Risk Disclosure and Cost of Equity: A Bayesian Approach *

Divulgación de información sobre riesgos y coste de los recursos propios: un enfoque bayesiano

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How to cite / Cómo citar

Tirado-Beltrán, J. M., Cabedo, J. D., & Muñoz-Ramírez, D. E. (2020). Risk Disclosure and Cost of Equity: A Bayesian Approach. *Revista CEA, 6*(11), 25-43. https://doi.org/10.22430/24223182.1497

Received: 13 September 2019
Accepted: 16 November 2019

Abstract

This paper aims to analyze the relationship between risk information disclosure and the cost of equity of companies in the Spanish capital market. This study uses a set of 71 firms listed on Madrid stock exchange between 2010 and 2015; all of them are non-financial listed companies for which profit forecasts existed. The problem was analyzed using a Bayesian linear regression approach. The results show that cost of equity and disclosed risk information are not related if a global view of the latter is adopted. However, a positive relationship between financial risks and the cost of equity occurs when risk information is divided into financial and non-financial risks.

Keywords: Cost of equity, risk disclosure, Bayesian approach.

JEL classification: C11, M41, G32.

* This article is derived from the project entitled "Risk Disclosure and Cost of Equity: A Bayesian Approach" and has been financed with own resources.

Resumen
El objetivo de este artículo es analizar la relación entre la divulgación de información sobre riesgo y el coste de capital de los recursos propios de empresas que cotizan en el mercado de capitales español. Este estudio utiliza un conjunto de 71 empresas que cotizaron en la Bolsa de Madrid entre 2010 y 2015; todas son empresas no financieras de las que había previsiones de beneficios. El problema se ha analizado bajo un enfoque de regresión lineal Bayesiana. Los resultados del estudio muestran que el coste de capital de los recursos propios y la información de riesgo divulgada no están relacionados cuando se toma la información de riesgos de manera global. Sin embargo, cuando la información de riesgo se divide en riesgos financieros y no financieros, se encuentra una relación positiva entre los riesgos financieros y el coste de capital de los recursos propios.

Palabras clave: coste de los recursos propios, divulgación de información sobre riesgos, enfoque bayesiano.

Clasificación JEL: C11, M41, G32.

1. INTRODUCTION

The usefulness of risk information disclosed by companies has received a great deal of attention in accounting research in recent years. Studies by (Peasnell, 1997), Solomon et al., (2000), and Cabedo and Tirado (2004) demonstrate the utility of this information for decision making. Empirical results also evidence this fact in the context of capital markets (Rajgopal, 1999; Jorion, 2002; Kravet & Muslu, 2013; Miihkinen, 2013; Campbell et al., 2014; Nelson & Rupar, 2015; Filzen, 2015; Hope et al., 2016). However, few studies have examined the influence of risk information on the cost of equity; only Jorgensen and Kirschenheiter (2003) and Heinle and Smith (2017) have explored this aspect from a theoretical point of view.

According to Jorgensen and Kirschenheiter (2003), under the assumption that managers are aware of the variance of future cash flows, they will only disclose such information when the variance is low, which leads to a reduction in the cost of equity. The absence of disclosure will be interpreted by investors as a situation in which there is a high variance, thus affecting the risk premium demanded by investors and producing an increase in the cost of equity. Recently, Heinle and Smith (2017) proposed a theoretical framework for the relationship between risk disclosure and the cost of equity. The authors assume that investors are unaware of the variance of future cash flows and analyze the effect of risk information disclosure as an imperfect signal of that variance. They indicate that risk information disclosure reduces the uncertainty that investors perceive in the variance distribution. However, the impact of this disclosure on the cost of equity depends on how investors perceive such information.

This study analyzes the relationship between risk disclosure and a company's cost of equity in the Spanish capital market. We examine this relationship through a regression analysis using a Bayesian approach. Unlike the classical approach, the Bayesian method allows us to obtain the density function for each parameter to be estimated and, therefore, we can test the hypotheses in terms of probability, which is not possible with the classical approach. Our study includes a sample of companies listed on Madrid Stock Exchange (Spain) during the period from 2010 to 2015; the final sample consists of 71 companies and 348 observations.

Our findings show that there is no relationship between the risk information disclosed by a company and the cost of equity if a global view is adopted. However, when risk information is broken down into financial and non-financial risks, a positive relationship is found between disclosed financial risk information and the cost of equity. These results suggest that investors have a negative perception of the financial risk information provided by companies and, thus, demand a higher cost of equity.

The rest of this article is organized as follows. Section 2 presents a review of the literature and the hypotheses that will be tested. Section 3 describes the methodology used to contrast these hypotheses, the sample, and the data employed in this study. Section 4 presents the results of the empirical study. Finally, Section 5 draws the main conclusions.

2. THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

Finance and accounting literature has focused on analyzing how information disclosure can influence a company's cost of equity. In this regard, Clarkson et al., (1996) argue that an increase in information disclosure reduces uncertainty. Since investors have more information, they can estimate future returns or cash flows more accurately. Consequently, this lower uncertainty in the estimation of risk will enable them to demand a lower premium, resulting in a lower cost of equity.

Diamond and Verrechia (1991), Kim and Verrecchia (1994), Verrecchia (1999) and Leuz and Verrecchia (2000) propose another viewpoint and explain the influence of information disclosure on the reduction of cost of equity. These authors argue that an increase in the disclosure of information reduces information asymmetry among investors and increases the liquidity of company securities, thus favoring a reduction in cost of equity.

Additionally, a large number of empirical studies have examined the influence of different sources of accounting information on the cost of equity (Albarrak et al., 2020; Beyer et al., 2010; Easley & O'hara, 2004). Authors such as, Botosan (1997), Hail (2002), and Francis et al., (2005) have analyzed the relationship between the voluntary disclosure of accounting information and cost of equity. Their results show that there is a reduction in the cost of equity when more information is disclosed. However, Francis et al., (2008) found that this relationship no longer exists when the variable *earnings quality* is incorporated into the model. In fact, their results indicate that, in relation to the cost of equity, the quality of the information is more important than the amount of it.

The literature has also examined other types of information that influence the cost of equity, such as interim information (Botosan & Plumee, 2002; Gietzmann & Ireland, 2005), social information (Richardson & Welker, 2001), business press (Kothari et al., 2009), segmented information (Blanco et al., 2015), and risk information (Jorgensen & Kirschenheiter, 2003; Nahar et al., 2016; Heinle & Smith, 2017).

Their results show that the disclosure of segmented information and business press are negatively related to the cost of equity which corroborates theoretical assumptions. However, Botosan and

Plumee (2002) and Gietzmann and Ireland (2005), who studied the relationship between the disclosure of interim information and cost of equity, obtained different results. Whereas Botosan and Plumee (2002) evidence a positive relationship, Gietzmann and Ireland (2005) find the contrary to be the case. The latter argue that the positive relationship found by Botosan and Plumlee (2002) could be due to specification problems in the model that was used, pointing out that, in the estimation of this model, the possible effects of the company's accounting policy (aggressive *versus* conservative) are not taken into account, as noted by Gietzmann and Trombetta (2003) in their theoretical proposal. According to the results of Gietzmann and Ireland (2005), in companies classified as aggressive, the disclosure of information is negatively related to the cost of equity; conversely, in the case of conservative companies, the cost of equity is not influenced by the degree of such disclosure.

Richardson and Welker (2001) concluded that, contrary to expected, there is a positive relationship between the disclosure of social information and the cost of equity. These results could be due to different viewpoints: on one side, supporters of corporate social responsibility, who promote projects with negative net present values but future cost savings and strategic advantages; and, on the other side, the market, which assesses such projects as riskier.

Finally, a series of studies have analyzed the usefulness of risk information disclosure in capital markets. In particular, Jorgensen and Kirschenheiter (2003) and Heinle and Smith (2017) adopted a theoretical approach to analyze the relationships among risk disclosure, share prices, and cost of equity. The theoretical model proposed by Jorgensen and Kirschenheiter (2003) assumes that company managers are aware of the variance of future cash flows and can disclose this information in an indirect way. They point out that managers disclose risk information when variance is low, whereas they withhold such information if variance is high. Therefore, in a voluntary disclosure equilibrium, only low variances are disclosed, and prices are higher than if managers did not disclose any information. Additionally, they showed that a firm's beta and risk premium increase when its manager discloses a high variance or there is no disclosure. These results show that risk disclosure does indeed affect the cost of equity, whose impact will depend on investors' perception of the variance of cash flows disclosed by the company.

Heinle and Smith (2017) also analyzed the effect of risk disclosure on the cost of equity from a theoretical point of view. Unlike Jorgensen and Kirschenheiter (2003), the model proposed by Heinle and Smith (2017) assumes that investors are unaware of the variance of a company's future cash flows. The authors studied how sending imperfect signals of this variance through risk information disclosure can affect the cost of equity. This uncertainty in the variance of future cash flows generates uncertainty in the variance of the risk premium under valuation and, consequently, influences the cost of equity. Disclosing the variance of future cash flows can, therefore, decrease investor uncertainty regarding the variance of a firm's risk premium and reduce the variance perceived by investors. Thus, if uncertainty is reduced, the cost of equity decreases. However, Heinle and Smith (2017) stress that the effect of uncertainty on the cost of equity depends on how investors perceive risk disclosure: "a risk disclosure that suggests the firm is facing a very uncertain economic climate reduces uncertainty about the variance but increases the risk premium itself" (p. 1461).

In this vein of research, the theoretical studies that analyze the relationship between the disclosure of accounting information and the cost of equity assume that the disclosed information is not neutral in tone and, therefore, its behavior is one-sided (Diamond & Verrecchia, 1991; Botosan, 1997).

Kothari et al., (2009) point out that the study of the relationship between information disclosure and cost of equity is influenced both by the index that reflects the quality of the information and by its content, which may be favorable or unfavorable. Likewise, favorable disclosure reduces the cost of equity, while unfavorable information increases it, as shown in the study by Kothari et al., (2009). Given that the risk information disclosed by companies has a negative tone, the relationship of the cost of equity and this type of information must be positive (Campbell et al., 2014): the more information is disclosed, the higher the cost of equity. Only Nahar et al. (2016) have found a negative relationship between risk disclosure and cost of equity in the Bangladeshi banking sector.

Based on the arguments presented above, we will test the following hypothesis in our study:

Hypothesis: The relationship between the disclosure of risk information and the cost of equity depends on investors' perception of such information.

3. METHOD

Other studies that indirectly analyze the utility of disclosing accounting information, such as the present one, apply the analytical pattern we use. First, we define the variable to be studied, which is the one that experiences the impact of the published information. Next, we establish a set of control variables which, according to literature, should be related to the variable under study. Finally, by means of regression techniques, we estimate a model in which the dependent variable is the one mentioned above, while the explanatory set is made up of control variables and variables related to the disclosure of the accounting information whose relevance we aim to contrast. The results of the regression analysis allow us to assess such relevance.

In most studies, regression analysis is performed using a classical approach. Such approach assumes that the parameters of the regression model are distributed according to a Student's t distribution function. For each of them, the 0 value null hypothesis is tested against the alternative one that assumes a non-null value for the parameter.

There are two particular aspects to highlight regarding this classical regression analysis. Firstly, it provides very limited information about the parameter. It only tells us whether the parameter is equal to 0, but it does not assign any kind of probability to this result. Therefore, the degree of statistical reliability that the test provides is not a probability level (see, e. g., Alamilla-López and Jiménez, 2010). And secondly, each analysis is carried out separately, only with the observations collected for each one of the particular studies. The classical analysis always starts from total ignorance and does not allow previous knowledge about the parameter to be incorporated.

This work follows the analytical scheme described above. The variable studied is, in this case, *cost of equity* calculated as explained later in this section. The control variables that the literature has defined for this context are *size*, *growth potential*, and *risk*. We want to assess the relevance of the variable *risk information published by companies in their financial statements*. For this purpose, we use the Bayesian regression analysis instead of the classical statistical approach.

The main characteristic of the Bayesian model is the incorporation of prior knowledge (a priori information) into the estimation of the given parameters, in order to obtain an estimation process with more information, drawing inferences about the unknown parameters (Hahn, 2014; Zellner, 1996). The knowledge about these parameters is reflected in the action of assigning them a probability distribution. This assignment is a measure of belief in a hypothesis, and, therefore, inference is a process of readjustment of belief measures when new axioms are known. On the basis of a priori information, the posterior distribution of probabilities is then generated. In other words, by using the Bayesian analysis for the estimation of a parameter, we can obtain all its information (and not limited information, as is the case with classic analysis), i.e., its probability distribution. Such distribution will allow us to test the hypothesis in terms of probability.

But the problem with the Bayesian analysis for many years was that forming a posterior distribution requires integral calculus. And, given that not all the functions can be integrated, posterior distribution functions could only be obtained for a very limited number of a priori distributions. In other words, Bayes did not provide solutions for general problems.

This limitation, however, has been overcome thanks to the calculation capacity of computers. As a result, we can use a method that approximates the solution of the aforementioned integral calculus and which, as demonstrated in the literature, provides a solution that converges towards the true distribution of parameters: The Markov Chain Monte Carlo method (MCMC).

The Monte Carlo method was developed in the late 1940s by John von Neuman and Stanislaw Ulan, and it is applied to simulations that involve stochastic variables. This method generates random numbers by means of a probability distribution while reducing probabilistic uncertainty by repeatedly generating random numbers, thereby approximating the model under study to reality. The procedure stops when the arithmetic mean and the variance of the values obtained become stable.

The Markov chain is a stochastic model where states depend on transition probabilities, i.e., the current state only depends on the previous state. Therefore, if the process trajectory is known until moment n, the distribution of the variable $X_n + 1$ depends only on the last observed value, i. e., X_n, and not on the previous values.

Let us consider the following process (1), where n >= 0

$$X_{n+1}/X_n, X_{n-1}, \dots, X_0 \sim P\,(X_{n+1}/X_n, X_{n-1}, \dots, X_0) = P(X_{n+1}/X_n) \qquad (1)$$

The distribution of $X_n + 1$, conditioned by the previous information, solely depends on the state of the chain in n (X_n) and not on the history of the chain.

From the Markov Chain model and the Monte Carlo method arose the MCMC method (Martin et al., 2011), which successively simulates values of a density function. Each generated value depends only on the previous simulated value, and thus the notion of the Markov chain. Following a high number of simulations, the results obtained are used as a sample of the desired distribution function.

The statistical software that performs Bayesian calculations (as is the case of R used in the present study) allows us to use the MCMC method. We used the Gibbs sampling algorithm, which guarantees that the stationary distribution of the generated samples is the target posterior we are interested in (Gilks et al., 1996). We also used a multivariate Gaussian prior on the beta vector and an inverse Gamma prior on the conditional error variance.

We applied a two-stage procedure to estimate the parameters of the two regression models we propose in this study. Following the MCMC method, we first carried out 1,000 simulations for each parameter[1]. The second step was to run 10,000 simulations in order to estimate the posterior probability distribution function[2] for each of the parameters of the regression model.

The first of the regression models we estimated is defined in Equation (2):

$$CoE_{it} = \alpha + \beta_1 DI_{it} + + \beta_2 \, SIZE_{it} + \beta_3 LEV_{it} + \beta_4 BTM_{it} + \varepsilon_{it} \quad (2)$$

Where:

- DI_{it} is the variable that includes the disclosure of risk information measured by an index;
- BTM_{it} is the book-to-market ratio;
- LEV_{it} is the leverage ratio: total debt to market capitalization;
- $SIZE_{it}$ is the firm's size, measured by the market capitalization logarithm;
- CoE_{it} is the cost of equity;
- $i = 1, \ldots, n$ represents the *i-nth* firm;
- $t = 1, \ldots T$ represents the financial year to which the data refers; and
- ε_{it} is the residual of the model.

In a second model, shown in Equation (3), we divided the disclosure of risk information into two groups: related to financial risks and related to non-financial ones.

$$CoE_{it} = \beta_0 + \beta_1 FRDI_{it} + \beta_2 NFRDI_{it} + \beta_3 BTM_{it} + \beta_4 LEV_{it} + \beta_5 SIZE_{it} + \varepsilon_{it} \quad (3)$$

Where:

- $FRDI_{it}$ represents the disclosed information on financial risks, measured by an index;
- $NFRDI_{it}$ represents the disclosed information on non-financial risks, measured by an index; and
- the rest of variables are defined the same as in model (2).

In both models, the expected cost of equity is used as the dependent variable. Such cost of equity has been calculated according to the procedure proposed by Easton (2004), who states that, when increases in abnormal growth in earnings are equal to zero, the rate of return (cost of equity) is equal to the relationship between the earnings forecast for one year and the share price of the previous year (4):

$$CoE_t = \frac{EPS_{t+1}}{P_{t-1}} \quad (4)$$

[1] We initialize the algorithm with random values. Therefore, the samples simulated based on this algorithm, at early iterations, may not necessarily be representative of the actual posterior distribution. These samples are commonly discarded. The discarded iterations are often referred to as the "burn-in" period.

[2] Strictly speaking, MCMC methods do not provide us with the posterior density function, only random samples from it. The posterior distribution can then be built from the moments of these samples.

Where:

- EPS_{t+1} represents the expected earnings per share for the following year (t + 1), and
- P_{t-1} is the average share price in the previous year (t – 1).

Furthermore, in both models, we use *size*, *growth potential* and *risk* as control variables, measured as follows:

- Size ($SIZE_t$): Large companies need more funding, which is why they are interested in providing more information about risks, the objective being to reduce information asymmetry. Several researchers draw attention to a negative relationship between company size and cost of equity (Botosan, 1997; Botosan & Plumlee, 2002; Embong et al., 2012). However, other studies have not found a significant relationship between them (Lan et al, 2013). In this study, we quantify size by using the natural logarithm of the stock market capitalization.
- Risk (LEVt): Risk has been introduced into the model through the leverage ratio, i.e., the total debt to market capitalization ratio of the firm, for each of the companies and years we have analyzed. A company with a high leverage level is perceived by the market and investors as highly risky; for that reason, a higher rate of return is required (Botosan & Plumlee, 2005; Gietzmann & Ireland, 2005; Hail, 2002). However, Linsley and Shrives (2006) and Mohobbot (2005) did not find any statistically significant relationship between cost of equity and leverage ratio.
- Growth potential (BTM_t) is measured by the book-to-market ratio, i.e., the ratio of equity at book value to market capitalization. This ratio represents a measure of company growth opportunities (Gebhardt et al., 2001). High values of this ratio indicate low growth opportunities, which would therefore generate an increase in the cost of equity. This positive relationship can be found in studies by Botosan and Plumlee (2005), Cheng et al., (2004), and Hail and Leuz (2006).

The variables that represent the risk information disclosed by firms have traditionally been measured by the number that times certain sentences or predetermined keywords appear in a text (Abraham & Cox, 2007; Linsley & Shrives, 2006; Mohobbot, 2005). Cabedo Semper and Tirado Beltrán (2009) found that, in the case of using sentences or words, it is assumed that, if a company formulates two statements regarding a certain risk, it is reporting twice as much as a firm that only issues one statement about the same risk. In fact, it is possible that both companies are providing the same content, although one does so with a greater narrative. These authors, therefore, propose an alternative way to measure published risk information, based on disclosure indexes constructed from a series of phases. They defined phases as informative levels regardless of the number of sentences concerning a given aspect of risk. In this study, we use such method for measuring informative content.

We defined five phases which are not exclusive. A company can match more than one phase according to the characteristics of the provided information:

- Phase 1 (E1): The company only mentions the risks it is exposed to.
- Phase 2 (E2): The company describes the risk and how it is affected by it.

- Phase 3 (E3): The company quantifies the impact of the risk.
- Phase 4 (E4): The company informs on risk management.
- Phase 5 (E5): The company informs on the type of tools used to mitigate the risk.

Taking the above into account, we analyzed the risk information published in annual accounts and management reports. This information was classified into a series of phases. Based on said classification, we calculated disclosure indexes, by adding up the phases defined for each type of risk of each firm in the sample. Specifically, the following is the index we propose to measure the level of risk disclosure:

$$DI_i = FRDI_i + NFRDI_i \qquad (5)$$

Where:

- DI_i is the risk information index of firm *I*;
- $FRDI_i$, the financial-risk disclosure index of the firm; and
- $NFRDI_i$, the non-financial risk disclosure index of firm *i*.

The financial-risk ($FRDI_i$) and non-financial risk disclosure indexes ($NFRDI_i$) are calculated using Equations (6) and (7):

$$FRDI_i = \sum_{j=1}^{m} \sum_{rf=1}^{Krf} E_{i,j}^{rf} \qquad (6)$$

where *rf* is the type of financial risk; $E_{i,j}^{rf}$ is the value of phase *j* of the financial risk *rf* for firm *i*; $E_{i,j}^{rf}$ takes a value of 1 if firm *i* is in this phase or 0 if it is not; and *m* is the number of phases.

$$NFRDI_i = \sum_{j=1}^{m} \sum_{rNf=1}^{KrNf} \sum_{h=1}^{n} f_{i,h} \, E_{i,j}^{rNf} \qquad (7)$$

where, *rNf* is the type of non-financial risk; $E_{i,j}^{rNf}$ is the value of phase *j* of the non-financial risk *rNf* for firm *i; $E_{i,j}^{rNf}$* takes a value of 1 if the firm *i* is in this phase or 0 if it is not; *m* is the number of phases; and $f_{i,h}$ will take the value of each *n* factor of non-financial risk.

We obtained the information needed to estimate the models from the following sources:

- The data of the control variables, as well as those needed to determine the values of the dependent variable, were obtained from the Thomson One Banker database.
- For the calculation of the risk disclosure indexes, we used data from the consolidated annual accounts and management reports of the companies that composed the sample, as found in the Spanish Securities and Exchange Commission, *Comisión Nacional del Mercado de Valores* (CNMV).

The initial sample contained all the non-financial firms listed on the Madrid Stock Exchange between 2010 and 2015: 128 in total. We ruled out companies for which no profit forecasts were available because it was not possible to obtain values of the dependent variable for them. Likewise, we eliminated observations of years in which a firm's profit forecasts were negative. The final sample comprised 71 firms and 348 observations.

Table 1 presents the main descriptive statistics of the variables used in the models. We should point out that, on average, the risk disclosure index (DI) is 24.49 (out of a maximum of 80). The average value of this index is mainly composed of information related to financial risks (FRDI = 17.21, against a value of NFRDI = 7.28). Only 25 % of the companies have a risk disclosure index (ID) higher than 30. In turn, the average cost of equity (CoE) is 8.1 %.

Table 1. Descriptive statistics

Tabla 1. Descriptivos estadísticos

Variables	Min	1st Qtr.	Median	Mean	3rd. Qtr.	Max
CoE	0.00	0.04	0.06	0.08	0.09	1.70
DI	0.00	17.00	20.00	24.49	30.0	80.00
FRDI	0.00	15.00	17.00	17.21	20.00	32.00
NFRDI	0.00	0.00	4.000	7.284	11.25	48.00
Lev	0.00	19,32	32.91	32.92	45.74	90.27
Size	10.06	12.66	14.09	14.00	15.03	18.21
BooktoMarket	-0.63	0.34	0.64	0.76	1.02	10.00

Note: *CoE* is the estimation of the cost of equity calculated according to (3); *DI*, the risk disclosure index calculated according to (4); *FRDI*, the financial risk disclosure index calculated according to (5); *NFRDI*, the non-financial risk disclosure index calculated according to (6); *Lev*, the ratio of total debt to market capitalization; *Size*, the logarithm of market capitalization; and *BooktoMarket*, the book-to-market ratio.

Source: Created by the authors.

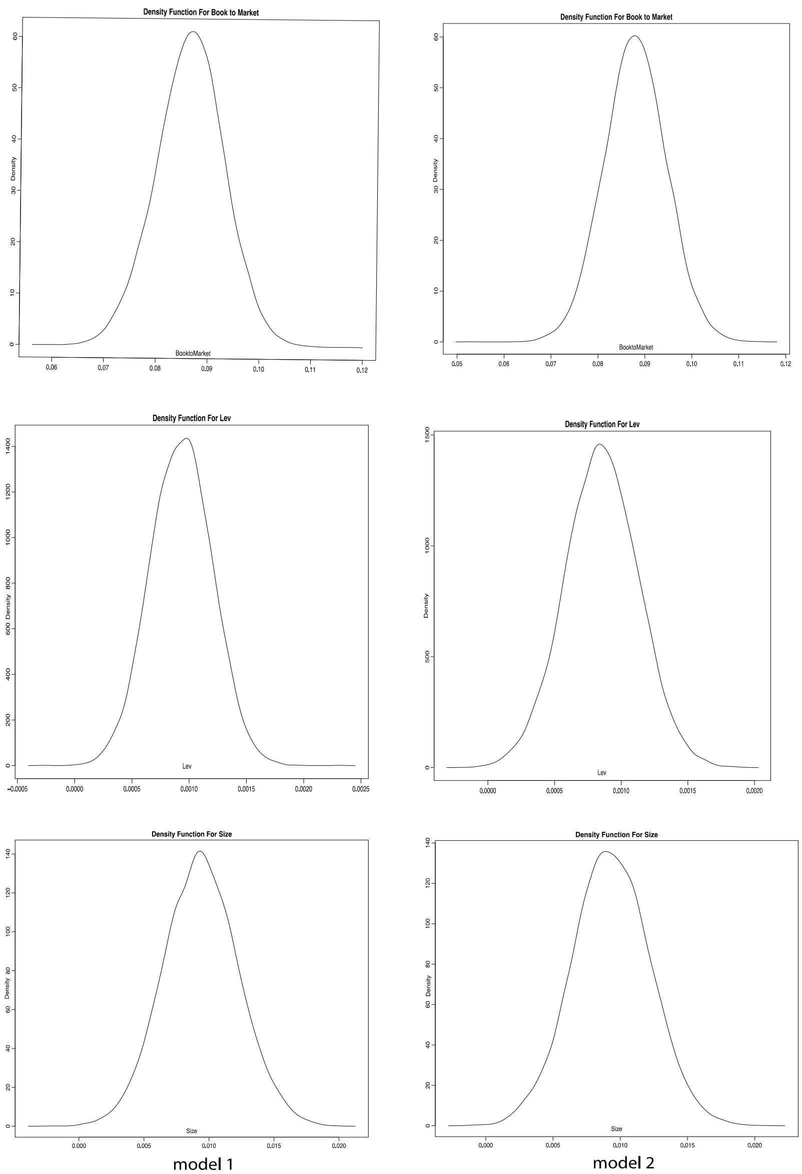
4. RESULTS

Table 2 presents the results of the regression analysis, based on the Bayesian methodology, and the estimates obtained for the two proposed models. The first model includes disclosed risk information as a whole, while the second one differentiates information related to financial risks and information related to non-financial risks.

The estimated coefficients based on the Bayesian analysis cannot be interpreted in the same terms as the classical statistical analysis. It is true that the coefficient value of each variable provided by the Bayesian approach (which corresponds to the average value of the posterior probability distribution for that coefficient) coincides with the value of the coefficients obtained by a conventional regression analysis (e.g., ordinary least squares). As a matter of fact, one may interpret the parameters of the "MEAN" column in Table 2 in the same way as those of the coefficients of a classical regression model. For example, the positive value (0.0009) of the variable Lev in Model 1 (see Table 2) tells us how much the cost of equity (dependent variable) will increase in case of a unitary change in Lev.

However, when we carry out the classical analysis, the only inference we can draw from the coefficient's value is to establish whether or not it is significantly equal to (or higher than) a certain value (usually 0). The Bayesian analysis, as described above, allows us to determine a degree of probability, i.e., we can assess the probability of the estimated coefficient being equal to (or higher than) a certain value.

For example, in the case of the variable Size in Model 1, the average value of the coefficient's posterior distribution (which coincides with the estimated value in a classical regression model) is 0.0093. The probability of this coefficient being higher than 0 is 99.96 % (see Table 2). We were able to calculate this last value because of the Bayesian analysis, which allows us to establish the statistical distribution of the coefficient. Thus, we obtained not only a point estimate, but also its density function. Similarly, we can apply this logic to the rest of the control variables of the two estimated models (see Figure 1).



Lev is the total debt ratio per market capitalization (a) model 1 and (b) model 2
Size is the logarithm of market capitalization (a) model 1 and (b) model 2.
BTM is the book to market ratio

Figure 1. Posterior density for control variables (Models 1 y 2).

Figura 1. Función de densidad a posteriori de las variables de control (Modelos 1 y 2).

Source: Own elaboration with research results.

Table 2. Summary of posterior distribution of Models 1 and 2

Tabla 2. Resumen de la distribución a posteriori de los Modelos 1 y 2

	Model 1			Model 2		
	MEAN	SD	P(β > 0)%	MEAN	SD	P(β > 0)%
(Intercept)	-0.1530	0.0407	3.00	-0.1774	0.0439	1.00
DI	0.0002	0.0004	72.22			
FRDI				0.0020	0.0012	95.35
NFRDI				-0.0003	0.0005	28.28
Lev	0.0009	0.0002	99.98	0.0008	0.0002	99.92
Size	0.0093	0.0028	99.96	0.0093	0.0028	99.93
BooktoMarket	0.0864	0.0065	>99.99	0.0879	0.0066	>99.99
sigma2	0.0077	0.0005	99.99	0.0077	0.0005	99.99

Note: *CoE* is the estimation of the cost of equity calculated according to (3); *DI*, the risk disclosure index calculated according to (4); *FRDI*, the financial risk disclosure index calculated according to (5); *NFRDI*, the non-financial risk disclosure index calculated according to (6); *Lev*, the ratio of total debt to market capitalization; *Size*, the logarithm of market capitalization; and *BooktoMarket*, the book-to-market ratio.

Source: Created by the authors.

Table 3. 95% credible interval for the variables of model 1

Tabla 3. Intervalos de credibilidad al 95% para las variables del modelo 1

Variables	Lower	Upper
Intercept	-0.2329330	-0.069206
DI	-0.0006379	0.001084
Lev	0.0004352	0.001487
Size	0.0037202	0.015216
BooktoMarket	0.0740816	0.100045
sigma2	0.0065463	0.008885

Note: *DI* is the risk disclosure index calculated according to (4); *Lev* is the ratio of total debt to market capitalization; *Size* is the logarithm of market capitalization; *BooktoMarket* is the book-to-market ratio.

Source: Created by the authors.

Table 4. 95% credible interval for the parameters of model 2

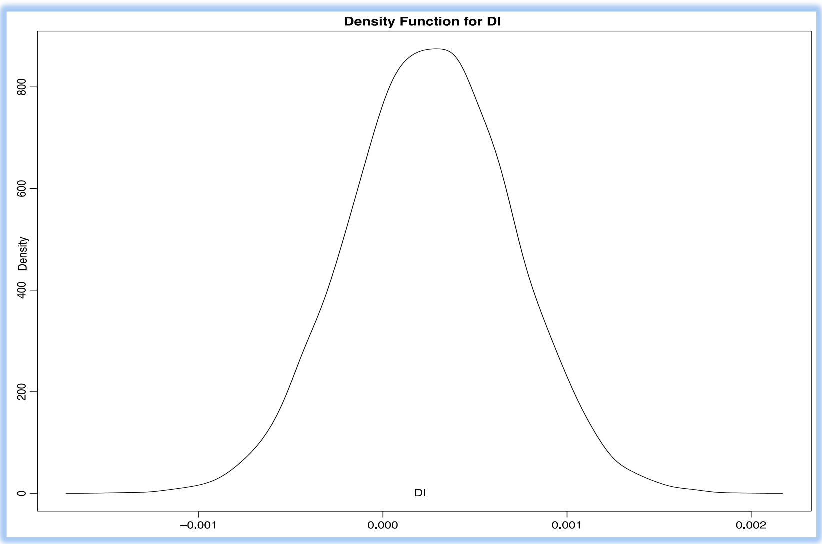
Tabla 4. Intervalos de credibilidad al 95% para las variables del modelo 2

Variables	Lower	Upper
Intercept	-0.2585097	-0.0842552
FRDI	-0.0004089	0.0043647
NFRDI	-0.0014513	0.0008054
Lev	0.0003201	0.0014009
Size	0.0034130	0.0149371
BooktoMarket	0.0753932	0.1016446
Sigma2	0.0065391	0.0088577

Note: *FRDI* is the financial risk disclosure index calculated according to (5); *NFRDI* is the non-financial risk disclosure index calculated according to (6); *Lev* is the ratio of total debt to market capitalization; *Size* is the logarithm of market capitalization; *BooktoMarket* is the book-to-market ratio.

Source: Created by the authors.

Regarding the risk information disclosed by firms, Table 2 shows that the coefficient of the variable that refers to disclosed information as a whole (DI) presents an average value of 0.0002 (the 95% credible intervals for the variables can be seen in tables 3 and 4). Beyond this relatively low average value, the most relevant number is the probability that this coefficient is higher than zero: 72.22 % (Figure 2 shows the density function of the parameter's posterior distribution). Consequently, since there is a high probability (27.78 %) that the parameter is less than 0, it would be risky (in terms of probability) to make a prediction about its sign. In short, we cannot conclude anything about the sign of this coefficient. Therefore, the variable will probably be irrelevant in the estimated model. This means that, when a company discloses risk information as a whole, it does not influence the cost of equity. These results contradict the theoretical assumptions of Heinle and Smith (2017) and Jorgensen and Kirschenheiter (2003).



DI: risk disclosure index

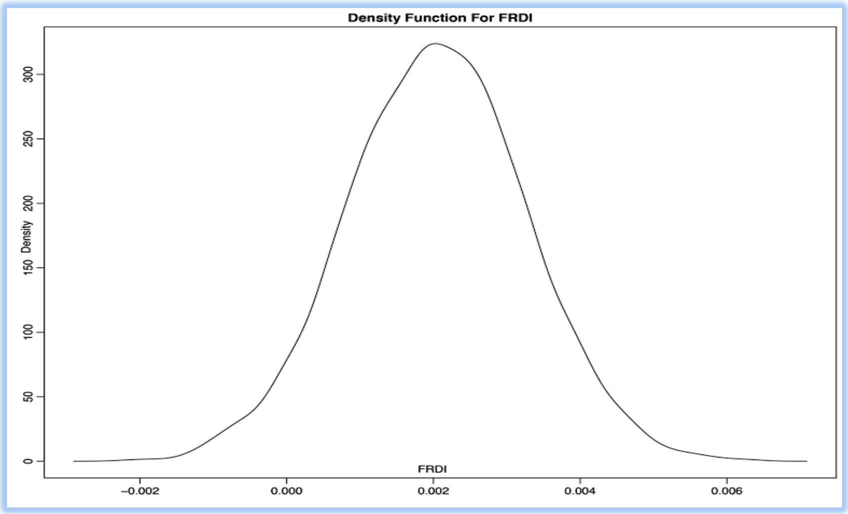
Figure 2. Posterior density of DI (Model 1)

Figura 2. Función de densidad a posteriori de DI (Modelo 1)

Source: Created by the authors.

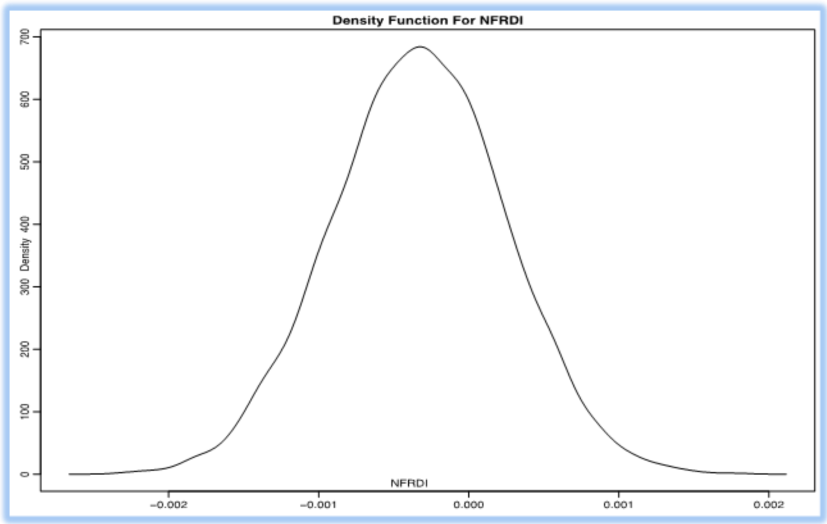
Model 2 differentiates between financial and non-financial risk information. Additionally, the average values of the estimated coefficients are 0.0020 and 0.0003 for FRDI and NFRDI, respectively. As can be seen from Table 2, the probability of the coefficient of the latter (regarding information on non-financial risks) being higher than 0 is 28.28%, i.e., we cannot categorically state that its coefficient's sign is negative since there is also a high probability of it being positive (see Figure 3). Consequently, these results lead us to conclude that the information disclosed about non-financial risks does not influence the cost of equity.

However, the situation for FRDI is different: the probability that the value of the coefficient of this variable is positive is 95.35% (see Table 2). Based on this level of probability, we can say that this coefficient is higher than 0 (also see Figure 4). Consequently, it can be pointed out that financial risk disclosure is related to cost of equity. A higher degree of financial risk disclosure is perceived by investors as a greater risk factor and thus requires higher costs. These results concur well with the theoretical assumptions of Heinle and Smith (2017), which indicate that sending imperfect signals of the variance of future cash flows (seen as a proxy of risk disclosure) reduces investor uncertainty about this variance and, therefore, influences the cost of equity. Nevertheless, the effect on cost of equity, as shown by Heinle and Smith (2017), will depend on the perception investors have of the risk information disclosed by firms. Our results indicate that investors perceive financial risk information as a major risk factor, penalizing the company and demanding a higher risk premium, and thereby increasing its cost of equity.



FRDI: financial risk disclosure index
Figure 3. Posterior density of FRDI (Model 2)
Figura 3. Función de densidad a posteriori de FRDI (Modelo 2)
Source: Created by the authors.

The coefficients of the control variables (*Lev*, *Size*, and *BooktoMarket*) are positive and have a high probability of being higher than zero in both models (see Table 2 and Figure 1 Appendix). According to the probability levels detailed in Table 2, both the level of debt and book-to-market (which measures company growth) are positively related to cost of equity. These results are consistent with previous literature (Botosan and Plumlee, 2005; Cheng et al., 2004; Hail, 2002; Hail and Leuz, 2006), but this is not the case for the variable *Size.* With the level of probability previously described, cost of equity and size have a positive relationship. This indicates that investors perceive the large size of firms as a risk factor, which then determines the cost of equity.



NFRDI: non-financial risk disclosure index
Figure 4. Posterior density of NFRDI (Model 2)
Figura 4. Función de densidad a posteriori de NFRDI (Modelo 2)
Source: Created by the authors.

5. CONCLUSIONS

There is abundant literature on the relationship between the information published by corporations and their cost of equity. However, in said literature, few studies have addressed the relationship between cost of equity and corporate risk disclosure. Our study focused on this subject and made an additional contribution in terms of the methodology we adopted: A Bayesian analysis using the Markov Chain Monte Carlo Method (MCMC). In effect, to date, all the studies that have empirically analyzed the relationship between disclosed information and cost of equity have applied a classical statistical approach, which only allows us to establish whether there is a significant relationship between cost of equity and the information variables under study. In other words, the classical analysis only enables us to infer a yes/no type of relationship among variables. The Bayesian analysis, however, allows us to go one step further and assign probabilities to the estimates of the model's parameters.

We applied this methodology to a sample of firms listed on the Spanish Stock Market. Our results show that the cost of equity and disclosed risk information (when a global view of the later is adopted) are not related. However, when risk information is divided into financial and non-financial risks, a significant relationship can be found. Specifically, there is a relationship between cost of equity and the financial risk information disclosed by firms. The positive sign of this relationship indicates that, for the market, greater risk information means a greater level of risk, which involves a higher cost of equity for the company.

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