ratio levels (LEVDIF), as outlined in equations (3). We define LEVDIF as the dependent variable and ESGDIF as the independent variable as we argue that firms with better ESG performance unknowingly strive for a harmonized capital structure. We divide ESGDIF by 100 to scale the coefficients for ascetic purposes. We also substitute the environmental pillar score (ENV), social pillar score (SOC), and governance pillar score (GOV) into ESGDIF as independent variables. In this model, we include dummy variables for firm effects (FIRM) to explore the temporal dynamics of the absolute deviations. Therefore, we assume that if the absolute deviation of ESG scores from the twelve-year maximum ESG performance decreases, the absolute deviation of the leverage targets from the golden ratio levels also decreases. We anticipate a positive and statistically significant β_1-coefficient, suggesting a positive association between ESG performance and golden ratio-based leverage targeting.

$$LEVDIF_{i,t} = \beta_1 \cdot ESGDIF_{i,t} + \sum_{i=1}^{N} \alpha_i \cdot FIRM_i + \varepsilon_{i,t} \quad (3)$$

where

$$ESGDIF_{i,t} = \left|ESG_{i,t} - \max\left(ESG_i\right)\right|$$

In order to estimate equation (2), the system generalized method of moments (system GMM) proposed by Blundell and Bond (1998) is employed. This approach is suitable for dynamic panel models when a correlation exists between the error term ($\varepsilon_{i,t}$) and the independent variable because of the first lag of the leverage. The second and third lags and differences of the explanatory variables were employed as instruments, and Sargan's (1958) test was applied to evaluate the viability of these instruments. The second-order serial correlation

is also examined in the first differenced equation. In addition, our estimation incorporates the instrument matrix transformation proposed by Roodman (2009) and the robust standard errors method introduced by Arellano (2009). This model allows us to examine the temporal dynamics of leverage in relation to the deviation of the leverage targets from the levels defined by the golden ratio.

In order to obtain estimates for equation (1), we employ a dummy variable least squares (DVLS) estimator with dummy variables for financial years. Therefore, it is possible to isolate the temporal component of our panel data and analyze the cross-sectional relationship between leverage and the firm characteristics. We also include further dummy variables for regions and sectors. To estimate equation (3), we apply the DVLS estimator with dummy variables for firm effects to examine the temporal dynamics of the deviations. Additionally, robust standard errors proposed by Arellano (2009) are employed in our analysis.

Sample selection and descriptive statistics

The sample chosen for this study comprises publicly traded firms originating from Europe and the United States. The inclusion criteria for these firms were based on the availability of their environmental, social, and governance (ESG) scores and financial data from LSEG Data & Analytics. The selected time frame for data collection spans from financial years 2010 to 2021. The sample construction process involved the use of the following selection criteria: the sample exclusively comprises firms that possess ESG score data for every financial year within the chosen timeframe. We consider only the North American Industry Classification System (NAICS) sectors that align with conventional manufacturing, trade, or service characteristics while excluding industries such as agriculture, mining, real estate, finance, insurance, and utilities. According to the provided excerpt, the sample comprises nine sectors. We include only those firms in the sample whose financial year ends at the end of December and whose market capitalization, total equity, total revenue, total assets, and total debt exceed zero. Therefore, we focus our analysis on the leveraged firms.

We have been able to analyze 338 publicly listed firms over a span of twelve years in accordance with our predetermined selection criteria. The sample encompasses a total of 4056 financial years. The sample consists of 3168 financial years from manufacturing sector, 564 financial years from the service sector, and 324 financial years from the trade sector. Our sample consists of 2328 financial years of European listed firms and 1728 financial years of listed firms from the United States, concerning geographical regions.

In our analysis, we use the assumption that the firms unwittingly adjust their market and book leverage targets towards the important levels defined by the golden ratio. Thus, the leverage targets tend to converge towards the ratios observed in the Fibonacci sequence. We specify golden ratio levels based on the previous literature and empirical evidence from our sample to compare the leverage targets with the chosen golden ratio levels. Ulbert et al. (2022) compare the equity to total assets ratio to 38.2% and find that a golden ratio-based capital structure benefits the firm's financial performance and market acceptance, especially in the United States and the service sector. Compared to our leverage ratio, they use a broader measure for the capital structure, which includes all the liabilities justifying higher debt ratios. Amin and Cek (2023) applied the same book leverage ratio as ours and compared it to 61.8% but found contradicting results in the United Kingdom and France.

Upon examining the empirical evidence, we compare the important ratios of the Fibonacci sequence to the means of the market and book leverage of the firms in our sample. Table 3. presents the mean market and book leverage of the sectoral and regional subsamples, together with their respective deviations from the important levels determined by the golden ratio. Based on the mean leverages, we choose to compare the market leverage to 23.6%, which is $\frac{1}{1.618}^{3}$, and the book leverage to 38.2%, which is $\frac{1}{1.618}^{2}$. The mean market leverage ratio observed among the manufacturing companies is 23.72%, exhibiting a marginal deviation of 12 basis points from the desired level of 23.6%. The mean book leverage observed among manufacturing companies is 38.45%, exhibiting a marginal deviation of 25 basis points from the desired level of 38.2%. In the context of manufacturing firms, the differences between the mean values of leverage and the golden ratio-based levels can be considered insignificant. The mean market leverage ratio observed among service sector companies is 25.46%, exhibiting a deviation of 1.86% from the desired level. The difference is significantly larger, 7.58%, in the case of the book leverage of the service sector firms. The differences are significant at the 1% level. Significant differences in market leverage and negligible differences in book leverage are observed within the trade sector. Significant differences from the desired values are observed upon examination of the regional subsamples. According to the sectoral descriptive statistics of market and book leverage, we argue that choosing leverage close to the golden ratio-based levels is attributed to sector-specific characteristics.

Table 3: Descriptive statistics of leverage in the sectoral and regional subsamples

		Variable	Mean	Standard Deviation	Number of Obs.	Deviation from the golden ratio levels
Sector	Manufacturing	$MLEV_{i,t}$	0.2372	0.1806	3168	0.0012 (0.3689)
		B$LEV_{i,t}$	0.3845	0.1884	3168	0.0025 (0.7495)
	Services	$MLEV_{i,t}$	0.2546	0.1813	564	0.0186*** (2.4423)
		B$LEV_{i,t}$	0.4578	0.2196	564	0.0758*** (8.1934)
	Trade	$MLEV_{i,t}$	0.2611	0.1841	324	0.0251*** (2.4542)
		B$LEV_{i,t}$	0.3842	0.1798	324	0.0022 (0.2237)
Region	Europe	$MLEV_{i,t}$	0.2533	0.2017	2328	0.0153*** (3.6596)
		B$LEV_{i,t}$	0.3703	0.1974	2328	0.1323*** (32.3321)
	USA	$MLEV_{i,t}$	0.2257	0.1475	1728	-0.0123*** (-3.4775)
		B$LEV_{i,t}$	0.4275	0.1844	1728	0.1895*** (42.7359

Table 3. presents the mean leverage in the sectoral and regional subsamples. BLEV denotes the book leverage, and MLEV denotes the market leverage. Market leverage is compared to 23.6%, and book leverage is compared to 38.2%. We present the t-statistics in parentheses, and ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The descriptive statistics of the financial years are presented in Table 4. The ESG scores exhibit an average value of 59.57 points and a standard deviation of 19.44 points. Furthermore, the mean absolute deviation of the ESG scores from the twelve-year maximum amounts to 14.49 points. The ESG pillar scores exhibit similar patterns. On average, the market leverage is 24.15%, with a standard deviation of 18.11%. Additionally, the mean of the market leverage target is 24.28%, and the absolute deviation of the market leverage target from the chosen golden ratio level is 13.85%. In contrast, the mean book leverage is 39.47%, with a standard deviation of 19.40%. The mean of the book leverage target is 39.45%, and the absolute deviation of the book leverage target from the chosen golden ratio level is 15.38%. Upon examining the difference between the leverage targets and the actual leverage, it is observed that the market\book leverage deviates just a little from the leverage targets as MTDIF and BTDIF depict the error terms in equation (2). When examining market leverage, the observed difference is only 12 basis points on average, whereas in the context of book leverage, the

difference stands at 0. Average profitability is 8.01%, the average market-to-book ratio equals 3.72, the average non-debt tax shield is 3.56%, and the average tangibility equals 23.51%.

Table 4: Descriptive statistics of the financial years

Variables	Mean	Standard deviation	Minimum	Median	Maximum	Number of observations
$ESG_{i,t}$	59.5698	19.4371	2.7100	62.3300	95.7700	4056
$ENV_{i,t}$	56.4840	26.6064	0.0000	61.2250	98.8900	4056
$SOC_{i,t}$	62.8067	22.9130	0.2600	66.805	98.4700	4056
$GOV_{i,t}$	57.5537	21.6867	1.9900	59.6300	97.8200	4056
$MLEV_{i,t}$	0.2415	0.1811	0.0000	0.1994	0.9752	4056
$BLEV_{i,t}$	0.3947	0.1940	0.0000	0.3857	0.9996	4056
$PROF_{i,t}$	0.0801	0.0802	-0.5849	0.0729	1.0752	4056
$SIZE_{i,t}$	23.0019	1.3708	18.7557	22.8747	27.3407	4056
$MTB_{i,t}$	3.7195	11.3949	0.1700	2.3900	641.9800	4056
$NDTS_{i,t}$	0.0356	0.0220	0.0000	0.0327	0.2920	4056
$TANG_{i,t}$	0.2351	0.1695	0.0000	0.2010	0.8795	4056
$MTARGET_{i,t}$	0.2428	0.0917	0.0000	0.2455	0.8261	4056
$BTARGET_{i,t}$	0.3945	0.0808	0.0000	0.3934	1.0000	4056
$MTDIF_{i,t}$	0.0012	0.1519	-0.9314	0.0200	0.7881	4056
$BTDIF_{i,t}$	0.0000	0.1740	-0.7378	0.0065	0.6516	4056
$ESGDIF_{i,t}$	14.4893	12.6965	0.0000	11.4000	75.5100	4056
$ENVDIF_{i,t}$	16.0979	16.8197	0.0000	10.8000	91.8900	4056
$SOCDIF_{i,t}$	15.8302	15.2659	0.0000	11.3500	93.5000	4056
$GOVDIF_{i,t}$	19.7771	15.6903	0.0000	16.8650	72.8200	4056
$MLEVDIF_{i,t}$	0.1385	0.1168	0.0000	0.1137	0.7392	4056
$BLEVDIF_{i,t}$	0.1538	0.1189	0.0000	0.1266	0.6176	4056

Table 4. presents descriptive statistics of the variables used in our analysis. ESG stands for the ESG score, ENV for the environmental pillar score, SOC for the social pillar score, GOV for the governance pillar score, MLEV for the market leverage, BLEV for the book leverage, PROF for profitability, SIZE for the firm size, MTB for the market-to-book ratio, NDTS for the non-debt tax shield, TANG for tangibility. MTARGET denotes the market leverage target, and BTARGET is the book leverage target. Leverage targets are estimated from equation (1). Target leverage estimates are bounded to the [0,1] interval. MTDIF equals the deviation of the market leverage target from the actual market leverage. BTDIF equals the deviation of the book leverage target from the actual book leverage. ESGDIF equals the absolute deviation of the ESG Score from its twelve-year maximum. ENVDIF equals the absolute deviation of the environmental pillar score from its twelve-year maximum. SOCDIF is measured as the absolute deviation of the social pillar score from its twelve-year maximum. GOVDIF is the absolute deviation of the governance pillar score from its twelve-year maximum. MLEVDIF stands for the absolute deviation of the market leverage target from the chosen level of the Fibonacci sequence (23.6%). BLEVDIF equals the absolute deviation of the book leverage target from the chosen level of the Fibonacci sequence (38.2%). i and t are indices for firms and financial years, respectively.

Results

Golden ratio-based leverage targeting and the ESG performance

Table 5. presents the estimates of the market and book leverage target equations. We estimate equation (1), where the dependent variables are the market and book leverage, which is explained by firm characteristics such as profitability, market-to-book ratio, non-debt tax shield, tangibility, and firm size. We include dummy variables for financial years, regions, and sectors to capture the time-varying and firm-specific nature of leverage targets. This way, we can assess the cross-sectional heterogeneity of market and book leverage.

Table 5. Leverage and firm characteristics.

Independent variable	Dependent variable	
	$BLEV_{i,t}$	$MLEV_{i,t}$
α	-0.4181*** (0.0656)	-0.3785*** (0.0568)
$PROF_{i,t}$	-0.5675*** (0.1098)	-0.9645*** (0.0923)
$MTB_{i,t}$	0.0024 (0.0060)	-0.0005 (0.0042)
$TANG_{i,t}$	0.0885*** (0.0210)	0.1773*** (0.0208)
$NDTS_{i,t}$	-0.2754 (0.1797)	-0.3928** (0.1928)
$SIZE_{i,t}$	0.0337*** (0.0027)	0.0297*** (0.0023)
$Services$	0.0798*** (0.0089)	0.0288*** (0.0072)
$Trade$	0.0210** (0.0093)	0.0359*** (0.0091)
$United\ States$	0.0489*** (0.0107)	-0.0272*** (0.0081)
$Financial\ years$	Yes	Yes
$Firms$	No	No
Adj. R^2	18.5026%	28.0455%
Number of observations	4056	4056

Table 5. presents the estimates of the market and book leverage target equations. BLEV stands for book leverage, MLEV for market leverage, PROF for profitability, MTB for the market-to-book ratio, TANG for tangibility, NDTS for non-debt tax shield, and SIZE for firm size. To estimate equation (1), we employ a dummy variable least squares (DVLS) estimator with dummy variables for financial years. We include further dummy variables for regions and sectors. Robust standard errors proposed by Arellano (2009) are presented in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Concerning the leverage and firm characteristics, we find that profitability has a significant negative relationship with leverage. One percentage point increase in profitability results in -56.75 basis points decrease in book leverage, and 96.45 basis points decrease in market leverage. These results support the assumptions behind the pecking order theory. The market-to-book ratio has a significant effect only if we estimate the equations without robust standard errors. Thus, we leave MTB in the equations. Tangibility has a significant positive effect on

leverage. One percentage point increase results in an 8.85 basis point increase in book leverage and a 17.73 basis point increase in market leverage. Non-debt tax shields have a significant effect only in the case of market leverage. One percentage point increase results in a 39.28 basis points decrease in the market leverage. Size has a significant impact on both market and book leverage. Service and the trade sector apply higher leverage than the manufacturing sector. Considering the regions, firms in the United States have higher book leverage but lower market leverage than European firms. The R^2 for the book leverage equation is 18.5%, and for the market leverage equation, 28.05%. These explanatory powers are identical to the findings of Adeneye et al. (2022) and Dang (2011). Based on these regressions, we define leverage targets as the estimated market and book leverage. Leverage targets are bounded to the [0,1] interval.

Table 6. presents an analysis of the relationship between ESG performance and the distance between the leverage targets and the golden ratio levels. We estimate equation (3), where the dependent variable is the distance of the leverage targets, and the independent variable is the ESG performance, as we assume that better ESG performance can guide firms towards more harmonized leverage targets. We study the association between the absolute deviations in a temporal setting, and coefficients are scaled for ascetic purposes.

Positive and statistically significant coefficients are predominantly observed in relation to subsamples of Europe and the manufacturing sector. When examining the subsamples of Europe and the manufacturing sector, it becomes apparent that the coefficients of ESGDIF, SOCDIF, and GOVDIF demonstrate a positive and statistically significant relationship with both market and book leverage, while ENVDIF has a positive coefficient only in the case of book leverage. Considering the relationship between the deviation of book leverage and the deviation of the ESG score in the subsample of Europe, one point decrease in the absolute deviation from the maximum ESG performance is associated with a 5.82 basis points decrease in the distance of leverage targets from the levels defined by the golden ratio. Thus, firms with better ESG performance choose leverage targets closer to the golden ratio levels.

Concerning the subsamples of the United States and the service sector, negative, statistically significant coefficients are observed in the case of book leverage, and positive coefficients are observed in the case of market leverage. In these subsamples, firms with better ESG performance have market leverage targets closer to the golden ratio levels, and book leverage targets are redundant. In addition, we find that the relationship is mostly insignificant or negative in the trade sector.

Table 6: Golden ratio-based leverage targeting and the ESG performance in the regional and sectoral subsamples

Dependent variable	Independent variable	Coefficient	Europe	Manufacturing	USA	Service	Trade
$MLEVDIF_{i,t}$	$ESGDIF_{i,t}$	β	0.0268***	0.0329***	0.0349***	0.0514**	-0.0199
			(0.0091)	(0.0087)	(0.0122)	(0.0203)	(0.0258)
		Adj. R^2 (%)	54.8022	50.5973	40.0918	29.4066	49.8525
$BLEVDIF_{i,t}$		β	0.0582***	0.0310***	-0.0591***	-0.1462***	-0.0369*
			(0.0083)	(0.0080)	(0.0107)	(0.0167)	(0.0210)
		Adj. R^2 (%)	53.8992	50.7775	49.2515	48.3777	61.2319
$MLEVDIF_{i,t}$	$ENVDIF_{i,t}$	β	0.0065	0.0117	0.0209**	0.0482***	-0.0157
			(0.0078)	(0.0076)	(0.0098)	(0.0153)	(0.0211)
		Adj. R^2 (%)	54.6021	50.3299	39.9370	29.7885	49.8544
$BLEVDIF_{i,t}$		β	0.0502***	0.0222***	-0.0346***	-0.0844***	-0.0243
			(0.0070)	(0.0067)	(0.0084)	(0.0142)	(0.0180)
		Adj. R^2 (%)	53.8787	50.6834	48.6537	45.3747	60.9817
$MLEVDIF_{i,t}$	$SOCDIF_{i,t}$	β	0.0240***	0.0301***	0.0272**	0.0306**	-0.0283
			(0.0068)	(0.0071)	(0.0109)	(0.0149)	(0.0206)
		Adj. R^2 (%)	54.8701	50.6775	39.9999	28.9245	50.1275
$BLEVDIF_{i,t}$		β	0.0364***	0.0163**	-0.0545***	-0.0998***	-0.0365**
			(0.0061)	(0.0066)	(0.0098)	(0.0138)	(0.0168)
		Adj. R^2 (%)	53.4019	50.5272	49.3807	46.0847	61.4567
$MLEVDIF_{i,t}$	$GOVDIF_{i,t}$	β	0.0186***	0.0203***	0.0207**	0.0274*	-0.0002
			(0.0068)	(0.0062)	(0.0085)	(0.0145)	(0.0155)
		Adj. R^2 (%)	54.7784	50.4782	39.9208	29.0109	49.6844
$BLEVDIF_{i,t}$		β	0.0264***	0.0212***	-0.0255***	-0.0810***	-0.0004
			(0.0062)	(0.0056)	(0.0073)	(0.0123)	(0.0125)
		Adj. R^2 (%)	53.0452	50.6870	48.2309	45.9831	60.4002
Number of observations			2328	3168	1728	564	324

Table 6. presents an analysis of the relationship between ESG performance and the distance of the leverage targets from the levels defined by the golden ratio in the regional and sectoral subsamples. MLEVDIF is the absolute deviation between the market leverage targets and the chosen golden ratio level (23.6 %). In comparison, BLEVDIF equals the absolute deviation of the book leverage target from the chosen golden ratio level (38.2%). ESGDIF equals the absolute deviation of the ESG Score from its twelve-year maximum. ENVDIF equals the absolute deviation of the environmental pillar score from its twelve-year maximum. SOCDIF is measured as the absolute deviation of the social pillar score from its twelve-year maximum. GOVDIF is the absolute deviation of the governance pillar score from its twelve-year maximum. i and t are indices for firms and financial years, respectively. To estimate equation (3), we employ a dummy variable least squares (DVLS) estimator with dummy variables for firm effects. Coefficients are scaled for ascetic purposes. Robust standard errors proposed by Arellano (2009) are presented in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 7. presents an analysis of the relationship between ESG performance and the distance between leverage targets and golden ratio levels by regions and sectors. We estimate equation (3) and examine whether firms with better ESG performance choose to have leverage targets closer to the golden ratio levels. We study the association between absolute deviations in a temporal setting, and coefficients are scaled for ascetic purposes.

Table 7.: Golden ratio-based leverage targeting and the ESG performance by regions and sectors

Dependent variable	Independent variable	Coefficient	Manufacturing (Europe)	Manufacturing (USA)	Services (USA)	Services (Europe)	Trade (USA)	Trade (Europe)
$MLEVDIF_{i,t}$	$ESGDIF_{i,t}$	β	0.0421***	0.0245*	0.0953***	-0.0049	0.0039	-0.0332
			(0.0098)	(0.0141)	(0.0287)	(0.0277)	(0.0416)	(0.0338)
		Adj. R^2 (%)	58.6530	41.8462	28.4273	32.6616	51.3327	47.1033
$BLEVDIF_{i,t}$		β	0.0972***	-0.0301**	-0.1602***	-0.1282***	-0.1473***	0.0251
			(0.0088)	(0.0122)	(0.0235)	(0.0236)	(0.0295)	(0.0234)
		Adj. R^2 (%)	61.7086	41.9045	44.5017	30.2406	72.1926	59.8331
$MLEVDIF_{i,t}$	$ENVDIF_{i,t}$	β	0.0102	0.0129	0.0632***	0.0136	-0.0068	-0.0237
			(0.0082)	(0.0119)	(0.0188)	(0.0256)	(0.0311)	(0.0297)
		Adj. R^2 (%)	58.1954	41.7389	28.0370	32.7315	51.3756	46.9604
$BLEVDIF_{i,t}$		β	0.0717***	-0.0156	-0.0935***	-0.0632**	-0.0714***	0.0175
			(0.0074)	(0.0099)	(0.0172)	(0.0254)	(0.0264)	(0.0214)
		Adj. R^2 (%)	60.7311	41.6536	41.1792	26.3115	66.3116	59.6843
$MLEVDIF_{i,t}$	$SOCDIF_{i,t}$	β	0.0363***	0.0233*	0.0688**	0.0006	-0.0291	-0.0280
			(0.0075)	(0.0124)	(0.0269)	(0.0172)	(0.0313)	(0.0259)
		Adj. R^2 (%)	58.7571	41.8904	27.0951	32.6526	51.7426	47.1333
$BLEVDIF_{i,t}$		β	0.0649***	-0.0379***	-0.1126***	-0.0898***	-0.1693***	0.0105
			(0.0068)	(0.0109)	(0.0252)	(0.0147)	(0.0255)	(0.0176)
		Adj. R^2 (%)	60.6689	42.4104	39.7089	29.5057	75.1067	59.5212
$MLEVDIF_{i,t}$	$GOVDIF_{i,t}$	β	0.0294***	0.0109	0.0616***	-0.0039	0.0234	-0.0168
			(0.0077)	(0.0098)	(0.0217)	(0.0184)	(0.0231)	(0.0214)
		Adj. R^2 (%)	58.5881	41.7108	27.5929	32.6671	51.9211	46.8492
$BLEVDIF_{i,t}$		β	0.0459***	-0.0041	-0.1067***	-0.0575***	-0.0497***	0.0344**
			(0.0070)	(0.0084)	(0.0188)	(0.0159)	(0.0179)	(0.0151)
		Adj. R^2 (%)	59.4155	41.4704	42.1430	27.4986	63.3079	60.7377
Number of observations			1812	1356	264	300	108	216

Table 7. presents an analysis of the relationship between ESG performance and the distance of the leverage targets from the levels defined by the golden ratio by regions and sectors. MLEVDIF is the absolute deviation between the market leverage targets and the chosen golden ratio level (23.6 %). In comparison, BLEVDIF equals the absolute deviation of the book leverage target from the chosen golden ratio level (38.2%). ESGDIF equals the absolute deviation of the ESG Score from its twelve-year maximum. ENVDIF equals the absolute deviation of the environmental pillar score from its twelve-year maximum. SOCDIF is measured as the absolute deviation of the social pillar score from its twelve-year maximum. GOVDIF is the absolute deviation of the governance pillar score from its twelve-year maximum. i and t are indices for firms and financial years, respectively. To estimate equation (3), we employ a dummy variable least squares (DVLS) estimator with dummy variables for firm effects. Coefficients are scaled for ascetic purposes. Robust standard errors proposed by Arellano (2009) are presented in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Considering the results in Table 7., we find positive and statistically significant coefficients predominantly in the case of the European manufacturing sector. Meanwhile, the manufacturing sector in the United States exhibits positive coefficients at the 10% level in the case of market leverage, and mostly negative and insignificant coefficients are observed. Considering the relationship between the deviation of book leverage and the deviation of the ESG score in the subsample of European manufacturing firms, one point decrease in the absolute deviation from the maximum ESG performance is associated with a 9.72 basis points decrease in the distance of leverage targets from the levels defined by the golden ratio. Considering the service sector of the United States, we find positive coefficients in the case of market leverage and negative coefficients in the case of book leverage. However, mostly insignificant and negative coefficients are observed in the European service sector and trade sectors in the United States and Europe exhibit similar patterns.

Our findings show that firms with better ESG performance choose to have leverage targets closer to the golden ratio levels. The results also exhibit regional and sectoral differences, as European firms in the manufacturing sector adjust both their market and book leverage targets towards golden ratio levels, while firms in the manufacturing and service sector of the United States adjust only the market leverage targets towards the golden ratio levels. We argue that in these cases, firms with better ESG performance unwittingly strive for more harmonized leverage targets.

Golden ratio-based leverage targeting and the adjustment of leverage

Table 8. presents an analysis of whether the distance between leverage targets and golden ratio levels has a positive relationship with the actual leverage adjustment. We estimate equation (2), where the dependent variable is the first difference of market and book leverage, which is explained by the first lags of the deviation of leverage from the leverage targets and the absolute deviation between the leverage targets and the golden ratio levels. If firms consider the distance between the leverage targets and the golden ratio levels in relation to leverage adjustments, then we anticipate positive coefficients for MLEVDIF and BLEVDIF. In addition, positive coefficients for MTDIF and BTDIF depict that firms adjust their leverage towards the leverage targets.

According to Sargan's (1958) test, we can prove the viability of the instruments, and the second-order autocorrelation is not present in most of the models. The viability of the instruments is violated alone in the context of the market leverage model of the European

manufacturing sector. In addition, we can find significant second-order autocorrelation in the context of the book-leverage model of the manufacturing sector in the United States and the market leverage model of the European trade sector.

We can observe that the distance of the leverage targets has a significant positive effect only in the case of the book leverage adjustments in the European manufacturing sector. However, we can observe significant negative effects in the case of the book leverage adjustments in the European service sector and the manufacturing sector of the United States. These results prove that firms consider golden ratio-based leverage targeting only to a lesser extent and that leverage targets mostly unwittingly converge towards the golden ratio levels in the presence of better ESG performance. Furthermore, the regional and sectoral differences in the results strengthen our assumption that prudential sustainability reporting regulations in Europe and higher ESG exposure in the manufacturing sector incentivize firms to adjust their leverage towards a more harmonized capital structure.

Table 8.: Golden ratio-based leverage targeting and the adjustments of leverage by region and sectors

	Dependent variable	Independent variable	Coefficient(β)	Number of Observations	Sargan Test: p-value	AR2 Test: p-value
Europe (Manufacturing)	$\Delta MLEV_{i,t}$	$MLEVDIF_{i,t-1}$ $MTDIF_{i,t-1}$	-0.1853 (0.1704) 0.0627*** (0.0203)	1812	0.0041	0.1061
	$\Delta BLEV_{i,t}$	$BLEVDIF_{i,t-1}$ $BTDIF_{i,t-1}$	0.4582** (0.1969) 0.0488*** (0.0181)	1812	0.9788	0.6716
Europe (Service)	$\Delta MLEV_{i,t}$	$MLEVDIF_{i,t-1}$ $MTDIF_{i,t-1}$	-0.9992 (0.6392) 0.0782 (0.0705)	300	0.3811	0.6879
	$\Delta BLEV_{i,t}$	$BLEVDIF_{i,t-1}$ $BTDIF_{i,t-1}$	-0.2888* (0.1697) 0.0843** (0.0404)	300	0.5441	0.5068
Europe (Trade)	$\Delta MLEV_{i,t}$	$MLEVDIF_{i,t-1}$ $MTDIF_{i,t-1}$	-0.9805 (0.8043) 0.0724 (0.2394)	216	0.3552	0.0030
	$\Delta BLEV_{i,t}$	$BLEVDIF_{i,t-1}$ $BTDIF_{i,t-1}$	0.0972 (0.5391) 0.0367 (0.0464)	216	0.3652	0.8670
USA (Manufacturing)	$\Delta MLEV_{i,t}$	$MLEVDIF_{i,t-1}$ $MTDIF_{i,t-1}$	-0.0227 (0.1546) 0.1009*** (0.0265)	1356	0.1288	0.0669
	$\Delta BLEV_{i,t}$	$BLEVDIF_{i,t-1}$ $BTDIF_{i,t-1}$	-0.3379*** (0.1196) 0.1479*** (0.0348)	1356	0.1724	0.0216
USA (Services)	$\Delta MLEV_{i,t}$	$MLEVDIF_{i,t-1}$ $MTDIF_{i,t-1}$	0.2695 (0.2444) 0.0990 (0.0727))	264	0.9196	0.9831
	$\Delta BLEV_{i,t}$	$BLEVDIF_{i,t-1}$ $BTDIF_{i,t-1}$	0.0414 (0.1159) -0.0414 (0.0359)	264	0.1529	0.8720
USA (Trade)	$\Delta MLEV_{i,t}$	$MLEVDIF_{i,t-1}$ $MTDIF_{i,t-1}$	-0.7705 (1.5966) 0.1853 (0.2581)	108	0.2101	0.2351
	$\Delta BLEV_{i,t}$	$BLEVDIF_{i,t-1}$ $BTDIF_{i,t-1}$	0.0378 (0.1692) 0.1771*** (0.0467)	108	0.3069	0.9922

Table 8. presents an analysis of the relationship between the distance of leverage targets from the golden ratio levels and the actual leverage adjustment. ΔMLEV stands for the first difference in market leverage, while ΔBLEV stands for the first difference in book leverage. MTDIF equals the deviation of the market leverage target from the actual market leverage. BTDIF equals the deviation of the book leverage target from the actual book leverage. MLEVDIF stands for the absolute deviation of the market leverage target from the chosen level of the Fibonacci sequence (23.6%). BLEVDIF equals the absolute deviation of the book leverage target from the chosen level of the Fibonacci sequence (38.2%). i and t are indices for firms and financial years, respectively. To estimate equation (2), the system generalized method of moments (system GMM) proposed by Blundell and Bond (1998) is employed. The second and third lags and differences of the explanatory variables were employed as instruments, and Sargan's (1958) test was applied to evaluate the viability of these instruments. The second-order serial correlation is also examined in the first differenced equation. In addition, our estimation incorporates the instrument matrix transformation proposed by Roodman (2009). Robust standard errors proposed by Arellano (2009) are presented in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Discussion

Our paper aimed to scrutinize whether golden ratio-based leverage targeting is linked to better ESG performance. To answer our research question, we examined the relationship between ESG performance and the distance between leverage targets and levels defined by the golden ratio. We also explored the temporal dynamics of leverage in relation to the distance of leverage targets from the golden ratio levels.

In the H1 hypothesis, we posit that firms adjust their leverage considering the distance between the leverage targets and levels defined by the golden ratio. The H1a hypothesis considers market leverage adjustments, while the H1b hypothesis deals with book leverage adjustments. The H2 hypothesis posits that firms with better ESG performance choose to have leverage targets closer to the important levels defined by the golden ratio. The H2a hypothesis examines the relationship between ESG performance and leverage targeting based on the golden ratio levels in the context of market leverage. The H2b hypothesis suggests a connection between better ESG performance and golden ratio-based leverage targeting in relation to book leverage.

Overall, the findings about ESG performance and golden ratio-based leverage targeting are presented comprehensively in Table 9. The results highlight regional and sectoral differences as European firms in the manufacturing sector adjust both their market and book leverage targets toward golden ratio levels. In contrast, firms in the manufacturing and service sectors of the United States adjust only the market leverage targets towards the golden ratio levels. We argue that in these cases, firms with better ESG performance unwittingly strive for

more harmonized leverage targets. Conversely, firms in the trade sector and the European service sector mostly exhibit negative and insignificant coefficients. In summary, our findings indicate that we can only partially reject our H2, H2a, and H2b hypotheses.

Table 9: Summary of the results

Dependent variable	Independent variable	EU	M	M (EU)	M (USA)	USA	S	S (USA)	S (EU)	TR	TR (USA)	TR (EU)
$MLEVDIF_{i,t}$	$ESGDIF_{i,t}$	+	+	+	+	+	+	+				
$BLEVDIF_{i,t}$		+	+	+	-	-	-	-	-	-	-	
$MLEVDIF_{i,t}$	$ENVDIF_{i,t}$					+	+	+				
$BLEVDIF_{i,t}$		+	+	+		-	-	-	-		-	
$MLEVDIF_{i,t}$	$SOCDIF_{i,t}$	+	+	+	+	+	+	+				
$BLEVDIF_{i,t}$		+	+	+	-	-	-	-	-	-	-	
$MLEVDIF_{i,t}$	$GOVDIF_{i,t}$	+	+	+		+	+	+				
$BLEVDIF_{i,t}$		+	+	+		-	-	-	-		-	+

Table 9 summarizes results concerning the relationship between ESG performance and golden ratio-based leverage targeting. +\- signs indicate statistically significant positive and negative relationships between ESG performance and the distance of leverage targets from the golden ratio levels. EU denotes Europe, USA denotes the United States, M denotes the manufacturing sectors, S denotes the service sector, TR denotes the trade sector. MLEVDIF is the absolute deviation between the market leverage targets and the chosen golden ratio level (23.6 %). In comparison, BLEVDIF equals the absolute deviation of the book leverage target from the chosen golden ratio level (38.2%). ESGDIF equals the absolute deviation of the ESG Score from its twelve-year maximum. ENVDIF equals the absolute deviation of the environmental pillar score from its twelve-year maximum. SOCDIF is measured as the absolute deviation of the social pillar score from its twelve-year maximum. GOVDIF is the absolute deviation of the governance pillar score from its twelve-year maximum. i and t are indices for firms and financial years, respectively.

Considering the distance between leverage targets and golden ratio levels in relation to the leverage adjustments, we find a significant positive effect only in the case of the book leverage adjustments in the European manufacturing sector. However, significant negative effects can be observed in the case of the book leverage adjustments in the European service sector and the manufacturing sector of the United States. These results suggest that firms do not consider golden ratio-based leverage targeting in most cases, and leverage targets mostly unwittingly converge towards the golden ratio levels in the presence of better ESG performance. In addition, the regional and sectoral differences in the results strengthen our assumption that prudential sustainability reporting regulations in Europe and higher ESG exposure in the manufacturing sector incentivize firms to adjust their leverage towards a more harmonized capital structure. Thus, we can reject the H1a hypothesis and only partially reject the H1 and

H1b hypotheses as we find contradicting results in the manufacturing sector of the United States and Europe.

Our paper has three main theoretical contributions. First, we argue that although the golden ratio has been discovered and utilized in finance for a long time, firms do not consciously utilize golden ratio-based leverage targeting in their capital structure decisions. However, in some cases, firms adjust their leverage to minimize the distance between leverage targets and levels defined by the golden ratio to reach a more harmonized capital structure. Thus, golden ratio-based leverage targeting can complement optimal and dynamic capital structure theories, assuming that firms strive for harmonic symmetry in their capital structure.

Second, our results complement the literature about ESG performance and capital structure. Adeneye et al. (2022) find that firms with better ESG performance can aim for higher leverage targets. Finding a positive, statistically significant relationship between ESG performance and golden ratio-based leverage targeting in the European manufacturing sector and the manufacturing and service sector of the United States, we argue that superior ESG performance can guide firms towards more harmonized leverage targets.

Furthermore, our research adds to the existing literature on golden ratio-based capital structure. Specifically, we explore the relationship between ESG performance and the golden ratio-based approach to leverage targeting. Ulbert et al. (2022) and Amin and Cek (2023) discovered capital structure strategies based on the golden ratio that exhibited exceptional financial performance and gained significant market acceptance. We enhance the existing body of knowledge by demonstrating that firms with superior ESG performance tend to have leverage targets that align closely with the levels defined by the golden ratio.

Conclusion and implications

The relationship between ESG performance and golden ratio-based leverage targeting is not coincidental but stems from their conceptual coherence. The golden ratio is a mathematical approximation that represents harmony and proportionality observed in nature, art, architecture, and what we have been able to reconfirm in business and finance. It symbolizes a universal balance beyond aesthetic appeal and suggests order in complex systems. ESG principles promote a well-rounded approach to business operations, highlighting the significance of incorporating environmentally friendly behavior and operations, social responsibility, and governance practices into the fundamental strategy of companies. The two areas, although seemingly different, are united by the idea of overall sustainability.

The consistency of leverage targets with the golden ratio levels among firms that exhibit superior ESG performance can be seen as a manifestation of the broader principle of harmony. Firms that demonstrate excellence in ESG practices inherently recognize the importance of maintaining balance, not only in their financial frameworks but also in their interactions with stakeholders and the environment as a whole. The recognition of equilibrium reflected in their economic decisions can be understood as the fulfillment of a 'divine purpose' - to use a metaphorical term - where ethical and sustainable practices are rewarded with financial stability and increased market valuation.

From this perspective, our research indicates that the use of leverage targeting based on the golden ratio by firms with better ESG performance is not just a tactical financial choice but rather a demonstration of profound dedication to conducting business operations that are both harmonious and sustainable. This statement suggests that companies that operate in accordance with the natural order, represented by the golden ratio, and show respect for the complex network of relationships with stakeholders, as defined by ESG principles, are more likely to achieve higher financial performance and gain acceptance in the market. The connection between mathematical harmony and ethical business conduct highlights a fundamental principle: genuine sustainability and success are attained when all elements of business operations are harmoniously balanced and integrated, mirroring the inherent order and harmony in the natural world.

Our research has limitations since we do not examine the direction of the causality upon examining the association between ESG performance and golden ratio-based leverage targeting. In addition, we do not incorporate the previous research findings about golden ratio-based capital structure into our analysis as we do not consider the impact of market valuation and financial performance on the investigated relationship. Further analysis is needed to explore the interconnections between market valuation, financial performance, ESG performance, and golden ratio-based capital structure, which could determine the causal relationships and reinforce the performance implications of maximizing ESG performance and striving for harmony.

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