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Nonlinear modelling of target leverage with latent determinant variables — new evidence on the trade-off theory

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ABSTRACT

This paper applies a nonlinear structural equation framework to analyze dynamic capital structure choice. I test the hypothesis that firms adjust leverage towards a time-varying target, and that this target is determined by solving an optimization problem: optimal leverage is achieved when the difference between the expected net present value of the tax shield and the expected net present value of the costs of insolvency is maximized. Results indicate that firm size is an important determinant of the validity of this simple trade-off model.

1. Introduction

This paper applies a new methodology to analyze firms' behaviour when adjusting their capital structure over time. By means of nonlinear structural equation modelling, a joint hypothesis is tested: first, that firms adjust their capital structure towards a moving target, and second, that this target is chosen so as to maximize the difference between the debt tax shield and costs of insolvency. Uncertainty about the value of future tax savings and the probability of insolvency is accomodated by applying a structural model of corporate default along the lines of Merton (1974), which has been specified using a jump-diffusion process so that it is capable of reproducing empirical patterns of credit spreads. This is achieved by explicitly stating the optimization problem that reflects the trade-off, and testing whether the actual target towards which observed capital structures converge can be proxied by the optimal solution. It is found that the explanatory power of the trade-off model depends on firm size: it can explain up to 24% of the variation of leverage adjustments of medium-sized firms, but only 16% (11%) for firms in the smallest (largest) size subsample. In addition, the explanatory power of the trade-off model is compared to a model that captures any linear relationship between company variables and target leverage and that does not distinguish between different theories of capital structure choice. The trade-off model explains most of the variation that is explained by linear relationships for medium-sized firms, but only around half of it for the smallest and largest firms. The approach taken here combines the theoretical concept of nonlinear dynamic models of optimal leverage, as in Goldstein, Ju, and Leland (2001) or Dangl and Zechner (2004), with the idea of empirical adjustment models, such as recently applied by Byoun (2008), which, however, usually specify the target as a linear function of company variables.[1]

This linear approach suffers from a number of drawbacks. First, establishing a significant linear relationship between a company variable and the leverage target can provide support for the claim that a certain company characteristic plays a role in determining the capital structure target. However, in a number of cases, different theories on capital structure choice lead to the same hypothesis regarding the relationship between an observable determinant variable and target leverage.[2] In such a case, the statistical analysis cannot provide criteria for or against a particular theory. The hypothesis of this paper is rather

[1] See Elsas and Florysiak (2008) for a recent survey.

[2] For instance, if a substantial part of a firm's assets consists of goodwill, it can be assumed that the firm has a lot of growth options available. In such a case, the underinvestment problem suggests that the firm should take on a low level of debt. At the same time, a high proportion of goodwill indicates that the losses in case of insolvency will be substantial, because then, goodwill often becomes worthless. This also suggests that firms with a high proportion of assets made up of goodwill should take on less debt. Furthermore, consider a firm with strong free cash flows. On the one hand, the agency cost of free cash flow hypothesis suggests that this firm should take on a high level of debt in order to discipline management. On the other hand, free cash flow indicates that the firm has a well established, low-risk business model and thus, low expected costs of insolvency. According to the trade-off theory, this firm can take on a high level of debt.

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that a specific model of the underlying economic decision and coordination problem can explain observable patterns of leverage. The approach taken here is based on the trade-off theory and could act as a benchmark for future attempts to model that problem. If observable patterns will be explained better (or worse) by a different model, this would be a challenge to (or support for) the trade-off theory. Second, specifying the target as a linear function ignores nonlinear relationships between firm characteristics and target leverage. Instead, this paper specifies target leverage as a non-parametric function of company characteristics. This approach is consistent with the hypothesis that coordination on the capital market leads to a capital structure that maximizes the value of the total cash stream flowing to shareholders and debtholders. Third, theories predict relationships between corporate characteristics and target leverage, while empirical studies usually assess relationships between *observable* variables and target leverage. This ignores measurement error, and neglects additional information on the same characteristic that could be provided by different observable variables. In contrast, in this study, relevant corporate characteristics – asset volatility and loss given default – are defined as latent variables in a structural equation framework, where a number of observable instrumental variables are used to estimate the latent characteristics (Table 1).

Leverage has various effects on firm value beyond the tax shield and costs of insolvency, such as agency effects (see Jensen, 1986; Jensen & Meckling, 1976; Myers, 1977) and signalling effects, see Myers and Majluf (1984) and Ross (1977). However, CFO survey results indicate that taxes on company level and the risk of insolvency are more important factors for real-world capital structure decisions than agency costs or signalling issues, see Graham and Harvey (2001), pp. 11 ff. for the U.S. market, Bancel and Mittoo (2004), pp. 113 ff. and Brounen, De Jong, and Koedijk (2006), pp. 1414 ff. for the European market. However, managers might be hesitant to admit that their decisions are governed by agency issues, so that survey results could understate the true relevance of agency costs. Furthermore, survey results show that the majority of managers aim at attaining or maintaining a capital structure target. Theoretical relationships between the tax shield, the costs of insolvency and the value of the firm are straightforward, whereas some agency or signalling effects imply costs associated with debt as well as benefits. Because of that, there is no robust model that quantifies these costs and benefits, and it suggests that this ambiguity prevents decision-makers from assigning too much weight to them. This provides support for concentrating on the trade-off model in empirical studies.

Apart from that, there are leverage effects that pertain to redistributing wealth between different investors. These play a significant role in managers' decision-making. Market timing seems to be especially important (see e.g. Baker & Wurgler, 2002). By timing the capital markets, directors can exploit private information and transfer wealth from new shareholders or debtholders to old shareholders. Survey results support the case for the importance of market timing (see e.g. Graham & Harvey, 2001; Bancel & Mittoo, 2004). These effects cannot be incorporated into the value optimization problem suggested in this study, and variation in leverage adjustments beyond those that can be ascribed to the trade-off theory are likely to be strongly influenced by distributional effects. The results of this paper suggest that the relative importance of different effects with an influence on capital structure decisions varies with firm characteristics, most noticeably with firm size.

The rest of the paper is structured as follows. Section 2 briefly presents relevant results from the empirical literature on capital structure, while Section 3 describes the model and its calibration and estimation. Section 4 provides details on data sources and adjustments, Section 5 presents and discusses the results and Section 6 concludes.

Table 1
Summary statistics.

	Mean	Median	Std. dev.
Leverage	0.3279	0.2706	0.2445
Market-implied asset volatility p.a.	0.5027	0.4392	0.3115
Std. dev. of sales growth p.a.	0.2619	0.1438	0.3324
Std. dev. of cost to sales ratio	0.4097	0.0357	1.4055
Book asset volatility p.a.	0.2404	0.1499	0.2503
Loss rate	0.4574	0.4775	0.2792
Nonliquid assets rate	0.7338	0.8185	0.2489
R&D expense rate	0.0938	0.0397	0.1385
Total book assets (mUSD)	1674.47	75.21	16,164.30
Market capitalization (mUSD)	1856.72	86.19	13,263.29

Mean, median and standard deviation of firm-specific variables for the complete sample over all years (22,333 observations, from 1991 to 2006). An observation is defined as a firm-year, i.e. an observation of a specific firm in a specific year.

2. Capital structure theories and empirical tests

In the following, due to the vast empirical literature on capital structure choice, only a brief overview of issues closely related to the aim of this paper will be given. First, models of optimal dynamic capital structure will be discussed. Second, examples where different theories imply the same empirical pattern will be shown. And third, evidence on the trade-off theory, recent general results on capital structure determinants and methodological advances relevant to the approach taken in this study will be presented.

The Goldstein, Ju, and Leland (2001) model defines the firm's EBIT as an underlying state variable which is independent of the capital structure, and specifies shareholders', debtholders' and the government's cashflows as a function of it. This allows, on a theoretical basis, to estimate the value of the tax shield and to predict optimal leverage ratios which are consistent with observed ratios. Collin-Dufresne and Goldstein (2001) find that incorporating mean reversion of leverage into a structural model of credit risk produces credit spreads more consistent with empirical findings. Dangl and Zechner (2004) specify the dynamics of the inverse leverage ratio given discrete adjustments to debt and show that this allows for the alleviation of misestimations created by models with constant leverage ratios or debt levels. Hennessy and Whited (2005) model the dynamic nature of leverage in the sense that capital structure decisions are taken frequently, rather than once, and thus relate to the level of debt until the next decision rather than for the rest of the life of the firm. While they consider the relationship between financing decisions and the investment policy, they assume that a collateral constraint ensures risk-free debt even in the event of liquidation of the firm's assets.

According to Fama and French (2002), both an advanced version of the pecking order theory and the presence of agency costs predict that firms with more investment opportunities will have less leverage: either, limiting current debt will avoid foregoing future investment opportunities due to limited borrowing capacity, or, the presence of investment opportunities limits the need for the disciplining effect of debt. Baker and Wurgler (2002) find that firms are more likely to issue equity when their market to book ratio is high. However, a high market to book ratio could indicate either that the firm has acquired substantial growth options and equity is issued because of the asymmetric participation schedule of debtholders with regard to the risk associated with such growth options, or indicate that the market overprices the firm's equity and that equity is issued to benefit from this overvaluation. Myers (1977) shows that tangible assets are more likely to be financed by debt than intangible assets are. While on the one hand, tangible assets could be considered less risky and therefore debt would have less of an impact on the risk of insolvency it was also argued that the underinvestment problem is less prevalent in firms with fewer growth opportunities and more tangible assets, and thus that these firms would take on more debt. Predictions implied by the trade-off theory have been partially confirmed not only in manager survey studies such as Graham and Harvey (2001), but also by studies focussing on company data such as Wald (1999) or Rajan and Zingales