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Estimating financial distress likelihood

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Abstract

This study develops an ex-ante model for estimating financial distress likelihood (FDL), and contributes to the literature by presenting a financially-based definition of distress that is independent of its legal consequences, a theoretically supported model for the FDL, and an appropriate methodology that uses panel data to eliminate the unobservable heterogeneity. The model is then estimated cross-sectionally to obtain an indicator of the likelihood of financial distress that incorporates the specificity of each company. In doing so, this study provides a well-specified model that is stable in terms of magnitude, sign and significance of the coefficients and, more importantly, that yields a measure of the FDL that is more robust to time and the international context than the estimates of FDL that are based on seminal models. This measure could be appropriate for use in future research that deals with FDL, such as capital structure and the prevention of financial distress.

Keywords: Financial insolvency; Financial distress likelihood; Logit analysis

1. Introduction

The need to maintain low interest rates to fuel investment in the global economy has contributed to a growing fear of a credit crunch contagion effect. A recent demonstration of this danger occurred in August 2007, when stock markets all over the world suffered from the consequences of weak credit markets. There is widespread disappointment with the rating agencies because they limit their analyses to the probability of default, which is a more limited concept than the probability of financial distress. Broader reporting on the likelihood of financial distress would permit a better understanding of the financial dimension of firms that is revealed in moments of crisis.

The theoretical debate about financial distress is rooted in the study of capital structure. The static theory of capital structure postulates that the optimum debt level arises from the trade-off between the tax advantages of borrowed money and financial distress costs (Kim, 1978). This theory leads many scholars to incorporate a measure of financial distress likelihood (FDL), based on Altman's (1968) *Z*-score model, into the study of capital structure (see, for instance, Mackie-Mason, 1990; Graham, 1996; and, more recently, Leary and Roberts, 2005). In this vein, Miguel and Pindado (2001) argue that financial distress costs should include two components: a measure of the likelihood of a firm filing for bankruptcy and the consequences for the firm if bankruptcy occurs. However, the measure of FDL provided by Miguel and Pindado (2001) is improbable, since its values do not range from 0 to 1. A similar criticism applies to studies that rely on FDL measures based on Altman's (1968) study.

However, the potential contribution of a measure of FDL to financial research goes beyond capital structure literature. For instance, Nash et al. (2003) use Altman's *Z*-score when evaluating the costs and benefits of restrictive covenants in bonds; Denis and Mihov (2003) study the choice between bank debt, non-bank private debt and public debt by accounting for the FDL (computed by means of Altman's *Z*-score); Bhagat et al. (2005) analyze the relationship between investment and the internal funds of distressed firms, which are identified by using Altman's *Z*-score as well as Ohlson's (1980) bankruptcy likelihoods.

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In short, the development of a robust and stable measure of FDL would make a significant contribution to financial literature. In fact, studies by Dichev (1998), Grice and Dugan (2001), Grice and Ingram (2001), and Bhagat et al. (2005) suggest the use of methods and models other than those proposed by Altman (1968) in computing bankruptcy likelihood.

Initially, Altman (1968) applies a linear discriminant analysis. Ohlson (1980) then substitutes logistic analysis for linear discriminant analysis as the estimation method. Following this trend, Zmijewski (1984) opts for a probit analysis. More recent studies focus on re-estimating the models above to determine whether they remain useful for predicting bankruptcy in more recent and longer periods and, more importantly, for predicting other financial distress conditions besides bankruptcy (Begley et al., 1996; Grice and Dugan, 2001; Grice and Ingram, 2001). Grice and Dugan (2001) and Grice and Ingram (2001) provide empirical evidence suggesting that these models are still useful for predicting financial distress, but they indicate that the models' accuracy is significantly lower in recent periods. These results tend to improve when the models are re-estimated, but the magnitude and significance of the re-estimated coefficients differ from those reported in their original application. Thus, these studies reveal no stable pattern in the coefficients of the seminal modes when applied to more recent and longer periods.

The aforementioned extensions of the seminal models to predict financial distress brought about renewed interest in the topic, and motivate this paper. Thus this study is closely related to such literature and provides the following two major contributions.

First, consistent with an ex-ante approach, we propose a definition of financial distress that can be applied regardless of its legal consequences. In this way, this paper addresses previous criticisms of ex-post models by using a financial criterion when defining a crisis based on the company's failure to face its financial obligations. Specifically, a firm is considered financially distressed not only when it files for bankruptcy, but also whenever operational cash flows are lower than financial expenses and market value persistently falls. More importantly, this financial condition is re-assessed each period, constituting a key advantage over existing proxies of distress.

The second contribution refers to the estimation method. Specifically, the panel data methodology for discrete dependent variables is used. This choice is motivated by the need to capture the dynamic existing in our measure of financial distress, which is not compatible with traditional pooled data across years. Additionally, this methodology allows us to control for unobservable heterogeneity. Furthermore, using panel data solves the problem of choosing the estimation year before the crisis when using the maximum annual data for each firm and, thus, improving the accuracy of the model.

Empirical evidence from the U.S. validates the econometric specification of the proposed model. The estimated coefficients in panel data models yield the expected sign using both fixed and random effects panel data models. Specifically, our results show that a small number of theoretically supported factors are enough to explain the FDL. The results of the cross-sectional analysis strongly confirm the accuracy of the model and show high percentages of correct classification for all years studied. In short, these results from the U.S. market show that the model for the FDL is useful in predicting financial distress in more recent and longer periods than the models of Altman (1968), Ohlson (1980), and Zmijewski (1984). Furthermore, two robustness checks performed using the other G-7 countries and re-estimating benchmark models corroborate the stability of the model, in terms of significance and sign of the coefficients and its classification power.

The results of this paper suggest a major improvement to the financial distress literature by using a more accurate ex-ante approach and applying a more appropriate methodology. In particular, this study provides a well-specified and theoretically supported model that is stable in terms of magnitude, sign and significance of the coefficients and, more importantly, that yields a measure of the FDL that is more robust to time and the international context than the estimates of FDL that are based on seminal models. It is worth noting the relevance of this gain since, as emphasized by the evidence in Begley et al. (1996) and in Grice and Dugan (2001), a more stable model of FDL that offers a consistent pattern in terms of significance and sign of coefficients and a consistent classification power for different periods and countries was needed. The development of a robust and stable measure of the FDL would make a significant contribution to literature in that, as we have already pointed out, such a measure has potential applications in many financial fields and topics.

The remainder of the paper is organized as follows. Section 2 describes the data set. Section 3 specifies a model for estimating FDL, and Section 4 describes the innovative estimation strategy used (panel data and cross-sectional analyses). Section 5 presents and discusses the estimation results of the FDL model using data from the U.S. market and the results of two robustness checks. Section 6 presents the conclusions of this study.

2. Data

To meet the objectives of this study, data from several countries are needed to ensure that the model for FDL works, regardless of the data used to estimate it. Thus, this study uses an international database, the Compustat Global Vantage, as the source of information.

For each country, the study constructs a panel of firms with information for at least six consecutive years from 1990 to 2002. Firms meeting these criteria can only be found in a few countries, such as the G-7 countries. The sample period comprises 13 years, and the selected countries represent a variety of institutional environments, which permits checking the stability of the model over recent and longer periods and across different institutional and legal contexts. This study constructs an unbalanced panel combining the available Compustat Global Industrial Active files, which contain information on active companies, and the Compustat Global Industrial Research files, which provide data on companies suspended from quotation for some reason after a certain period in the capital market. Thus, this study uses an unbalanced panel that reduces the possible survival bias that arises when the observations in the initial cross-section are independently distributed and when the subsequent entries and exits in the panel occur randomly. The analysis excludes the financial companies in Compustat Global because they have their own specificity. The selected sample contains 1583 companies (15,702 observations) for the U.S. and 2250 companies (18,160 observations) for the other G-7 countries.

Following Ohlson (1980) and Zmijewski (1984), the present study uses a sample in which the percentage of distressed firms is representative of the population. In fact, Ohlson (1980) indicates that sample selection procedures, such as the matched-pair design, give rise to biases. Zmijewski (1984) in particular provides evidence of biased parameters when the likelihood of a firm entering the sample is dependent on variable attributes, and shows that this bias decreases as the likelihood of bankruptcy in the sample approaches that of the population. Panel A of Table 1 provides the classification of the annual observations as normal and financially distressed. The U.S. sample comprises 4.1% of financially distressed observations, which is similar to the percentages reported in the pioneering studies by Ohlson (1980) and Zmijewski (1984).

3. A model for the likelihood of financial distress

3.1. A finance-based definition of financial distress

This study focuses on financial distress regardless of its legal consequences. This preference is based on the primary objective of obtaining a measure of FDL and not of predicting the event of bankruptcy. As Barnes (1987, 1990) indicates, the relevance of such a preference is that failure to meet financial obligations does not necessarily lead to bankruptcy. Additionally, Altman (1984) highlights the importance of using a definition of financial crisis that is independent of its outcome. These arguments call for the definition of the dependent variable consistent with an ex-ante approach.

Consequently, this study uses a financial criterion in defining a crisis, because definitions of financial distress based on the company's failure to meet its financial obligations are consistent with an ex-ante approach. Specifically, following Wruck (1990), Asquith et al. (1994), Andrade and Kaplan (1998), Whitaker (1999) and, more recently, San and Ayca (2006), the present study adopts a definition of financial distress that evaluates the company's capacity to satisfy its financial obligations. This permits the prediction of financial distress situations other than bankruptcy similar to those of Grice and Dugan (2001) and Grice and Ingram (2001). Thus, the study classifies a company as financially distressed not only when it files for bankruptcy, but also whenever it meets both of the following conditions: (1) its earnings before interest and taxes depreciation and amortization (EBITDA) are lower than its financial expenses for two consecutive years, leading the firm into a situation in which it cannot generate enough funds from its operational activities to comply with its financial obligations; (2) a fall in its market value occurs between two consecutive periods. A company that suffers from the previously mentioned operational fund deficit is

Table 1

Panel A. Classification of annual observations into normal and financially distressed

U.S. sample				Sample of other G-7 countries			
N	FD	Total	% FD	*N*	FD	Total	% FD
17,439	721	18,160	4.1	14,514	1188	15,702	7.6

Panel B. Summary statistics of the explanatory variables of the model for the FDL

	Profitability		Financial expenses		Retained earnings	
	USA	Other	USA	Other	USA	Other
Observations	15,702	18,160	15,702	18,160	15,702	18,160
Mean	0.073	0.058	0.024	0.015	0.083	0.115
Std. deviation	0.131	0.088	0.020	0.012	0.530	0.196
Minimum	−0.901	−0.350	0.000	0.000	−4.555	−1.295
Maximum	0.593	0.427	0.144	0.095	0.838	0.646

Panel C. Summary statistics of the explanatory variables of Altman's *Z*-score model

	Working capital		Retained earnings		Profitability		Market value		Sales	
	USA	Other	USA	Other	USA	Other	USA	Other	USA	Other
Observations	15,702	18,160	15,702	18,160	15,702	18,160	15,702	18,160	15,702	18,160
Mean	0.213	0.146	0.106	0.186	0.082	0.065	2.957	1.599	1.210	1.171
Std. deviation	0.222	0.197	0.530	0.472	0.139	0.096	5.037	2.254	0.757	0.652
Minimum	−0.590	−0.501	−3.818	−1.109	−0.662	−0.415	0.015	0.034	0.057	0.050
Maximum	0.755	0.691	0.914	4.726	0.470	0.444	45.953	24.143	4.440	4.726

N and FD stand for normal and financially distressed, respectively. A firm is classified as FD not only when it files for bankruptcy, but also whenever it meets both of the following conditions: i) its profitability is lower than its financial expenses for two consecutive years, and ii) a fall in its market value occurs between these two periods. Total is the number of observations. % FD is the percentage of financially distressed observations for each year. Explanatory variables of the model for the FDL are scaled by the replacement value of total assets. Explanatory variables of Altman's *Z*-score model are defined as in the original work. For each variable, the table reports the number of observations and the values of the following statistics: mean, standard deviation, minimum, and maximum.

expected to be assessed negatively by the market and its stakeholders; hence, it will suffer the negative consequences of financial distress until the improved economic condition is recognized again.

The study therefore considers a firm as financially distressed in the year that immediately follows the occurrence of these two events. In this way, we are introducing dynamic in the criterion of financial distress, which is a key development in existing proxies of distress, suited for large data panels. This criterion divides the sample into two groups and leads to the construction of a binary dependent variable that takes a value of one for financially distressed companies, and zero otherwise.

3.2. A theory-based selection of explanatory variables

A significant feature of this study is the selection of the explanatory variables in the model, which has a theoretical basis. This selection of variables permits the specification of a logistic model that is intended to be stable and parsimonious. A parsimonious selection of the explanatory variables would provide a more stable model in terms of magnitude, sign, and significance of the variables. One can conclude from the revision of some previous discriminant models that they do not require a huge set of variables to reach its maximum level of efficiency (Zmijewski, 1984; Pindado and Rodrigues, 2004). Consequently, the FDL model includes a small set of variables that financial theory suggests are closely linked with financial distress. The selected variables are profitability, financial expenses, and retained earnings (see Appendix A for a detailed description and panel B of Table 1 for summary statistics). These variables show the highest discriminatory power in the models of Altman (1968), Altman et al. (1977), and Ohlson (1980), as well as in subsequent studies by Begley et al. (1996) and Dichev (1998).

The first explanatory variable, profitability (EBIT/RTA), captures the capacity of the firm to manage its assets efficiently and generate enough funds to meet its financial obligations. Profitability ratios are generally used as measures of firm performance in the research on financial distress (Joseph and Lipka, 2006). This first ratio, in particular, is a measure of the productivity of the firm's assets, which is independent of any tax or leverage factors. It is also the main driver of liquidity. Creditors typically rely on measures of profitability when extending credit or renegotiating repayments to estimate the return generated by the firm on borrowed capital (Claessens et al., 2003). Given this, profitability will negatively influence FDL.

Second, financial expenses (FE/RTA) replace debt stock ratios because the latter seem to lose explanatory power compared to the chosen flow variable. Indeed, the research on FDL reveals the advantages of using a variable that considers the flow of financial expenses instead of the stock of debt. Since the revision of the *Z*-score carried out by Altman et al. (1977), many other subsequent studies point out that debt variables have less power in explaining financial distress than variables of financial expense (see, for instance, Andrade and Kaplan, 1998). Asquith et al. (1994) also show how the financial expense effect absorbs the leverage effect. Altman et al. (1977) replace the leverage variable by a debt service variable in their model, which allows them to account for the potential benefits of leverage (Jensen, 1986, 1989). Also, Begley et al. (1996) explain the better performance of the re-estimated *Z*-score relative to the classification made by using the coefficients of the original model. The reason for this is that the correction of this leverage bias is then translated into a reduced contribution of the leverage variable to the total discriminating power of the model. Thus, recent literature shows that the flow of financial expense is more appropriate than the stock of debt. For this reason, the model includes the variable of financial expense, which is expected to have a positive relation with the FDL.

Third, retained earnings (RE/RTA) are the total reinvested earnings or losses of a firm over its entire life. This is a measure of cumulative profitability over time, and is one of the most crucial predictors of financial crisis. In particular, Routledge and Gadenne (2000) highlight the usefulness of past profitability in predicting future results and capacity for self-financing. Accordingly, consistent with the pecking order theory proposed by Myers and Majluf (1984), the model includes retained earnings as an explanatory variable, for which a negative relation with FDL is expected.

3.3. Econometric specification

This study proposes a model to obtain a FDL that includes the variables mentioned above. Following Cleary (1999), all financial variables are for the beginning of the period except for EBIT and FE, which represent firm profitability and financial expenses during period *t*.

The logistic regression is expressed in terms of the odds ratio, which quantifies the likelihood of being financially distressed according to the criterion described in Section 3.1. Accordingly, the logistic model to estimate the FDL is as follows:

$$\log\left(\frac{\text{Prob(event)}}{\text{Prob(noevent)}}\right) = \beta_0 + \beta_1 \text{EBIT}_{it}/\text{RTA}_{it-1} + \beta_2 \text{FE}_{it}/\text{RTA}_{it-1} + \beta_3 \text{RE}_{it-1}/\text{RTA}_{it-1} + d_t + \eta_i + u_{it} \quad (1)$$

where all variables are indexed by an i for the individual cross-sectional unit ($i=1,\ldots, N$) and a t for the time period ($t=1,\ldots, T$). d_t is the time effect, η_i denotes the individual effect, and u_{it} is the random disturbance. The explanatory variables in the logistic regression (see Section 3.2) are profitability, financial expenses, and retained earnings. Their respective coefficients, β_1, β_2, and β_3, can be interpreted as follows. The first coefficient (β_1) is associated with the capability of assets to generate returns, and it will be negative. The second one (β_2) will be positive, since the FDL increases as the company's risk of not being able to comply with its financial obligations rises. Finally, the third coefficient (β_3) will be negative because the economic agents' expectations are based on past profitability and self-financing.

4. Strategy and methods of estimation

4.1. Strategy of estimation

In the present study, the first stage of the strategy consists of developing the econometric specification of the model according to financial theory, as described in the previous section. In the second stage, the study presents the innovation of estimating this model by using panel data. The traditional maximum likelihood estimator of the βs would be also consistent, but it will be inefficient because of unobservable heterogeneity, generating biased standard errors for the βs, and consequently leading to an incorrect specification of the model. In contrast, fixed and random effects panel data models are robust to unobservable heterogeneity, and thus serve to verify the significance of the βs. Moreover, the implementation of this second stage requires large data panels to consistently estimate the models of FDL, which becomes possible through the enhanced definition of financial distress developed in this study.

However, despite providing robust estimates of the parameters, these panel data models do not directly lead to obtaining a FDL because they do not consider the individual effects. To overcome this limitation, the third stage cross-sectionally estimates a regression for each year, thus obtaining an appropriate indicator of the FDL for each company and year.

4.2. Estimation methods

Logit analysis is a better estimation method than discriminant analysis, since the hypotheses on which the latter relies do not generally hold true (see, for instance, Einsenbeis, 1977 and, more recently, Hair et al., 1995). Additionally, discriminant analysis is not suitable for dealing with unobservable heterogeneity and other characteristics common to panel data samples. Finally, some authors who began using discriminant analysis, such as Altman and Sabato (2005), explicitly recognize the potential advantage of re-estimating the original model within a logistic regression structure.

Panel data models for discrete dependent variables check the specification of the model by eliminating the bias of omitted variables that arises when the unobserved individual-specific effects (η_i) are correlated with the explanatory variables. Thus, it is necessary to distinguish between fixed effects models (which do not assume a relationship between the individual effects and the remaining right-hand side variables) and random effects models (which specify the functional form of this relation). Consequently, the choice between fixed and random effects models depends on the assumptions regarding the dependence of the error distribution on the explanatory variables. Given the difficulty in establishing this relation, this study follows Arellano and Honoré (2001) in suggesting the suitability of estimating both models.

5. Results

5.1. Results from the U.S. market

The first and second columns of Table 2 present the results for the fixed and random effects models, respectively. The goodness-of-fit tests identify the high explanatory power of all the variables in both the fixed effects models (see likelihood ratios, LR) and the random effects models (see Wald tests). Additionally, Wald tests of the joint significance of the time dummies validate the use of such variables in both models, thus confirming that financial distress processes fluctuate over time. These results show that the inclusion of these dummy variables is important since they accommodate the impact of changes in the macroeconomic environment. Finally, the estimation of random effects models includes additional tests that verify the existence of unobservable heterogeneity (see $\rho=0$), suggesting the need to validate the model using panel data.

Table 2
Estimation results of the panel data models for the FDL

Dependent variable: FDL is a binary variable that takes a value of one for financially distressed firms, and zero otherwise

	Results from the U.S.		Results for other G-7 countries	
	Fixed effects model	Random effects model	Fixed effects model	Random effects model
Profitability	−0.877 (0.124)*	−1.646 (0.096)*	−3.706 (0.404)*	−4.400 (0.277)*
Financial expenses	3.910 (2.829)	1.354 (2.396)*	26.766 (6.641)*	26.539 (5.328)*
Retained earnings	−4.262 (.366)*	−7.123 (0.352)*	−7.714 (0.708)*	−1.967 (0.595)*
Time χ^2	93.46 (12)	71.92 (12)	11.62 (12)	5.48 (12)
LR χ^2	387.17 (15)		285.53 (15)	
$\ln\sigma_\eta^2$		1.451 (−0.061)		1.376 (0.057)
σ_η		2.066 (0.064)		1.980 (0.057)
ρ		0.565 (0.015)		0.546 (−0.014)
ρ=0 χ^2		1299.96 (1)		94.91 (1)
Wald χ^2		842.49 (15)		647.91 (20)

Panel B of Table 1 describes the explanatory variables. i) Heteroskedasticity consistent asymptotic standard error in parentheses; ii) *, **, *** indicate significance at the 1%, 5% and 10% levels, respectively; iii) time is a Wald test of the joint significance of the time dummy variables, asymptotically distributed as χ^2 under the null of no relationship, degrees of freedom in parentheses; iv) LR is the maximum likelihood ratio test of goodness-of-fit, asymptotically distributed as χ^2 under the null of no joint significance of the coefficients, degrees of freedom in parentheses; v) ρ=0 is a test of the joint significance of individual effects, asymptotically distributed as χ^2 under the null of no joint significance, degrees of freedom in parentheses; and vi) Wald is a test of goodness-of-fit, asymptotically distributed as χ^2 under the null of no joint significance of the coefficients, degrees of freedom in parentheses.

Given that the estimated coefficients in both panel data models are statistically significant and have the theoretically expected sign, the results are jointly described. First, the variable that captures profitability negatively affects the FDL. This evidence is consistent with the seminal studies. Second, the positive effect of financial expenses confirms the expectations regarding the capacity of this variable to capture the firm's financial vulnerability, particularly in periods of low inflation and low interest rates, when the leverage constraints are lower. This result is consistent with Begley et al. (1996). Finally, the coefficient on retained earnings is negative, which confirms the relevance of past profitability to financial health.

After checking that the panel data model is correctly specified and that the variables used to explain the FDL are validated and supported by financial theory, the next step is to estimate cross-sectionally the correctly specified model for each year. Panel A of Table 3 presents the results, which support the stability of the model in terms of sign and significance of the coefficients. The effect of profitability and retained earnings on the FDL is negative and significant for all years studied, and the effect of financial expenses remains positive and significant, except for the last two years, when this effect becomes statistically nonsignificant. These results demonstrate that the company's efficiency in extracting returns from its assets, and the trade-off between this way of generating funds and the need to comply with its financial expenses during the financial year, significantly explain the FDL. Additionally, higher historical profitability tends to reduce the company's FDL, which can serve as a cushion to provide wider financial solutions to the crisis.

The cross-sectional estimation of the model of the FDL is particularly useful because it provides an indicator of the likelihood that includes the individual effects. Note that the panel data estimation eliminates the individual effects by taking first differences of the model. Thus, the relevant output from the cross-sectional models is the FDL obtained for each company and year. The mean of this likelihood is low (0.075), which is reasonable since this study follows an ex-ante approach. Another indicator of the accuracy of the study is the standard deviation of the FDL, which is very small (0.1509). Additionally, the percentage of correct classifications is stable for the different years with a mean value of 87%, which also supports this study. Finally, the percentage of normal observations classified as financially distressed (Type I error) is 18%, which is beyond a naive classification, thus proving that the model is accurate in terms of classification, especially when the same cut-off point is used for all years. Since this study does not aim to predict financial distress but rather to offer a model of its likelihood, and given the differences between these two objectives (see Palepu, 1986), the discussion is not focused on the percentage of correct classifications. Consequently, this study does not attempt to find an optimal cut-off point for the different years, and it uses the percentage of financially distressed firms in the sample as the cut-off point.

5.2. Robustness checks

This section replicates the estimation of the FDL using data on G-7 countries (other than the U.S.) to determine whether the

Table 3
Estimation results of the cross-sectional model for the FDL

Dependent variable: FDL is a binary variable that takes a value of one for financially distressed firms, and zero otherwise

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Panel A. Results from the U.S.													
Profitability	−1.3479*	−1.001*	−0.919*	−1.137*	−1.047*	−1.063*	−1.129*	−0.937*	−1.17*	−1.199*	−0.921*	−1.297*	−1.549*
Financial expenses	22.7979*	2.037*	31.107*	24.34*	14.779**	1.261***	17.458*	23.094*	1.159**	8.208***	11.944**	6.656	−2.672
Retained earnings	−1.718*	−6.026*	−11.517*	−5.999*	−9.253*	−8.446*	−4.634*	−7.183*	−5.025*	−4.070*	−5.090*	−1.122*	−12.260*
Pseudo R-squared	0.273	0.1758	0.3028	0.2349	0.317	0.317	0.2994	0.3788	0.3113	0.296	0.2789	.401	.4028
LR	116.20	79.44	145.46	104.02	168.14	266.56	208.76	296.29	242.40	207.46	209.48	315.75	328.58
Observations	766	806	831	876	985	985	1458	1539	1516	1486	1433	1356	1264
Panel B. Results for other G-7 countries													
Profitability	−0.2521	−2.601**	−0.709	−2.404*	−2.514*	−1.528**	−2.646*	−4.615*	−5.472*	−2.935*	−2.308*	−3.644*	−3.509*
Financial expenses	24.2466	2.644	28.444***	1.4	28.401***	46.306*	38.989*	36.844*	8.398	16.205	13.882	8.569	17.642
Retained earnings	−17.698*	−11.977*	−12.147*	−6.476*	−9.508*	−8.505*	−11.092*	−13.119*	−1.251*	−11.302*	−1.541*	−11.076*	−9.846*
Pseudo R-squared	0.3577	0.316	0.317	0.225	0.293	0.249	0.19	0.3	0.298	0.28	0.237	0.285	0.277
LR	53.53	5201	60.58	45.27	63.12	65.23	96.51	204.77	231.77	193.98	170.35	219.48	200.21
Observations	432	461	486	523	694	791	1821	2227	2213	2200	2169	2131	2012

Panel B of Table 1 describes the explanatory variables. i) *, **, *** indicate significance at the 1%, 5%, and 10% levels, respectively; ii) pseudo-R^2 is a measure of the goodness-of-fit of the model that is equivalent to the R^2. *psuedo*-$R^2 = \frac{-2\mathrm{LL}_{\mathrm{null}} - (-2\mathrm{LL}_{\mathrm{full}})}{-2\mathrm{LL}_{\mathrm{null}}}$, where -2LL is the likelihood value and where the null model is the one including only the constant; iii) LR is the likelihood ratio statistic that tests the joint significance of the independent variables in the model, which is asymptotically distributed as χ^2 with degrees of freedom in parentheses under the null of the lack of joint significance; iv) *observations* stands for the number of observations included each year to run the cross-sectional logit model.

Table 4
Estimation results of the cross-sectional model: evidence from the re-estimated *Z*-score model

Dependent variable: FDL is a binary variable that takes a value of one for financially distressed firms, and zero otherwise

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Panel A. Results from the U.S.													
Working capital	0.7404	0.466	−0.032	0.108	3.131*	1.789*	1.227**	−0.233	−0.03	0.064	−0.221	−1.036*	.129
Retained earnings	−1.9473*	−1.107*	−1.401*	−1.14*	−1.326*	−1.168*	−1.495*	−1.178*	−1.006*	−1.201*	−0.933*	−1.062*	−1.354*
Profitability	−9.1309*	−6.385*	−9.431*	−5.672*	−7.955*	−7.059*	−4.788*	−5.94*	−4.074*	−2.678*	−3.787*	−7.947*	−9.781*
Market value	−0.0746	−0.568*	−0.014	−0.023	−0.048**	−0.004	−0.102*	−0.008	0.014	−0.003	0.01	.017***	−0.033
Sales	0.2928	0.184	0.101	0.06	−0.143	−0.061	0.317*	0.016	0.115	−0.536*	−0.178	−0.157	−0.323***
Pseudo *R*-squared	0.2509	0.202	0.265	0.206	0.349	0.349	0.318	0.367	0.301	0.321	0.277	0.397	0.411
LR	101.52	88.03	123.03	88.82	182.93	271.00	213.23	280.52	229.06	221.83	206.19	308.03	330.995
Observations	727	767	793	838	948	948	1412	1493	1470	1445	1397	1321	1232
Panel B. Results for other G-7 countries													
Working capital	0.7404	0.466	−0.032	0.108	3.131*	1.789*	1.227**	−0.233	−0.03	0.064	−0.221	−1.036*	0.129
Retained earnings	−1.9473*	−1.107*	−1.401*	−1.14*	−1.326*	−1.168*	−1.495*	−1.178*	−1.006*	−1.201*	−0.933*	−1.062*	−1.354*
Profitability	−9.1309*	−6.385*	−9.431*	−5.672*	−7.955*	−7.059*	−4.788*	−5.94*	−4.074*	−2.678*	−3.787*	−7.947*	−9.781*
Market value	−0.0746	−0.568*	−0.014	−0.023	−0.048**	−0.004	−0.102*	−0.008	0.014	−0.003	0.01	0.017***	−0.033
Sales	0.180	0.157	0.175	0.168	0.200	0.163	0.117*	0.139	0.090	0.207*	0.162	0.152	0.185***
Pseudo *R*-squared	0.3664	0.324	0.33	0.209	0.229	0.225	0.168	0.256	0.215	0.247	0.216	0.2	0.211
LR	54.64	53.17	60.68	40.15	49.14	58.50	85.18	174.43	167.24	171.12	154.71	152.45	150.71
Observations	426	454	476	511	680	777	1808	2215	2201	2187	2160	2122	2003

Panel C of Table 1 describes the explanatory variables. i) *, **, *** indicate significance at the 1%, 5%, and 10% levels, respectively; ii) pseudo-R^2 is a measure of the goodness-of-fit of the model that is equivalent to the R^2. *pseudo*-$R^2 = \frac{-2LL_{null}-(-2LL_{full})}{-2LL_{null}}$, where −2LL is the likelihood value and where the null model is the one including only the constant; iii) LR is the likelihood ratio statistic that tests the joint significance of the independent variables in the model, which is asymptotically distributed as χ^2 with degrees of freedom in parentheses under the null of the lack of joint significance; iv) *observations* stands for the number of observations included each year to run the cross-sectional logit model.

model for the FDL remains stable when applied to different institutional and legal contexts. The third and fourth columns of Table 2 provide the estimation results of the fixed and random effects models, respectively. The estimated coefficients remain significant and have the expected sign in both cases; that is, the FDL is negatively affected by a firm's profitability and retained earnings, and is positively affected by its financial expenses. Moreover, the results of the cross-sectional estimation of the model in panel B of Table 3 indicate that these relations are stable across the sample period. The consistency of this evidence strongly shows that selecting explanatory variables that rely on a theoretical justification to specify a stable model rectifies the lack of stability of the magnitude and significance of the coefficients when applied to different periods and countries. Consistent with the evidence from the U.S., the mean of the FDL for the other G-7 countries is low (0.0397) as is its standard deviation (0.0949). The percentage of correct classifications has a mean value of 83%, and it is stable across all years despite using the same cut-off point for all years.

The second robustness check extends the analysis performed by Begley et al. (1996) and Grice and Ingram (2001) by re-estimating Altman's *Z*-score model to check whether it reports consistent results for periods, sectors, and countries other than those in their original application, and whether it remains useful for predicting financial distress conditions other than bankruptcy. Panels A and B of Table 4 present the results of the cross-sectional estimation of the model for the U.S. and the other G-7 countries, respectively. Overall, the estimated coefficients reveal that only profitability and retained earnings maintain their significance in the re-estimated *Z*-score model for the different countries and years. Thus, these variables are the only ones that present a consistent pattern of significance and sign of their effects on FDL for the different countries and years. Similar to Begley et al. (1996) and Grice and Ingram (2001), this study finds that the leverage coefficient does not show a consistent pattern of significance and sign. This lack of consistency supports the approach of replacing leverage with the burden of interest because the latter is more crucial in predicting financial distress processes.

Taken as a whole, the results presented in this section corroborate the accuracy of our approach and indicate that our FDL model remains useful for predicting financial distress conditions other than bankruptcy when applied to different periods, sectors, and institutional and legal contexts.

6. Conclusions

This study offers an approach to estimating the likelihood of financial distress that can be applied to different periods and countries. This approach consists of first developing a theoretically supported model that relies on a criterion of financial distress that is independent of legal institutions. Second, the specification of the resulting logistic model is tested using panel data to eliminate the unobservable heterogeneity. Third, the correctly specified model is cross-sectionally estimated to incorporate the specificity of each company into the final estimates of the likelihood of financial distress.

The results obtained confirm the proposed specification and reveal that all the coefficients are statistically significant and have the expected sign. Specifically, the company's returns on assets, and the consequent trade-off between this manner of generating funds and the company's need to comply with its financial expenses during the financial year accurately explain FDL. Further results corroborate the stability of the model in terms of the significance and sign of its coefficients, and its classification power for the different periods and countries. Additionally, a comparison between the results for the re-estimated *Z*-score and the findings of this study reveals that the ex-ante approach and the methodology proposed provide major contributions to the literature because they yield a model for FDL that is more stable in terms of the sign and significance of its coefficients.

Based on our main results, this paper provides a major improvement to the financial distress literature by using a more accurate ex-ante approach and applying a more appropriate methodology. In particular, this study provides a well-specified and theoretically supported model that is stable in terms of magnitude, sign and significance of the coefficients and, more importantly, that yields a measure of the FDL that is more robust to time and international context than the estimates of FDL that are based on seminal models. It is worth noting the relevance of this achievement in that Begley et al. (1996) and Grice and Dugan (2001) have already emphasized the need for a model of FDL that offers a more stable pattern in terms of the significance and sign of its coefficients, and that provides a consistent classification power for different time periods and countries. The development of a robust and stable measure of the FDL would make a significant contribution to literature in that, as we have already pointed out, has potential applications in many financial topics. For instance, this improved measure is of great value for research that requires a proxy for the likelihood of financial distress.

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Appendix A. Explanatory variables

Profitability: $EBIT_{it}/RTA_{it-1}$, where $EBIT_{it}$ denotes earnings before interest and taxes.

Financial expenses: FE_{it}/RTA_{it-1}, where FE_{it} denotes financial expenses.

Retained earnings: RE_{it-1}/RTA_{it-1}, where RE_{it} denotes retained earnings.

These three variables are scaled by the replacement value of total assets at the beginning of the period (RTA_{it-1}). This scaling factor is less biased than the book value of total assets, which is particularly dependent on accounting principles. The replacement value of total assets is computed as $RAT_{it}=RF_{it}+(TA_{it}-BF_{it})$, where RF_{it} is the replacement value of tangible fixed assets, TA_{it} is the book value of total assets, and BF_{it} is the book value of tangible fixed assets. The last two terms are obtained from the firm's balance sheet, and the first one is calculated according to Perfect and Wiles (1994):

$$RF_{it} = RF_{it,-1}\left[\frac{1+\phi_t}{1+\delta_{it}}\right] + I_{it}$$

for $t>t_0$ and $RF_{it0}=BF_{it0}$, where t_0 is the first year of the chosen period (in this case, 1990). On the other hand, $\delta_{it}=D_{it}/BF_{it}$ and $\phi_t=(GCGP_t-GCGP_{t-1})/GCGP_{t-1}$, where $GCGP_t$ is the growth of capital goods prices reported in the Main Economic Indicators published by the Organization for Economic Cooperation and Development (OECD).

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