Capital structure determinants and the new High-Tech firms: The critical distinction between fixed and random effects through a static panel data investigation

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Abstract

The aim of our research is to study the association between observed leverage and a set of explanatory variables, using panel data analysis to establish the determinants of a time varying optimal capital structure from new high-tech firms over the period 1998-2002, and to explore whether the main theories of firm financing (Trade-Off Theory and Pecking Order Theory) can explain the capital structure of these firms. We consider the static models, introducing the critical distinction between fixed and random effects.

This is the first time the scope of studying the determinants of the capital structure has been extended to new high-tech firms with the use of many techniques of panel data.

Considering the results of the most powerful estimation (WG) as our reference, the empirical evidences obtained are stable and similar to those documented in the previous empirical researches.

Confirming the pecking order model but contradicting the trade-off model, we find that more profitable firms use less leverage. We also find that large companies tend to use more debt than smaller companies, and that firms which have high operating risk can lower the volatility of the net profit by reducing the level of debt.

Leverage is also closely related to tangibility of assets and to the ratio of non-debt tax shield.

Keywords: Capital structure, Trade-Off theory, Pecking order theory, Panel data, Fixed effect, Random effect.

JEL Classification: C33, G32

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1 Introduction

The basic objective of any corporate finance study of capital structure is to identify factors explaining the firm's decision with respect to its financial leverage. Starting with Modigliani and Miller (1958), the literature on capital structure has been expanded by many theoretical and empirical contributions. Much emphasis has been placed on releasing the assumptions made by MM, in particular by taking into account corporate taxes (Modigliani and Miller, 1963), personal taxes (Miller, 1977), bankruptcy costs (Stiglitz, 1972; Titman, 1984), agency costs (Jensen and Meckling, 1976; Myers, 1977), and informational asymmetries (Myers, 1984).

1. Two main theories dominate currently the capital structure debate: the Trade-Off Theory (TOT) and the Pecking Order Theory (POT). According to Stewart C. Myers, the trade-off theory says that firms seek debt levels that balance the tax advantages of additional debt against the costs of possible financial distress. The pecking order theory says that the firm will borrow, rather than issuing equity, when internal cash flow is not sufficient to fund capital expenditures. Thus the amount of debt will reflect the firm's cumulative need for external funds.

Consequently, the aim of our research is to study the association between observed leverage and a set of explanatory variables, using panel data analysis to establish the determinants of a time varying optimal capital structure from new high-tech firms over the period 1998-2002, and to explore whether the main theories of firm financing (Trade-Off Theory and Pecking Order Theory) can explain the capital structure of these firms. We will use annual data from 99 German firms on the Deutsch Boerse. A total of 476 observations are available for analysis.

New high technology firms, for purposes of this research, include firms in many sectors such as Biotechnology, Software, Information Technology Services, Internet...There was an unprecedented flow of venture capital to these firms over the last years.

The latter sectors are of particular interest because of the nature of their activities. On the one hand, high-tech firms are projected to grow faster than non-technology companies; they may not be able to rely on cash flow to finance growth because they market overseas twice as often as non-technology firms. On the other hand, the squeeze on profit margins may restrict the amount of their cash that can be directed toward financing growth.

So, as the Foreign Minister of Germany remarked, it is often argued that a bank-based system like Germany suffers from inadequate financing of young and innovative firms. But, following the famous Modigliani and Miller theorem (Modigliani-Miller, 1958), the way a firm is financed does not matter. Thus, high-tech firms could either be financed via debt or equity. However, to get the necessary financing, high-tech companies turned to nontraditional sources.

Moreover, these firms often suffer the problems associated with asymmetric information, such as adverse selection and moral hazard. In this way, they are affected by the typical problems studied in the theory of pecking order.

Nevertheless, these firms could also set their financial policy by following a target indebtedness ratio, as maintained by trade off theory.

Thus, our focus is on answering three questions: Do corporate financial leverage decisions differ significantly for new high-tech firms? Are the factors that affect their capital structure similar to those determined for other firms? And finally, are both theories, trade-off theory and pecking order theory, enable us to describe the financial behavior of new high-tech German firms?

Regarding methodology, this study attempts to empirically determine the factors that affect the optimal debt level by using the panel data analysis. Thus, as a solution to problems of heteroskedasticity and autocorrelation, and for the purpose of comparison we will study both Fixed and Random Effects static panel models based on the book value measures of leverage. Each kind of model needs different diagnostic tests and different estimation techniques in order to achieve efficient and consistent estimators.

In section 2 we review related theories and practices of capital structure. In section 3 we proceed with the description of the determinants of the capital structure. In section 4 the process of sample selection is explained and the data is described. Section 5 covers the model specification and discusses the principal problems of estimating with panel data models. Section 6 presents the empirical analyses. Finally, section 7 concludes.

2 Theory and practice of capital structure

2.1 Theories of capital structure

The last three decades have witnessed large changes in the level and composition of capital structure, both among industrial economies and between industrial and developing countries.

Traditionally, the term capital structure has referred to a firm's split between debt and equity financing. Thus, a firm choosing an optimal capital structure is interpreted as choosing an optimal level of debt. In a dynamic setting, the firm chooses a set of optimal debt levels over time.

Following on the famous irrelevance result of Modigliani and Miler (1958), the literature on capital structure has been expanded by many theoretical and empirical contributions, which have sought to explain capital structure by introducing many frictions.

Therefore, the capital structure theory can be divided into four categories[1]: first Modigliani and Miller's models with and without taxes, second models that introduce financial distress and agency costs, third static trade-off models, and last pecking order theory with asymmetric information.

In the static Trade-Off Model (Myers, 1977), two frictions: the agency costs of financial distress and the tax-deductibility of debt finance generate an optimal capital structure. An alternative model (Myers and Majluf, 1984) emphasizes frictions due to asymmetric information between managers and outside investors. In the Pecking Order Model, a financial hierarchy descends from internal funds, to debt, to external equity.

2.2 Related empirical studies

Over the years numerous studies on capital structure theory have appeared. Modigliani and Miller (1958) were the first who theorized the issue by illustrate that the valuation of a firm will be independent from its financial structure under certain key assumptions. Internal and external funds may be regarded as perfect substitutes in a world where

[1] For an in-depth review of literature on capital structure, see Harris and Raviv (1991).

capital markets function perfectly, where there are no transaction or bankruptcy costs and the firm cannot increase its value by changing its leverage.

Five years later, Modigliani and Miller (1963) argue that, due to tax deductibility of interest payments, companies may prefer debt to equity. They showed that borrowing would only cause the value of the firm to rise by the amount of the capitalized value of the tax subsidy. However, Miller (1977) emphasizes the effect of personal taxation. Moreover, DeAngelo and Masulis (1980) argue that interest tax shields may be unimportant to companies with other tax shields, such as depreciation. Based on asymmetric information, Meyers and Majluf (1984) predict that companies will prefer internal to external capital sources.

Most empirical researches of capital structure are not recent (Taggart, 1977; Marsh, 1982; Jalilvand and Harris, 1984; Titman and Wessels, 1988). Those authors made a significant contribution in formulating and testing the determinants of the capital structure, but they caution on the difficulty of finding suitable proxies for these determinants.

In their cross-sectional study, Rajan and Zingales (1995) attempt to test for the G7 countries the extent to which at the level of the individual firm, leverage may be explained by four key factors, market to book, size, profitability and tangibility. These authors find similar levels of leverage across countries, the determinants of capital structure that have been reported for the US are important in other countries as well. While financial economists have devoted considerable attention to empirically testing theories of optimal capital structure, relatively little research has focused on explaining the dynamics of a firm's capital structure. These researches may be classified into two groups depending on whether they utilize cross-sectional or time-series data. Fisher, Henkel, and Zechner (1989) use cross-sectional data in testing their model of the optimal dynamic capital structure and the presence of transactions costs. They attempt to employ a dynamic approach to study capital structure to the extent that they study the factors that determine the firm's debt ratio range, defined as the difference between its maximum and minimum debt ratio.

The second group of studies of capital structure dynamics utilizes pooled time-series/cross-sectional data (Taggart, 1977; Marcus, 1983; Jalilvand and Harris, 1984;

Sharpe, 1991). In the presence of adjustment costs, firms are assumed to gradually adjust their capital ratio at a constant rate so as to eliminate deviations between their optimal (or desired) and actual capital ratio. Other recent studies, which have considered capital structure dynamics, offer better insight on the adjustment process toward the target debt-to-equity ratio (Kremp et al, 1999; De Miguel and Pindado, 2001; and Ozkan, 2001). Kremp et al (1999) analyze a large panel of French and German firms and confirm the existence of a dynamic adjustment process stress the role of Husband System in Germany, and the impact of tax policy and the end of the so-called "indebtedness economy" in France. These findings are confirmed by De Miguel and Pindado (2001) who show that firms have a target leverage ratio in Spain, and that companies adjust to the target ratio relatively fast.

3 Determinants of capital structure

Prior research on capital structure by Rajan and Zingales (1995) suggests that the level of leverage in UK companies is positively related to size and tangibility, and negatively correlated with profitability and the level of growth opportunities. However, as argued by Harris and Raviv (1991), the interpretation of results must be tempered by an awareness of the difficulties involved in measuring both leverage and the explanatory variables of interest...

In this section, we provide a review of the six main variables that have been used in previous studies examining the determinants of capital structure.

3.1 Growth opportunities

The empirical evidence regarding the relationship between leverage and growth opportunities is rather mixed. While Titman and Wessels (1988), Chung (1993) and Barclay et al. (1995) find a negative correlation, Kester (1986) does not find any support for the predicted negative relationship between growth opportunities and gearing. Despite this controversy, Rajan and Zingales (1995) uncover evidence of negative correlations between market-to-book and gearing for all G-7 countries. They suggest that, a priori, one would expect a negative relation between growth opportunities and the level of leverage.

This is consistent with the theoretical predictions of Jensen and Mekling (1976) based on agency theory, and the work of Myers (1977), who argues that, due to information asymmetries, companies with high gearing would have a tendency to pass up positive net present value investment opportunities (also known as growth options). Myers therefore argues that companies with large amounts of investment opportunities would tend to have low gearing ratios.

3.2 Size

Large size companies tend to be more diversified, and hence their cash flows are less volatile. Size may then be inversely related to the probability of bankruptcy (Titman and Wessels, 1988; Rajan and Zingales, 1995). Ferri and Jones (1979) suggest that large firms have easier access to the markets and can borrow at better conditions. For small firms, the conflicts between creditors and shareholders are more severe because the managers of such firms tend to be large shareholders and are better able to switch from one investment project to another (Grinblatt and Titman, 1998).

Size can serve as an indicator of riskiness of the firm in that:

- Smaller firms have higher product market risk,
- Small firms have a higher probability to be takeover targets.
- According to Whited (1992) small firms cannot access long-term debt markets since their growth opportunities exceed their assets. Titman and Wessels (1988) argue that larger firms have easier access to capital markets.

Rajan and Zingales include size in their cross-sectional analysis. They say that: "The effect of size on equilibrium leverage is more ambiguous. Larger firms tend to be more diversified and fail less often, so size may be an inverse proxy for the probability of bankruptcy…"

3.3 Profitability

One of the main theoretical controversies concerns the relationship between leverage and profitability of the firm. Profitability is a measure of earning power of a firm. The earning power of a firm is the basic concern of its shareholders.

According to the pecking order theory, firms prefer using internal sources of financing first, then debt and finally external equity obtained by stock issues.

The more profitable firms are, the more internal financing they will have. This relationship is one of the most systematic findings in the empirical literature.

In a trade-off theory framework, an opposite conclusion is expected. When firms are profitable, they should prefer debt to benefit from the tax shield. In addition, if past profitability is a good proxy for future profitability, profitable firms can borrow more as the likelihood of paying back the loans is greater.

3.4 Tangibility

Previous empirical studies by Titman and Wessels (1988), Rajan and Zingales (1995) and Fama and French (2000) argue that the ratio of fixed to total assets (tangibility) should be an important factor for leverage. The tangibility of assets represents the effect of the collateral value of assets of the firm's gearing level.

Tangibility is defined as the ratio of tangible assets to total assets. Harris and Raviv (1990) predicts that firm with higher liquidation value will have more debt. On the contrary, intangible assets such as good will can lose market value rapidly in the event of financial distress or bankruptcy. Firms with more tangible assets usually have a higher liquidation value.

Tangible assets are likely to have an impact on the borrowing decisions of a firm because they are less subject to informational asymmetries and usually they have a greater value than intangible assets in case of bankruptcy. Additionally, the moral hazard risks are reduced when the firm offers tangible assets as collateral, because this constitutes a positive signal to the creditors who can request the selling of these assets in the case of default. As such, firms with a higher proportion of tangible assets are more likely to be in a mature industry thus less risky, which affords higher financial leverage.

3.5 Non-debt tax shield

Firms will exploit the tax deductibility of interest to reduce their tax bill. Therefore, firms with other tax shields, such as depreciation deductions, will have less need to exploit the debt tax shield. Ross (1985) argues that if a firm in this position issues excessive debt, it may become "tax-exhausted" in the sense that it is unable to use all its potential tax shields. In other words, the incentive to use debt financing diminishes as non-debt tax shields increase. Accordingly, in the framework of the trade-off theory, one hypothesizes a negative relationship between leverage and non-debt tax shields. In fact, the empirical evidence is mixed.

Shenoy and Koch (1996) find a negative relationship between leverage and non-debt tax shield, while Gardner and Trcinka (1992) find a positive one.

3.6 Operating risk

Many authors have included a measure of risk as an explanatory variable of the debt level (Titman and Wessels, 1988; Kremp et al., 1999; Booth et al., 2001).

Leverage increases the volatility of the net profit. Firms that have high operating risk can lower the volatility of the net profit by reducing the level of debt. By so doing, bankruptcy risk will decrease, and the probability of fully benefiting from the tax shield will increase. A negative relation between operating risk and leverage is also expected from a pecking order theory perspective: firms with high volatility of results try to accumulate cash during good years, to avoid under investment issues in the future.

4 Sample selection and data description

4.1 Sample selection

Our sample consists of new high technology German firms listed on the Deutsche Boerse for the period 1996-2002. We use annual data extracted from http://deutsche-boerse.com.

This website provides much information on many indices. It is owned by the private company that runs the Frankfurt Stock Exchange: the Deutsche Boerse AG.

The data set includes a wide array of information on the companies including the annual Balance sheet, the Statement of income, the Statement of cash flow and the Profit and Loss Account.

All data were hand-collected from 500 annual reports of the selected firms at http://deutsche-boerse.com. From these reports, we made extract information necessary for our analysis, such as operating income, total assets, net income, depreciation, tangible assets, total equity, total debt...Then, we filled our data base on Excel. Finally, we imported our data on Eviews as a pooled data. This work was our starting point, it required much time and concentration.

Some firms report annual financial statements in a summarized manner. For example, one firm reports its quarterly financial statements in March, in June, in September and in December, but it doesn't report an annual financial statement which includes figures the year. So, we were obliged to do some preliminary calculus to have the desired amounts of variables in an annual basis.

Some other firms use the American dollar (USD) in their reports. So, we had to look for the average currency exchange rates observed during the considered quarter in order to convert the amount into (EUR).

Our sample thus contains Biotechnology, Financial Services, Industrial & Industrial Services, Internet, IT Services, Media & Entertainment, Medtech & Health Care, Software, Technology and Telecommunication sectors.

Table 1 shows the sample classification by sector and the percentage represented by each sector in the whole sample on 13/05/2003.

Table 1

Sample representation by sector

	Sectors	Firms	%
Sector 1	Biotechnology	11	11,1
Sector 2	Industrial & Industrial services	12	12,3
Sector 3	Internet	7	7
Sector 4	IT-Services	11	11,1
Sector 5	Medtech & Health care	4	4
Sector 6	Media & Entertainment	11	11,1
Sector 7	Technology	31	31,4
Sector 8	Telecommunication	5	5
Sector 9	Software	7	7
Total		99	100

From this sample only firms with at least four years of complete data and non-missing observations on key variables were retained. We also exclude observations for which we have negative figures on the balance sheet. As a result, the final sample consists of a pool of 99 firms. For these firms, the yearly data is from 1998-2002. This leaves us with a total of 467 observations. This panel character of our data allows us to use panel data methodology, simultaneously combining cross section and time series data.

4.2 Description of the data

After looking at the sample selection, we took great care to define the dependent and independent variables to be used in this analysis, in order that they were consistent with those of Rajan and Zingales (1995). However, whilst they define and calculate several alternative measures of leverage, their cross-sectional regression analysis is merely based upon one of these measures.

Of these we use a book value measure of leverage (LEV) defined as the ratio of book value of debt to the sum of book values of debt and equity, as a dependent variable in our analysis. The evolution of the mean leverage ratio over the period of analysis, 1998-2002, for global sample is presented in table 2.

Table 2

Mean Leverage ratio by year

	LEV	
YEAR	MEAN	SD
1998	0.510212	0.577845
1999	0.430558	0.253943
2000	0.435823	0.212993
2001	0.473090	0.211541
2002	0.504035	0.239274

It is interesting to compare our level of leverage with the results reported by Rajan and Zingales (1995) for their sample of G-7 countries. When leverages is defined as debt over capital, Rajan and Zingales (1995) report that U.S. and German firms have similar leverage around 38 percent. Interestingly, with this definition, our results deal with leverage ratios around 50 percent.

4.3 Explanatory variables

As discussed above, our set of explanatory variables consists of those that have commonly been documented in the literature to affect firm leverage. We adopt six independent variables, defined as follows:

- Growth opportunities (GROW): we use the percentage change in total assets from the previous to the current year as an empirical measure for the growth opportunities.
- Size (SIZE): we use the logarithm of total assets to test the effect of firm size on the optimal debt level.
- Profitability (PROF): we use the ratio of net income to total assets as a measure of profitability.
- Tangibility (TANG): that is defined as the ratio of tangible assets to total assets.
- Non-Debt Tax Shield (NDTS): we use total depreciation from the firm's profit and loss account divided by total assets as the empirical measure for non-debt tax shield.
- Operating Risk (RISK): we use the squared difference between the firm's profitability and the cross section mean (across firms) of profitability for each year as a measure of the operating risk.

Table 3 lists and defines the variables we will use in the study. These variables account for almost all major income statement, balance sheet and profit and loss account line items. All data were hand-collected from annual reports of the selected firms at http://deutsche-boerse.com.

Table 3

Data sources and variable definitions

This table presents description of the variables used in our estimations. Data are from annual reports of German firms available at http://deutsche-boerse.com.

Abbreviation	Description
TA	Total assets from the balance sheet
DEBT	Total debt from the balance sheet
EQUITY	Sher-holder equity from the balance sheet
NI	Net Income from income statement
TANG	Tangible assets from balance sheet / TA
DEP	Total dereciation from profit and loss account
GROW	$(TA_t - TA_{t-1}) / TA_{t-1}$
SIZE	Log(TA)
PROF	NI / TA
NDTS	DEP / TA
RISK	$(PROF_{firm} - PROF_{mean})^2$
LEV	DEBT / (DEBT+EQUITY)

Bellow, we present in table 4 the main descriptive statistics of those measures of all the observations. Summary statistics include the mean, the minimum, the maximum, the standard deviation, the Skewness and the Kurtosis for the period 1998-2002.

Table 4

Descriptive statistics of the explanatory variables

The sample contains 99 German firms listed on the Deutsch Boerse for which we have a minimum of four consecutive years of data for the period 1998-2002.

	PROF	SIZE	TANG	NDTS	GROW	RISK
Mean	-0.062	18.289	0.176	0.0627	1.769	0.067
Maximum	0.546	21.960	2.921	1.769	399.513	5.080
Minimum	-2.300	12.550	-0.282	0.000	-0.998	1.44E-07
Std. Dev.	0.262	1.364	0.249	0.121	18.703	0.336
Skewness	-3.819	-0.266	5.861	9.790	20.375	10.397
Kurtosis	23.994	3.472	51.910	124.314	432.538	131.054
Observations	476	476	476	476	475	477
Cross sections	99	99	99	99	99	99

In this descriptive table, we can see that profitability (PROF) and size (SIZE) have an asymmetric distribution to the left, while all the rest of proxy variables are asymmetric to the right. On the other hand, all variables show strong leptokurtosis.

5 Model specifications

Having discussed the variables that determine the optimal capital structure and variable that is used as measure of leverage in the previous section, we will now specify panel data models used in our study.

Modigliani and Miller (1958) say that leverage is a random variable. The static model tests this hypothesis, more specifically, the leverage is regressed on a set of explanatory variables, and if M-M holds, then these variables should not be significant from a statistical point of view.

We use explanatory variables to proxy for the determinants of capital structure as presented in the previous section. We posit that leverage can be explained as follow:

Leverage = f (size, growth, profitability, tangibility, non-debt tax shield, risk)

Let us consider the simple linear model in a static level:

$$y_{it} = \gamma_i + x_{1it}\beta_1 + x_{2it}\beta_2 + ... + x_{kit}\beta_k + \mu_{it} \; ; \quad i = 1, ..., N \; and \; t = 1, ..., T \qquad (1)$$

Or, compactly

$$y_{it} = \gamma_i + \beta' x_{it} + \mu_{it} \qquad (2)$$

where i = 1,…,N and t=1,…,T

and y_{it} : leverage of firm i in year t

x_{it} : a vector of 6 time-varying regressors (x_{1it}; x_{2it};…; x_{6it}) assumed to be strictly uncorrelated with past, present and future realization of μ_{it}

b' : a 6 x 1 vector of constants (b_1; b_2;…;b_6)

γ_i : individual effects or an unobserved heterogeneity

μ_{it} : error term (μ_{i1}; μ_{i2};…;μ_{iT}) independently and identically distributed with zero mean and variance σ_μ^2

In the case where observations on y_{it} and x_{it} are available, an aggregate time series regression would treat γ_i as part of the constant and thus unidentified, whilst a cross-section regression will yield a biased estimator of β if γ_i is correlated with x_{it}.

For these purpose, we must identify whether the unobserved individual effects γ_i are random or fixed, that is, if these effects are orthogonal or not to the explanatory variables considered in the model.

There are two basic frameworks used in this model. The fixed effects approach takes γ_i to be a group specific constant term in the regression model. The random effects approach specifies that γ_i is a group specific disturbance, similar to μ_{it} except that for each group, there is a single draw that enters the regression identically in each period.

5.1 Fixed effects model

Fixed effects model would have constant slopes but intercepts that differ according to the cross-sectional firms. It controls for the potential correlation between regressors and unobservable individual effects. The fixed effects approach takes γ_i to be a group specific constant term in the regression model.

In general terms, we can write a static fixed effects model as:

$$y_{it} = \gamma_i + \beta' x_{it} + \mu_{it} \quad i = 1, 2, ..., N \quad and \quad t = 1, 2, ..., T \qquad (3)$$

In the case of the presence of fixed effects, β and γ_i can be estimated consistently and efficiently by the Within Groups estimators (WG) which can be obtained by OLS after the data are transformed by subtracting group means from each observation (Hsiao, 1985). The idea is to transform equation (3) to eliminate γ_i, by first averaging over t=1,...,T.

$$\text{Let } \overline{y_i} = \frac{1}{T}\sum_1^T y_{it} \;\; ; \;\; \overline{x_i} = \frac{1}{T}\sum_1^T x_{it} \;\text{ and } \bar{\mu}_i = \frac{1}{T}\sum_1^T \mu_{it}$$

Then,

$$\bar{y}_i = \gamma_i + \beta' \bar{x}_i + \bar{\mu}_i \qquad (4)$$

Subtracting this equation from equation (3) to get:

$$(y_{it} - \bar{y}_i) = \beta' (x_{it} - \bar{x}_i) + (\mu_{it} - \bar{\mu}_i) \qquad (5)$$

$$\tilde{y}_{it} = \beta' \tilde{x}_{it} + \tilde{\mu}_{it} \qquad for\ t = 1, \ldots, T \qquad (6)$$

A natural way to estimate β is to apply pooled OLS to the transformed model (equation 6). The Within-groups transformation also eliminates any time-invariant variable (Hsiao, 1985).

Because γ_i is treated as a fixed constant, the estimator of β is called the "Within-Groups estimator" (β_{wg}):

$$\hat{\beta}_{WG} = \left[\sum_1^N \sum_1^T (x_{it} - \overline{x_i})(x_{it} - \overline{x_i})'\right]^{-1} \left[\sum_1^N \sum_1^T (x_{it} - \overline{x_i})(y_{it} - \overline{y_i})\right] \qquad (7)$$

The fixed effects estimators are given by:

$$\hat{\gamma}_i = \bar{y}_i - \bar{x}_i' \hat{\beta}_{WG} \qquad (8)$$

The one big advantage of the fixed effects model is that the error terms may be correlated with the individual effects. If group effects are uncorrelated with the group means of the regressors, it would probably be better to employ a more parsimonious parameterization of the panel model.

5.2 Random effects model

The random effects model is a regression with a random constant term; specific effect is viewed as an outcome of a random variable.

In general terms, a static random effects model may be described as follow:

$$y_{it} = \beta' x_{it} + \nu_{it} \qquad (9)$$
$$\nu_{it} = \gamma_i + \mu_{it}$$

where μ_{it} are independently and identically distributed such that :

- $E(\gamma_i)=E(\mu_{it})=0$
- $E(\gamma_i,\mu_{it})=0$
- $E(\gamma_i, \gamma_j)=\begin{cases} \sigma_\gamma^2 & i = j \\ 0 & i \neq j \end{cases}$
- $E(\mu_{it}, \mu_{js})=\begin{cases} \sigma_\mu^2 & t = s, i = j \\ 0 & t \neq s, i \neq j \end{cases}$
- $E(\gamma_i,x_{it})=E(\mu_{it},x_{it})=0$

The appropriate GLS estimator of β shows that the random effects estimator, given by β_{GLS}, is consistent.

6 Empirical analyses

From panel data of 99 new high-tech German firms sample, covering the five years period 1998-2002, we have tested some hypothesis of theoretical capital structure.

The panel character of our data allows us to use panel data methodology for testing our model discussed above, simultaneously combining cross section and time series data. Static Panel Models are classified into Fixed and Random models, depending on whether the individual effects are correlated with regressors or not. Each kind of model needs a different estimation technique in order to achieve efficient and consistent estimators.

The static model is estimated by Pooled Ordinary Least Squares (POLS), Pooled Ordinary Least Squares with Dummy Variables for year (POLSDV), Within Groups (WG) and General Least Square (GLS) estimators. To deal with the problem of heteroskedasticity, all coefficients are estimated using White-corrected standard error variance-covariance matrix.

Table 5 shows the POLS, POLSDV, WG and GLS estimation results for the static model. Our purpose is to base the analysis on the WG results, taking the POLS, POLSDV and GLS results as comparative references. The level of R-squared varies from 12% to 72%. The R-squared are substantially higher when we use Within-Groups estimators (Fixed Effects model).

Table 5

Static results

*In this table we present various static estimations of the determinants of leverage. All coefficients are estimated using White's (1980) heteroskedasticity consistent variance-covariance matrix estimator. Results are reported for Pooled OLS, Pooled OLS with Dummy Variables for year, Within Group and GLS estimators. All the estimations have been undertaken by the statistical software Eviews 4.0. ***/**/* denotes significance at the 1% ; 5% and 10% level.*

	POLS	**POLSDV for year**	**Fixed effects (WG)**	**Random effects (GLS)**
SIZE	0.0509	0.0749	0.0774	0.0231
	(0.013)***	(0.024)***	(0.019)***	(0.012)**
PROF	-0.0157	-0.0295	-0.3274	-0.1106
	(0.102)	(0.092)	(0.094)***	(0.086)
TANG	0.0960	-0.1676	0.0251	0.0502
	(0.085)	(0.246)	(0.043)	(0.042)
NDTS	0.2565	0.1733	0.1124	0.1550
	(0.166)*	(0.253)	(0.150)	(0.148)
RISK	-0.0608	-0.0681	-0.1441	-0.0768
	(0.070)	(0.098)	(0.072)***	(0.072)
GROW	-0.0012	-0.0014	-0.0002	-0.0007
	(0.002)***	(0.003)***	(0.004)**	(0.004)*
R^2	0.1279	0.1205	0.7237	0.4966
Adjusted R^2	0.1098	0.1016	0.5741	0.4862
Observations	397	397	397	397
Cross section	99	99	99	99

As a modelling strategy we proceed as follow:

(1) Estimate Fixed Effects model and test for serial correlation and heteroskedasticity (H0: No misspecification)

(2) Under H0 (no serial correlation and homoskedasticity), select appropriate model by testing Random versus Fixed Effects

(3) Under H1 (serial correlation and heteroskedasticity):

- If T is small then estimate Fixed Effects with robust covariance estimators and test against pooled regression.

- If T is medium then estimate Fixed Effects after correcting for serial correlation and heteroskedasticity.

- If T is large then consider Random Effects model.

A set of tests were undertaken on our models to verify the degree of consistency and robustness of the results obtained.

The Breuch-Pagan test for heteroskedasticity was carried out, whose associated static ($LM=nR^2$) is asymptotically distributed as ² with q degrees of freedom under the null hypothesis of homoskedasticity. This test is based upon the use of OLS residuals regression and it leads us to accept the null hypothesis of homoskedasticity in the errors. Thus for the sample, there is homokedasticity at the 95% confidence level.

Accepted way of testing is to specify a functional form for the persistence (correlation) in the residuals over time and test to see whether this specification is statistically valid. Usual test for this is to compute Durbin-Watson statistic. This test shows that there is no serial correlation. Then the error terms of the model are no correlated.

To deal with the problem of heteroskedasticity and serial correlation, we select an appropriate model by testing Random versus Fixed Effects models. To perform this comparison, the character of the individual effects is tested through the Hausman's specification test which is described above under:

$$H_0 : cov(\gamma_i, x_{it}) = 0$$

Our results for this test are reported in the following table:

Table 6

Fixed versus Random effects		
Fixed effects		
Dependent Variable: LEV		
Method: Whithin-Group		
Variable	**Coefficient**	**Std. Error**
SIZE	0.077401	0.019112
PROF	-0.327429	0.094667
TANG	0.025107	0.043518
NDTS	0.112420	0.150875
RISK	-0.144112	0.072994
GROW	-0.000253	0.000453
R-squared	0.723772	
Adjusted R-squared	0.574148	
Random effects		
Dependent Variable: LEV		
Method: GLS (Variance Components)		
Variable	**Coefficient**	**Std. Error**
SIZE	0.023181	0.012660
PROF	-0.110634	0.086897
TANG	0.050253	0.042859
NDTS	0.155051	0.148014
RISK	-0.076813	0.072271
GROW	-0.000715	0.000465
R-squared	0.496626	
Adjusted R-squared	0.486212	

Hausman test for fixed versus random effects

Null hypothesis	$H_0 : cov(\gamma_i, x_{it}) = 0$	**Test statistic**	h˜$\chi^2(6)$
Critical value	$\chi^{2*}(6)$ =16,812		h =38,510457
Decision	h > $\chi^{2*}(6)$ Reject H0		
Conclusion	The individual effects are supposed to be Fixed		

This procedure indicates that the individual effects are supposed to be fixed. Thus the WG estimators (Fixed effects model) are more efficient relative to the GLS estimators (Random effects model) under H0, confirming our prior estimation (Table 5).

7 Findings and Conclusion

Considering the results of the most powerful estimation (WG) as our reference, the empirical evidences obtained are stable and similar to those documented in the previous empirical researches.

Size is positively related to leverage, indicating that size is a proxy for a low probability of default. Moreover, the estimated coefficients on SIZE are generally not significant. This is similar to the results in Rajan and Zingales (1995).

Leverage is decreasing in risk (RISK) and profitability (PROF). Among all proxy variables, we find the strongest and most reliable relationship between these two determinants and leverage.

Tangibility is almost always positively correlated with leverage. The regression coefficient on (TANG) is not significant in about all regressions. This supports the prediction of the trade-off theory that the debt-capacity increases with the proportion of tangible assets on the balance sheet.

Growth opportunity is negatively correlated with Leverage. This indicates that specifically companies with high investment opportunities have significantly lower leverage than companies with low investment opportunities. This result is consistent with both the trade-off theory and the extended version of the pecking order theory.

Finally, our proxies for the non-debt tax shield (NDTS) are generally insignificant. Only in one regression specification the estimated coefficient is significant, but the sign is opposite to what the trade-off theory suggests.

But, this static approach, which normally estimates a simple cross-section regression of the ratio of observed debt on a set of explanatory variables, suffers two limitations. First, observed debt does not necessarily have to be identified with optimal debt, as this implies ignoring the difficulties companies suffer when adjusting their capital structure. Second, static empirical analysis is unable to explain the dynamic nature of company capital.

One way to handle the problem posed by the static model is to estimate the dynamic panel data models. These models are very powerful tools that allow for empirical modeling of dynamics while accounting for individual level heterogeneity. Because dynamic panel models explicitly include variable to account for past behavior and time invariant individual specific effects, they enable us to understand better what factors drive behavior over time, differentiating between true dynamics and factors that vary across, but not within, individuals over time. However, we must be careful when choosing from among the various dynamic panel estimators that are available.

Our results are robust to several alternative estimation techniques, and while they depend on the exact definition of leverage, they are similar to what has been previously reported.

In general term, both theoretical approaches, the pecking order and the trade off theories, appear to help explain the financial behavior of new high-tech German firms. However, given the nature of their activity, there is an implied suggestion that no ideal capital structure exists for these firms.

Thus, from an empirical perspective, emphasis should be placed on constructing dynamic models that enable us to describe the financial behavior of new high-tech firms with discrimination between the various factors that impact on the target and those that impact on the speed of adjustment of these firms. Nonetheless, in so doing we raise several future avenues of research which may hopefully allow more concrete conclusions to be drown such as the more complete analysis of capital structure choice in new high-tech firms, with the development of a new capital structure theory into an empirical model to describe the financial behavior of new high-tech firms.

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