University of Innsbruck


# Working Papers in Economics and Statistics

## Capital Structure, Corporate Taxation and Firm Age

Michael Pfaffermayr, Matthias Stöckl
and Hannes Winner

2008-09

# Capital Structure, Corporate Taxation and Firm Age

Michael Pfaffermayr*, Matthias Stöckl† and Hannes Winner‡

May 2008

**Abstract**

This paper analyzes the relationship between capital structure, corporate taxation and firm age. We adapt a standard model of optimal capital structure choice under corporate taxation, focusing on the financing and investment decisions a young firm is typically faced with. Our model allows to derive testable hypotheses about the relationship between corporate taxation, a firm's age and its debt to asset ratio. To test these hypotheses empirically, we use a cross-section of 405,000 firms from 35 European countries and 126 NACE 3-digit industries. In line with previous research, we find that a firm's debt ratio increases with the corporate tax rate. Further, we observe that older firms exhibit smaller debt ratios than their younger counterparts. Finally, consistent with our theoretical expectation, we find a positive interaction effect between corporate taxation and firm age, indicating that the impact of corporate taxation on debt is increasing over a firm's life-time.

*Keywords*: Corporate taxation; Capital structure; Firm age
*JEL codes*: H20, H32, G32, C31

*Department of Economics and Statistics, University of Innsbruck; Austrian Institute of Economic Research (WIFO), Vienna; CESifo and ifo-Institute, Munich. Address: Universitaetsstrasse 15/3, A-6020 Innsbruck, Austria. E-mail: michael.pfaffermayr@uibk.ac.at

†Department of Economics and Statistics, University of Innsbruck, Universitaetsstrasse 15/4, A-6020 Innsbruck, Austria. E-mail: matthias.stoeckl@uibk.ac.at

‡Department of Economics and Statistics, University of Innsbruck, Universitaetsstrasse 15/4, A-6020 Innsbruck, Austria. E-mail: hannes.winner@uibk.ac.at

# 1 Introduction

Since the seminal work of Modigliani and Miller (1958, 1963) and Miller (1977) there is a vast amount of literature dealing with the optimal financing structure of firms under corporate income taxation (see Graham 2003, for a comprehensive survey). Accordingly, firms are weighing the marginal tax benefits induced by the deductibility of interest payments on debt against the marginal financial costs of debt when determining their 'target' leverage ratio.

The tax-induced benefits of debt are increasing with the statutory corporate tax rate. The costs of debt are typically assumed to increase with the debt level but not with other firm characteristics. However, there is an eminent line of research indicating that the costs of debt financing are changing over the life-cycle of a firm. For instance, firms in their start-up phase ('young' firms) typically lack sufficient internal funds to finance investment (see, e.g., Beck, Demirguc-Kunt and Maksimovic 2004, Keuschnigg and Nielsen 2004), and, due to uncertainty and information asymmetries, have limited access to equity financing (see, e.g., Diamond 1991, Berger and Udell 1998, Fuest, Huber and Nielsen 2002, Beck and Demirguc-Kunt 2006).[1] Therefore, younger firms have to rely more on debt than older firms (see, Berger and Udell 1998 and Gordon and Lee 2001, for empirical evidence). Another reason for the diminishing importance of debt is that profitable mature firms tend to have more internal funds (i.e., retained earnings) available. They reduce their reliance on debt, although the costs of external debt financing might decrease with the maturity of a firm (e.g., banks might reduce the interest rate for 'surviving' firms; Fazzari, Hubbard and Petersen 1988, Petersen and Rajan 1994, provide empirical evidence). Consequently, if it holds that the costs of debt and, therefore, the reliance on debt financing is changing with the age of a firm, we would also expect that the impact of taxes on a firm's debt policy is varying over its life-time. Surprisingly, there is no study analyzing systematically the relationship between corporate taxation, firm age and debt policy. This paper tries to fill this gap using a cross-section of manufacturing firms from 35 European countries.

To derive empirically testable hypotheses about corporate taxation, a firm's age and its capital structure, we propose a stylized two-period model of op-

[1] Keuschnigg and Nielsen (2002: p. 175), for instance, argue that *"[F]inancing early stage businesses involves special problems and is fundamentally different from financing mature and well established companies. Because of lacking collateral and the absence of any past track record, and due to their informational advantages, pioneering entrepreneurs often face severe difficulties in convincing banks to finance projects with potentially high returns but high risks as well."* In a similar vein, Gordon and Lee (2001: p. 216) emphasize that *"[S]mall firms are more likely to be recent start-ups, that would need to rely much more on outside loans rather than retained earnings in order to finance new investment."*

timal capital structure choice under corporate taxation. The model analyzes the change in the financial structure between the two periods, and, therefore, allows to investigate the impact of a firm's age on its debt ratio. We demonstrate that the debt ratio is positively associated with the statutory corporate tax rate, and that under plausible assumptions older firms rely less on debt than their younger counterparts. Further, we show that the (positive) impact of corporate taxation on the debt ratio systematically changes with a firm's age, motivating an interaction term between the statutory corporate tax rate and firm age in our empirical analysis.

To test these hypotheses empirically, we use a cross-section of about 405,000 European firms as compiled by the Bureau van Dijk's AMADEUS database. We regress the debt ratio (defined as current and non-current liabilities over total assets) on our variables of interest (i.e., the statutory corporate tax rate, firm age and an interaction thereof) along with other controls (i.e., asset tangibility, firm size, profitability, proxies for financial distress). In line with our theoretical hypotheses, we find that a firm's debt ratio is positively influenced by the statutory corporate tax rate, and negatively affected by firm age. A significantly positive interaction term between firm age and the statutory corporate tax rate indicates that the impact of corporate taxation on the debt ratio is increasing over a firm's life-time, which is consistent with our theoretical expectation.

The remainder of the paper is organized as follows. Section 2 outlines a simple theoretical model that allows to derive empirically testable hypotheses about the relationship between corporate taxation, firm age and debt. Section 3 describes the data and presents some descriptive statistics. Section 4 introduces the econometric specification and presents the empirical results. Section 5 summarizes our main findings.

## 2 A simple model of corporate taxation, firm age and debt financing

We analyze a firm's investment and financing decisions in a two period framework (see Poterba and Summers 1985; Myles 1995 and Keuschnigg 2005, provide excellent textbook treatments). Investors are assumed to be risk-neutral, investing in a firm or, alternatively, in a risk-less asset earning a given market interest rate $r_t$, where $t \in \{0, 1\}$ denotes a time subscript. Investment $I_t$ can be financed with new debt, $B_t^N$, or with equity via retained earnings, $E_t$. For simplicity, we rule out financing via external equity (i.e., new share issues), and we also abstract from shareholder taxation. Capital $K_t$ is the

only factor of production, so that output is given by $\pi_t(K_t)$, with the usual assumptions $\pi'(K_t) > 0, \pi''(K_t) < 0$. The price of output is normalized to 1. Then, after-tax dividends are given by

$$D_t = (1 - \tau) [\pi_t(K_t) - m(B_t)] - E_t, \tag{1}$$

where $\tau$ denotes the statutory corporate income tax rate. $m(B_t)$ represents interest payments on debt. Following previous research, $m$ includes the market interest rate $r_t$ and a risk premium that increases with a firm's debt level, e.g., due to information asymmetries between borrowers and/or lenders and other market imperfections (see Stiglitz and Weiss 1981, Fazzari, Hubbard and Petersen 1988, Bernanke, Gertler and Gilchrist 1999, Huizinga, Laeven and Nicodéme 2008, among others). This aspect is captured by the assumptions that $m_t = m(B_t)$, with $m'(B_t) > 0$ and $m''(B_t) > 0$ (to satisfy the second order conditions derived below). Further, the first unit of debt has to pay the market interest rate $r_t$, i.e., $m(0) = r_t$.

The capital stock in $t = 1$ is given by

$$K_1 = gK_0 \quad \text{where} \quad g = \frac{K_0 + I_0}{K_0}. \tag{2}$$

Similarly, the stock of debt in this period is

$$B_1 = cB_0 \quad \text{where} \quad c = \frac{B_0 + B_0^N}{B_0}. \tag{3}$$

Hence, $c - 1$ and $g - 1$ represent the growth rates of debt and the capital stock. For the sake of brevity and without loss of generality, we ignore economic depreciation in (2).

Profits after tax and interest are either retained or paid out as dividends. The initial capital stock, $K_0$, is given and is financed with initial equity, $E_0$, and debt, $B_0$. At the end of the second period the firm is liquidated, outstanding debt is repaid and the value of the remaining assets is paid out to the shareholders, so that $K_2 = 0$, $B_2 = 0$ and $I_1 = -K_1$.

In $t = 0$, a share $e$ of investment expenditures $I_0$ is immediately deductible from the tax base, essentially representing an investment tax credit or extra tax allowances (e.g., accelerated depreciation). Under these assumptions,

dividends are defined as

$$\begin{aligned} D_0 &= (1-\tau)[\pi_0(K_0) - m(B_0)] + \underbrace{(c-1)B_0}_{B_0^N} - \underbrace{(g-1)K_0}_{I_0} + \underbrace{(g-1)K_0\tau e}_{I_0\tau e} \\ D_1 &= (1-\tau)[\pi_1(gK_0) - m(cB_0)] + \underbrace{gK_0}_{K_0+I_0} - \underbrace{cB_0}_{B_0+B_0^N} \end{aligned} \tag{4}$$

We rule out that investment in the first period exceeds cash flows (i.e., profit after tax and interest) plus new debt, implying the side condition

$$(1-\tau)\left[\pi_0(K_0) - m(B_0)\right] + (g-1)K_0\tau e + (c-1)B_0 \geq (g-1)K_0. \tag{5}$$

The objective of the firm is to maximize its firm value, $V_0$, which is given by the present value of the dividend stream

$$V_0 = D_0 + \frac{D_1}{R_1}, \tag{6}$$

with $R_1 = 1 + r_1$.

In the following, we focus on investment and financing choices taken in $t = 1$, given the decisions in $t = 0$ ($E_0, K_0$ and $B_0$). First, we maximize (6) assuming that the side condition of (5) is not binding. The corresponding first order conditions are given by

$$\begin{aligned} \frac{\partial V}{\partial c} &= B_0 + \frac{-(1-\tau)(m'(cB_0)B_0) - B_0}{R_1} = 0 \\ \frac{\partial V}{\partial g} &= -K_0 + K_0 e\tau + \frac{(1-\tau)(\pi_1'(gK_0)K_0) + K_0}{R_1} = 0. \end{aligned} \tag{7}$$

Re-arranging (7) yields

$$\begin{aligned} (1-\tau)m'(cB_0) &= r_1 \\ (1-\tau)\pi'(gK_0) + (1+r_1)\tau e &= r_1. \end{aligned} \tag{8}$$

Based on (8), we can formulate Proposition 1, which provides sufficient conditions for the ratio of debt to capital stock (henceforth debt ratio) to fall as firms become older.

**Proposition 1** *If* $(1-\tau)\pi'(c^*K_0) + (1+r_1)\tau e > r_1$*, then the optimal increase in investment* ($g^*$) *is higher than the optimal increase in debt* ($c^*$).

Under proposition 1, the debt ratio falls as firms become older. Obviously, the leverage effect of corporate taxation and interest payments increasing in debt are the driving forces behind this conclusion. The pre-condition un-

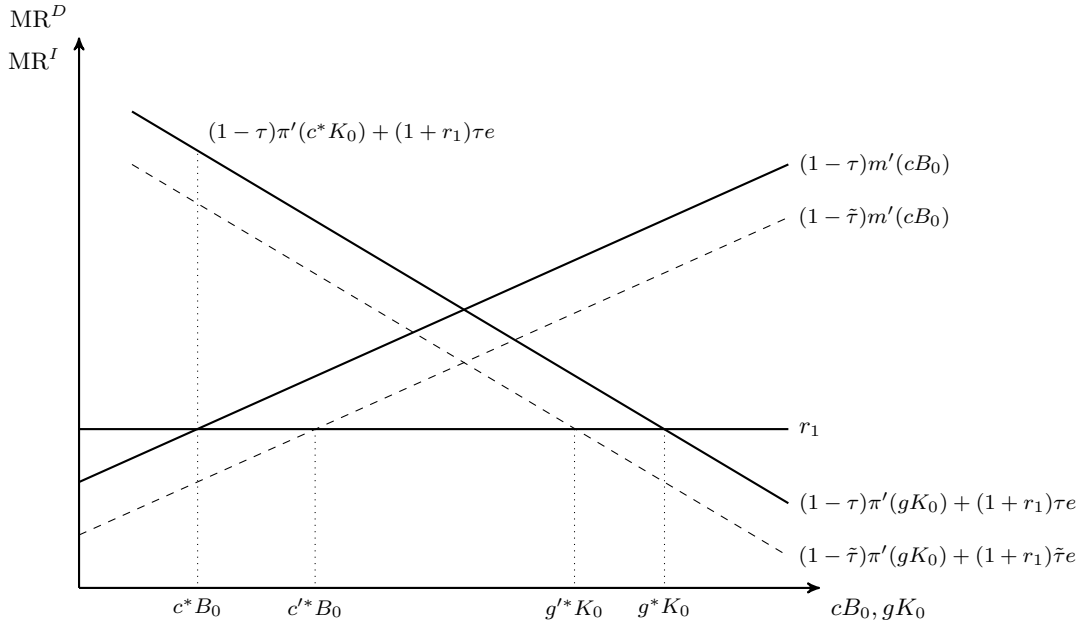


Figure 1: Side condition is not binding

derlying Proposition 1 is that the after tax marginal returns (including the investment tax credit) at a constant debt ratio is higher than its opportunity costs $r_1$. This is likely to be the case if firms are profitable and the risk premium increases sufficiently with the debt level. This result is illustrated in Figure 1, which depicts the first order conditions stated in (8). The downward-sloping curve refers to the first-order condition on investment. Its negative slope follows from the decreasing marginal product of capital. The upward-sloping curve captures the marginal after-tax interest payments (for simplicity, we draw this curve as linear). It shows that the firm has an incentive to increase its debt to take advantage of the tax-induced leverage effect. At $m = 0$, the after tax interest rate is lower than $r_1$. If the increase in the interest rate on debt ($m'$) is sufficiently large, the leverage effect is limited and it pays to finance some part of the investment via retained earnings. If the firm is highly profitable and the marginal product after tax at a constant debt ratio with $c^*K_0$ is higher than the interest rate $r_1$, older firms (i.e., in period 1) will decrease the debt ratio choosing $c^* < g^*$. Hence, under capital market imperfections, profitable old firms tend to reduce their debt ratio despite the leverage effect of corporate taxation.[2]

[2]Without corporate taxation, the model implies that the investment is exclusively financed by retained earnings. If $\tau = 0$, it follows that $m'(cB_0) = r_1$ and $\pi'(gK_0) = r_1$. In this case, the marginal product of capital reflects the opportunity costs $r_1$. Since $m(0) = r_1$ and $m' > 0$ it follows that it is optimal to finance investment by retained earnings exclusively, i.e., $c = \frac{1}{B_0}$.

To derive the impact of an increase in corporate taxation on the debt ratio, we totally differentiate the first order conditions in (8)

$$\begin{aligned}(1-\tau)m''B_0dc &= m'd\tau \\ (1-\tau)\pi''K_0dg &= (\pi' - (1+r_1)e)d\tau,\end{aligned} \tag{9}$$

which gives

$$\frac{dc}{d\tau} = \frac{m'}{(1-\tau)m''B_0} \tag{10}$$

$$\frac{dg}{d\tau} = \frac{\pi' - (1+r_1)e}{(1-\tau)\pi''K_0}. \tag{11}$$

To determine the sign of (10) and (11) we use the second order conditions from (7)

$$\begin{aligned}\frac{\partial^2 V}{\partial c^2} &= -\frac{(1-\tau)(m''B_0^2)}{R_1} < 0 \\ \frac{\partial^2 V}{\partial g^2} &= \frac{(1-\tau)\pi''K_0^2}{R_1} < 0.\end{aligned} \tag{12}$$

Then, it follows that $\frac{dc}{d\tau} > 0$ and $\frac{dg}{d\tau} < 0$, if $\pi' > (1+r_1)e$. This result can be formulated in the following Proposition:

**Proposition 2** *If $\pi' > (1+r_1)e$, $c^*$ increases and $g^*$ decreases with $\tau$.*

Proposition 2 implies that the decrease in the debt ratio as predicted in Proposition 1 for profitable firms is more pronounced at a higher $\tau$. In other words, the negative age effect is dampened under high corporate tax rates. Figure 1 illustrates this finding showing that both the debt schedule and the marginal profit schedule are shifted inwards as $\tau$ increases from $\tau$ to $\tilde{\tau}$. It should be noted, however, that the conclusion drawn from Proposition 2 only holds if the investment tax credit is not too large.[3]

If the side condition is binding, the internal funds of the company are not sufficient to achieve the desired investment level. The corresponding Lagrangian is given by

$$L = D_0 + \frac{D_1}{R_1} - \lambda\left[(g-1)K_0 - (c-1)B_0 - (g+1)K_0\tau e - C\right] \tag{13}$$

[3] Inspection of the corresponding first order conditions shows that this is the case as long as $\pi' > r_1$.

with $C = (1-\tau)\left[\pi_0(K_0) - m(B_0)\right]$, and first order conditions

$$\begin{aligned} \frac{\partial V}{\partial c} &= B_0 + \frac{-B_0 - (1-\tau)(m'(cB_0)B_0)}{R_1} - \lambda(-B_0) \\ &\Rightarrow \quad \lambda(1+r_1) = (1-\tau)m'(cB_0) - r_1 \end{aligned} \tag{14}$$

$$\begin{aligned} \frac{\partial V}{\partial g} &= -K_0 + K_0 e\tau + \frac{(1-\tau)(\pi_1'(gK_0)K_0) + K_0}{R_1} - \lambda(K_0 - K_0\tau e) \\ &\Rightarrow \quad (1-\tau)\pi'(K_0 g) + (1+r_1)\tau e - r_1 = \lambda(1-\tau e) \end{aligned} \tag{15}$$

$$\frac{\partial V}{\partial \lambda} = -(g-1)K_0 + (c-1)B_0 + (g+1)K_0\tau e + C \tag{16}$$

This case is illustrated graphically in Figure 2. The binding constraint on internal funds implies that $\lambda > 0$, so that $(1-\tau)m'(cB_0) > r_1$ and $(1-\tau)\pi'(gK_0) + (1+r_1)\tau e - r_1 > 0$. Therefore, a cash constrained firm exhibits a larger increase in debt and a smaller increase in investment as compared to the unconstrained one. Denoting the optimal growth rates of the debt ratio under cash constraints by $c^{**}$ and $g^{**}$, respectively, suggests the following Proposition, which is similar to Proposition 1:

**Proposition 3** *If* $(1-\tau)\pi'(c^{**}K_0)+(1-r_1)\tau e > r_1$, *then* $g^{**} > c^{**}$. *However,* $c^{**} > c^*$ *and* $g^{**} < g^*$.

Empirically, the propositions imply that one should control for age in addition to the corporate tax rate in explaining the debt ratio in a cross section of firms. From Proposition 1 and 3 we expect a negative relationship between the debt ratio and firm age (i.e., older firms are relying less on debt than their younger counterparts). Proposition 2 motivates an empirical specification, where firm age is interacted with the corporate tax rate. We expect that this interaction term exhibits a positive sign.

## 3 The data

**Data description:** We use firm-level data from 35 European countries as compiled by the Bureau van Dijk's AMADEUS database (Update 146, published in November 2006).[4] Generally, the AMADEUS database covers balance sheet information from about 8 million firms over the time period 1993

[4]In contrast to the earlier versions of the AMADEUS database, there are no inclusion criteria (minimum number of employees, minimum operating revenue or minimum total assets) in this version of the database. One obvious advantage of this database is, therefore, the inclusion of small and medium-sized enterprises.

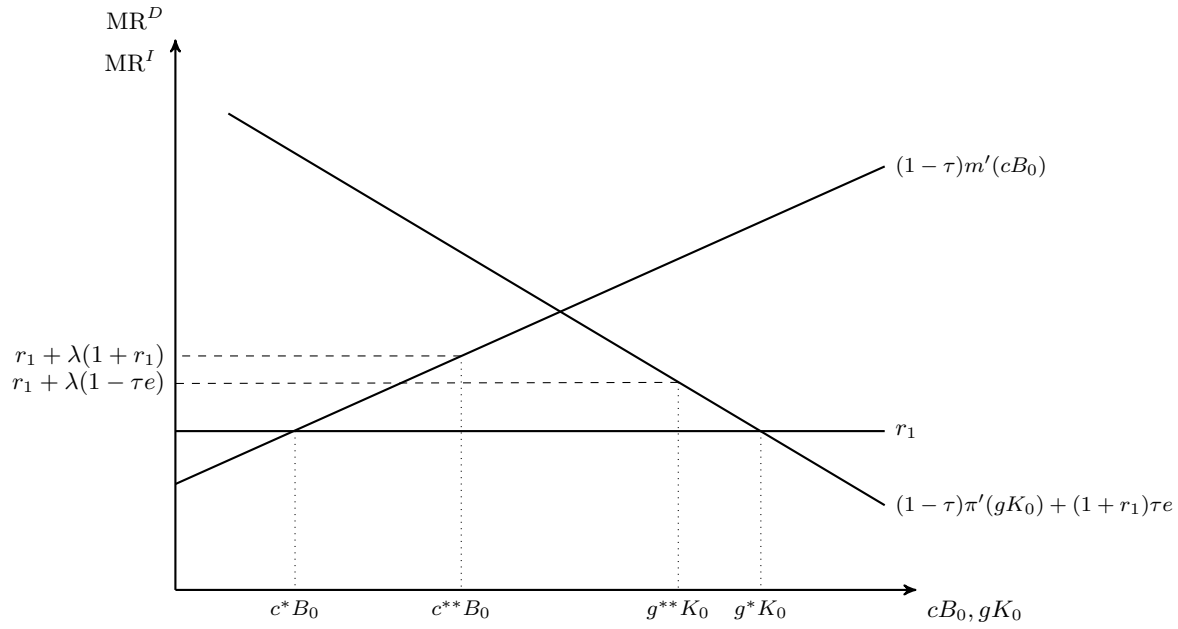


Figure 2: Side condition is binding

to 2006. The resulting panel of firms is highly unbalanced, and especially in the early years of coverage the data quality is relatively poor. Therefore, we focus on a cross-section of 959,125 firms encompassing the years between 1999 and 2004.

In the empirical analysis below, we confine our interest on active companies in the manufacturing sector (according to NACE 1-digit classification codes 15-37; see Table A.4 for a list of the included industries and the corresponding sample coverage). To ensure that each firm's financial statement is unambiguously attributable to the corporate tax rate of a single country, we exclude consolidated accounts (50,698 firms). As we only focus on corporate taxation, we drop all unincorporated firms (79,383 firms). The remaining dataset includes a cross-section of 829,044 firms. From these, we drop the ones with an operating revenue or total assets below zero (17,069 firms).

Regarding the debt variable, our theoretical model suggests to focus on debt ratios rather than debt levels or changes in debt levels. The debt ratio has been frequently used in previous empirical research (see Graham 1999 for a discussion). In our case, the total debt ratio is defined as the sum of current- and non-current liabilities over total assets. Some studies rely on subcomponents of debt, i.e., long-term and short-term debt (e.g., Booth, Aivazian, Demirguc-Kunt and Maksimovic 2001 make extensive use of long-term debt). To provide a comparison to such studies, we use variants of the total debt

ratios in a sensitivity check. In our sample, we exclude firms with a total debt ratio below zero and above 200 percent (14,702 firms).[5]

**Descriptive statistics:** Table 1 presents some country-specific stylized facts about debt, corporate taxation and firm age (Table A.2 provides further descriptives for the whole set of variables and the variable definitions are laid out in Table A.1). For all three variables together, our sample contains full information over 541,483 firms in 35 countries and 126 NACE 3-digit industries. As can be seen from the table, about two thirds of the firm coverage is due to Spanish, UK, French, Romanian and Italian firms. In three countries (Cyprus, Malta and Switzerland), firm-level information is only available for less than 100 firms.[6]

From Table 1 we can see that the total debt ratio at the country-level is around 71.6 percent on average, with a minimum of about 36 percent (Cyprus) and a maximum of about 81 percent (Romania). Most of the countries are lying within a range of 50 and 70 percent, which is very close to the debt ratios reported in Rajan and Zingales (1995). The next three columns summarize the statutory corporate tax rates (including company taxes at the local level) in 1999 and in 2004 (columns 3 and 4), and the average rate within these years (column 2). The average corporate tax rate between 1999 and 2004 is around 32.3 percent, ranging from 10.83 (Ireland) to 41.17 (Germany). Most of the countries reduced their corporate tax rates considerably within this time period. On average, the statutory corporate tax rate felt from 35 percent in 1999 to 31 percent in 2004. The most dramatical changes in tax rates took place in the Slovak Republic (from 40 to 19 percent), in Germany (from 50.1 to 36.4 percent) and in Poland (from 34 to 19 percent). In three countries, we observe a fairly small increase in corporate tax rates (in Finland from 28 to 29 percent, in Ireland from 10 to 12.5 percent and in Spain from 35 to 35.3 percent).

Firm age is defined as the time period between the year 2006 and the date of a firm's incorporation. Table 1 illustrates that in our sample the average firm is about 16.8 years old. As expected, the youngest firms are observed in the transition economies (e.g., in Romania the average firm is about 8.7

[5] In the middle- and short-run, a debt ratio above 100 percent might be possible due to losses in previous periods inducing negative shareholder equity in the current period. To include such firms in the sample, we set the threshold for the total debt ratio at a value of 200 percent. It turns out that our empirical results are unchanged when applying a threshold below 200 percent (see the robustness section).

[6] In the empirical analysis below, we account for the low sample coverage in these countries by applying a sensitivity check, where all countries with a coverage lower than 500 firms are excluded.

Table 1: Average debt ratios, corporate tax rates and firm age per country

| Country | Debt ratio | Corporate tax rate | | | Age | Obs. | Share in sample |
|---|---|---|---|---|---|---|---|
| | | 99-04 | 1999 | 2004 | | | |
| Austria | 69.97 | 34.00 | 34.00 | 34.00 | 21.00 | 999 | 0.18 |
| Belgium | 68.06 | 38.11 | 40.17 | 33.99 | 19.56 | 21,040 | 3.89 |
| Bosnia and Herzegovina | 48.52 | 30.00 | – | 30.00 | 10.62 | 538 | 0.10 |
| Bulgaria | 63.06 | 26.58 | 32.50 | 19.50 | 20.18 | 1,788 | 0.33 |
| Croatia | 64.87 | 25.00 | 35.00 | 20.00 | 18.80 | 3,183 | 0.59 |
| Cyprus | 35.99 | 23.33 | 25.00 | 15.00 | 33.39 | 23 | 0.00 |
| Czech Republic | 64.39 | 31.17 | 35.00 | 28.00 | 9.98 | 9,477 | 1.75 |
| Denmark | 66.93 | 30.67 | 32.00 | 30.00 | 14.92 | 8,566 | 1.58 |
| Estonia | 53.23 | 26.00 | 26.00 | 26.00 | 9.04 | 5,930 | 1.10 |
| Finland | 58.32 | 28.83 | 28.00 | 29.00 | 17.23 | 11,081 | 2.05 |
| France | 71.69 | 35.82 | 40.00 | 34.30 | 16.30 | 76,415 | 14.11 |
| Germany | 75.11 | 41.17 | 50.08 | 36.39 | 24.10 | 8,723 | 1.61 |
| Greece | 59.77 | 37.08 | 40.00 | 35.00 | 14.64 | 6,856 | 1.27 |
| Hungary | 57.47 | 17.67 | 18.00 | 16.00 | 10.63 | 3,622 | 0.67 |
| Iceland | 78.66 | 24.00 | 30.00 | 18.00 | 12.51 | 1,600 | 0.30 |
| Ireland | 70.43 | 10.83 | 10.00 | 12.50 | 15.31 | 8,033 | 1.48 |
| Italy | 76.33 | 39.75 | 41.20 | 37.30 | 24.04 | 45,878 | 8.47 |
| Latvia | 66.63 | 21.83 | 25.00 | 15.00 | 10.39 | 795 | 0.15 |
| Lithuania | 57.48 | 20.33 | 29.00 | 15.00 | 9.30 | 1,458 | 0.27 |
| Luxembourg | 64.58 | 33.92 | 37.45 | 30.38 | 19.03 | 247 | 0.05 |
| Macedonia | 57.60 | 15.00 | 15.00 | 15.00 | 20.64 | 190 | 0.04 |
| Malta | 53.73 | 35.00 | 35.00 | 35.00 | 23.63 | 94 | 0.02 |
| Netherlands | 77.93 | 34.75 | 35.00 | 34.50 | 27.37 | 17,651 | 3.26 |
| Norway | 74.99 | 28.00 | 28.00 | 28.00 | 11.40 | 10,799 | 1.99 |
| Poland | 60.94 | 27.67 | 34.00 | 19.00 | 21.69 | 5,617 | 1.04 |
| Portugal | 72.32 | 33.55 | 37.40 | 27.50 | 19.95 | 10,523 | 1.94 |
| Romania | 80.86 | 27.17 | 38.00 | 25.00 | 8.67 | 53,894 | 9.95 |
| Russian Federation | 64.82 | 29.50 | 35.00 | 24.00 | 27.80 | 7,893 | 1.46 |
| Serbia and Montenegro | 51.77 | 18.00 | 20.00 | 14.00 | 19.05 | 2,464 | 0.46 |
| Slovak Republic | 61.97 | 27.83 | 40.00 | 19.00 | 10.70 | 1,186 | 0.22 |
| Spain | 74.78 | 35.05 | 35.00 | 35.30 | 13.87 | 95,471 | 17.63 |
| Sweden | 62.44 | 28.00 | 28.00 | 28.00 | 20.21 | 23,877 | 4.41 |
| Switzerland | 64.09 | 24.61 | 25.04 | 24.37 | 67.82 | 11 | 0.00 |
| Ukraine | 45.00 | 29.17 | 30.00 | 25.00 | 22.69 | 4,182 | 0.77 |
| United Kingdom | 71.06 | 30.00 | 30.00 | 30.00 | 17.96 | 91,379 | 16.88 |
| *Average* | *71.62* | *32.34* | *34.85* | *30.97* | *16.81* | – | – |

**Notes:** The sample includes 541,483 manufacturing firms in 35 countries and 126 industries (NACE 3-digit classification codes 150-372; see Table A.5 in the Appendix).

years old). With the exemptions of Switzerland (firm age of about 67.8 years) and Cyprus (around 33.4 years), for which our sample includes less than 100 firms, the oldest firms are located in the Russian Federation (27.8 years), in the Netherlands (27.4 years), in Germany (24.1 years) and in Italy (24 years), on average.

Figure 1 provides further information on the age structure of all firms in the sample. Moreover, it contains information on the relationship between total debt ratios and firm age. Specifically, we plot the average total debt ratios against firm age in 10-year age cohorts. The entries in the figure indicate the mean debt ratios of each age cohort, and the whiskers illustrate the corresponding standard deviations. From the figure, we can draw three important conclusions regarding the subsequent empirical analysis. First, most of the total debt ratios are lying within a range of 50 to 70 percent, which is consistent with Table 1. This warrants the use of a linear specification (rather than a logistic one) when estimating the impact of firm age and taxation on debt. Second, up to a firm age of about 300 years we observe considerable variation in total debt ratios, which seems to be constant over the age cohorts. Eight firms are older than 300 years, indicating potentially influential outliers (the oldest firm is 1,018 years old; interestingly, there is one firm in the sample with zero leverage and firm age of 526 years; overall we have 5,577 firms with zero debt or about 1 percent of the sample).[7] Third, and perhaps most importantly, the sheer graphical inspection of Figure 1 clearly indicates a u-shaped relationship between debt and firm age, not only in a sample with firms younger than 300 years but also in the whole sample (see the regression lines in the figure). This motivates the inclusion of a quadratic term for firm age in our regressions.

Regarding the relationship between debt, corporate taxation and firm age, we observe some countries exhibiting a relatively high total debt ratio combined with a corporate tax rate above the average (e.g., France, Germany, Italy, or Spain), which is in line with our theoretical expectations. However, we also identify countries with a high debt ratio along with corporate tax rates below the average (Iceland and Norway), which is inconsistent with our hypotheses presented above. Similarly, for some countries we find that debt ratios are negatively associated with firm age (e.g., in France, Norway or Spain), but in other ones there is a positive correlation between those variables (e.g., in Italy or Portugal). Hence, the country-specific information from Table 1 is

[7] In the basic regressions, we include all observations in the regressions. As a robustness check, we account for potentially outlying observations regarding firm age by excluding firms (i) older than 150 years, and (ii) older than 50 years.

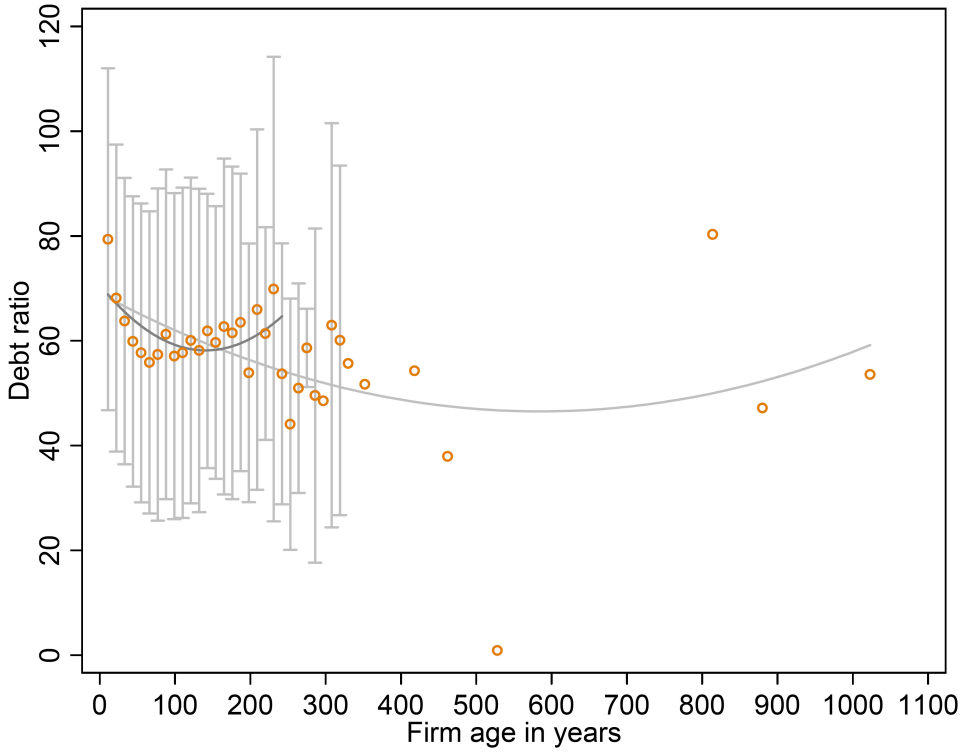


Figure 3: Average debt ratio per age cohort (stratified sample)

ambiguous on how the variables of interest are interrelated to each other, and especially on the question whether the impact of corporate taxation on debt financing is changing over the life-cycle of a firm.[8] In the following, we try to answer this question more systematically by applying a firm-level regression analysis.

# 4 Empirical Analysis

**Specification:** We are interested in the effects of corporate taxation and firm age on debt financing, and on how the influence of corporate taxation changes over the life-time of a firm. This motivates an empirical model, where the debt ratio is regressed on the statutory corporate tax rate, firm age and an interaction term between those variables. We introduce additional control variables that are not captured by our stylized model. However, these variables turned out important from a theoretical and empirical point of view in previous

[8]This conclusion seems to be confirmed by the correlation matrix in Table A.3, which is based on the firm- rather than the country-level. There, we observe a partial correlation coefficient of 0.08 between the debt ratio and the average statutory corporate tax rate, and a value of -0.21 between the total debt ratio and firm age. The correlation coefficient between firm age and the average corporate tax rate is around 0.13.

research. The econometric specification reads

$$b_{ijk} = \beta_1 \tau_j + \beta_2 A_i + \beta_3 A_i^2 + \beta_4 \tau_j A_i + \mathbf{Z}_i \boldsymbol{\delta} + \gamma_k + \varepsilon_{ijk}, \tag{17}$$

where $i$, $j$, and $k$ are firm-, country- and industry indices, respectively. $b_{ijk}$ is the debt to asset ratio for the $i$th firm in country $j$ and industry $k$, $\tau_j$ denotes the statutory corporate tax rate in country $j$, and $A_i$ is the firm-specific age. Note that $A$ enters three times in (17): The first two terms capture a possible non-linear (in- or decreasing) impact of firm age on debt (according to Figure 3), and the interaction term between firm age and the corporate tax rate allows to analyze whether the influence of corporate taxation on debt financing is changing over the life time of a firm. From Proposition 2 we expect a positive estimate for $\beta_4$.

$\mathbf{Z}_i$ is a vector of additional firm-specific control variables (including the constant) suggested by the previous empirical literature (Graham 2003 provides an excellent survey). $\gamma_k$ indicate NACE 3-digit industry fixed effects (overall, we include 126 industry dummies) and $\varepsilon_{ijk}$ is the remainder error term.

The vector $\mathbf{Z}_i$, firstly, comprises asset tangibility as measured by the share of fixed assets in total assets. This variable captures a firm's ability to borrow against fixed assets potentially serving as collateral in case of bankruptcy (see Rajan and Zingales 1995). Hence, we would expect a positive relationship between tangibility and debt ratios. On the other hand, DeAngelo and Masulis (1980) argue that firms with a high share of fixed assets may gain from non-debt tax shields resulting from higher amounts of depreciation and investment tax credits. Hence, depreciable assets might serve as a substitute for tax deductible interest payments when firms are trying to minimize their taxable profits. This, in turn, motivates a negative impact of asset tangibility on debt financing. Overall, the sign of this variable remains ambiguous. Further, we include the size of a firm, defined as the logarithm of sales.[9] Graham (1999) argues that large companies tend to be more diversified and might have more stable cash flows, making it easier to obtain external funds. In addition, small firms are faced with higher borrowing costs due to information asymmetries. For both reasons, we expect that large firms are more likely to be debt financed than smaller ones (see also Alworth and Arachi 2001, and Gropp 2002, for empirical studies).

[9] Since sales are log-normally distributed in the sample, we use the log of sales in the regressions (see, e.g., Rajan and Zingales 1995). Alternatively, we include the total number of employees as size measure. However, we obtain more or less the same parameter estimates when applying this size measure. Therefore, we do not report the results of this specification here. The results are available from the authors upon request.

The next variable in $\mathbf{Z}_i$ is firm profitability as measured by the return on assets (ROA), which is defined as the ratio of EBIT over total assets, where EBIT is earnings before interest and taxes (see Fama and French 2002). Our theoretical model suggests a negative relationship between profitability and debt.[10] It should be noted, however, that the previous literature is not entirely clear about the effects of firm profitability on debt financing. On the one hand, profitable firms may use their profits to pay back debt or to finance investment via retained earnings and, therefore, need less external funds (see Myers and Majluf 1984, Rajan and Zingales 1995, Gropp 2002). This is exactly the channel raised in our theoretical model and it motivates a negative relationship between ROA and the debt ratio. On the other hand, profitable firms typically possess free cash flow at their disposal. Some authors argue that debt financing in this situation is a meaningful instrument to restrict managers from undertaking less profitable investments (see Jensen 1986). In this case, we expect a positive parameter estimate for profitability.

Finally, following the previous empirical literature explaining debt financing, we add three variables informing about the financial situation of a firm (see, e.g., MacKie-Mason 1990, Graham 1999 or Alworth and Arachi 2001). First, we define a dummy variable with entry one if a firm reports a net operating loss in the period 1999 to 2004, and zero else (henceforth, we refer to this variable as NOL). Second, we include a dummy variable equal to one if a company reports negative shareholder funds (NSF), and zero else. Net operating losses and negative shareholder funds are associated with losses in previous (NOL) and consecutive (NSF) periods, the vanishing equity reserves automatically increase the debt position of a firm (see Graham 1999). Hence, we predict a positive sign on both coefficients. Third, the variable $Z$-score captures a firm's probability of bankruptcy, and, therefore, the expected financial distress of a firm (see Altman 1968).[11] Financial distress affects debt financing via two channels. First, highly-leveraged firms are more exposed to bankruptcy, inducing additional costs (e.g., legal fees). Thus, a company in financial distress should be more cautious in using debt. Second, firms in

[10] In the model, the downward sloping curve of the marginal product of capital is shifted upwards, inducing an increase of investment, which is entirely financed via internal funds (see also Figure 1).

[11] We follow Graham (1999) to define the $Z$-score as

$$\begin{aligned} Z\text{-score} &= 3.3 \cdot \frac{\text{EBIT}}{\text{Total assets}} + 1.0 \cdot \frac{\text{Operating revenue}}{\text{Total assets}} + 1.4 \cdot \frac{\text{Shareholder funds}}{\text{Total assets}} \\ &+ 1.2 \cdot \frac{\text{Working capital}}{\text{Total assets}} \end{aligned}$$

Due to data restrictions, we include shareholder funds instead of retained earnings (as in Alworth and Arachi 2001).

Table 2: Estimation results (*dependent variable*: debt to asset ratio)

| | Statutory corporate tax rate in the year(s) | | | |
|---|---|---|---|---|
| | 1999 | 2002 | 2004 | 99-04 |
| Corporate tax rate (SCTR) | 0.476 *** | 0.516 *** | 0.567 *** | 0.558 *** |
| | (0.010) | (0.012) | (0.011) | (0.013) |
| Firm age | −0.832 *** | −0.799 *** | −0.729 *** | −0.906 *** |
| | (0.018) | (0.036) | (0.033) | (0.027) |
| Firm age$^2$ | 0.003 *** | 0.003 *** | 0.003 *** | 0.003 *** |
| | (0.0001) | (0.0003) | (0.0003) | (0.0002) |
| SCTR·Age | 0.008 *** | 0.007 *** | 0.006 *** | 0.011 *** |
| | (0.0004) | (0.001) | (0.001) | (0.001) |
| Asset tangibility | −0.036 *** | −0.042 *** | −0.041 *** | −0.038 *** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Firm size (log of sales) | 1.288 *** | 0.945 *** | 1.039 *** | 0.952 *** |
| | (0.021) | (0.022) | (0.022) | (0.022) |
| Profitability (ROA) | −0.150 *** | −0.141 *** | −0.140 *** | −0.142 *** |
| | (0.005) | (0.005) | (0.005) | (0.005) |
| Net operating loss (NOL) | 6.779 *** | 6.548 *** | 6.799 *** | 6.609 *** |
| | (0.119) | (0.114) | (0.115) | (0.114) |
| Negative shareholder funds (NSF) | 44.951 *** | 45.929 *** | 45.743 *** | 45.756 *** |
| | (0.117) | (0.122) | (0.122) | (0.121) |
| Financial distress ($Z$-score) | −0.016 | −0.003 | −0.012 | −0.004 |
| | (0.039) | (0.035) | (0.037) | (0.035) |
| Observations | 404,849 | 405,373 | 405,373 | 405,373 |
| $R^2$ | 0.436 | 0.436 | 0.437 | 0.438 |
| Industry fixed effects: F-statistic | 636.00 | 503.11 | 485.89 | 573.12 |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 |

**Notes:** Constant and industry dummies not reported. White (1980) robust standard errors in parentheses. ***Significant at 1%, **Significant at 5%, *Significant at 10%.

financial distress are more likely to pay no taxes in the future, alleviating the tax-induced advantages of interest deductions from debt financing. In both cases, we predict a negative relationship between $Z-$score and the debt ratio.

**Estimation results:** The empirical results are presented in Table 2. In all of the empirical models discussed below, we exclude observations with a remainder error in the upper and lower end 1 percent percentile range (about 40,000 observations of the sample). Correcting for outliers in this way, we are left with about 405,000 observations.

As discussed above, our sample encompasses a cross-section of firms with averages over the period 1999 to 2004. Since the corporate tax rate has changed considerably over time (see Table 1), we estimate several versions of (17). One, where we use the average corporate tax rate within this period (column 4), and three further specifications applying the statutory corporate tax rates in 1999 (column 1), in 2002 (column 2) and in 2004 (column 3). It turns out that the estimation results are less sensitive to these variations in tax rates, and, therefore, we refer to the results in column 4 when discussing our empirical results.

Generally, the model fit seems well. The $R^2$ is relatively high, the industry effects are significant and the control variables are almost as expected. Asset tangibility enters significantly negative, which apparently lends support to the view that fixed assets serve as a substitute for debt in our sample (similar evidence, also based on the AMADEUS database, is provided by Huizinga, Laeven and Nicodéme 2008). Large firms exhibit higher debt ratios than smaller ones, which is consistent with prior evidence (see Rajan and Zingales 1995, Alworth and Arachi 2001, and Gropp 2002). Further, profitability (ROA) has a significantly negative coefficient, indicating that profitable firms tend to reduce their debt position via retaining profits. This finding is in accordance with the theoretical predictions of our model (and also Myers and Majluf 1984 and the empirical findings in Rajan and Zingales 1995 and Huizinga, Laeven and Nicodéme 2008). Finally, the impact of a firm's financial situation on debt financing seems decisive. As expected, firms with operating losses that are not cleared by equity injections are relying more on debt. Similarly, for firms with negative shareholder funds (NSF) we observe higher debt ratios, which seems plausible as discussed above (see also Graham 1999). The $Z-$score variable takes the expected negative sign, but is insignificant throughout.

Regarding our variables of interest, we find a significantly positive impact of corporate taxation on debt ratios as expected. The tax advantage of debt obviously provokes firms to increase their leverage. In line with Propositions 1 and 3, we find a negative effect of firm age, indicating that older firms exhibit lower debt ratios than younger ones, on average. However, as is indicated by the positive parameter estimate on age squared, there is a u-shaped relationship between firm age and debt financing. From estimated parameters of Table 2, we can see that the firm age, where the influence of age changes from negative to positive is around 105 years.[12] Finally, we observe a positive interaction term between firm age and the statutory corporate tax rate, which is significantly positive in all regressions. This finding seems to confirm Proposition 2, indicating that the role of corporate taxation on debt financing is changing over the life-time of a firm.

Table 3 reports the marginal effects of corporate taxation for the four versions of (17) presented in Table 2. Taking the specification with the average corporate tax rate between 1999 and 2004, the marginal effect of corporate taxation evaluated at the mean of firm age is around 0.73 ($\approx 0.558 + 0.011 \cdot$

[12] Taking the first derivative of (17) with regard to age and setting this expression equal to zero we obtain $\frac{\partial b}{\partial A} = \widehat{\beta}_2 + 2\widehat{\beta}_3 A + \widehat{\beta}_4 \tau = 0$. At the mean value of $\tau$ (0.326 in the sample), we have a minimum for $A$ at $\tilde{A} = (\widehat{\beta}_2 - 0.326\widehat{\beta}_4)/2\widehat{\beta}_3 = 105.44$.

Table 3: Marginal effect of corporate tax rate $\tau$

| | Firm age | SCTR in the year(s) | | | |
|---|---|---|---|---|---|
| | (99-04) | 1999 | 2002 | 2004 | 99-04 |
| Mean | 16.59 | 0.607 | 0.639 | 0.660 | 0.734 |
| Median | 13 | 0.578 | 0.612 | 0.640 | 0.696 |
| Lower 25 percent quartile | 8 | 0.539 | 0.575 | 0.612 | 0.643 |
| Upper 75 percent quartile | 20 | 0.633 | 0.664 | 0.679 | 0.770 |
| Lower 1 percent percentile | 2 | 0.492 | 0.531 | 0.578 | 0.579 |
| Upper 1 percent percentile | 81 | 1.119 | 1.117 | 1.019 | 1.418 |

**Notes:** Marginal effects are calculated from the parameter estimates of Table 2 using $\frac{\partial b}{\partial \tau} = \widehat{\beta_1} + \widehat{\beta_4} A$.

16.59), and about 0.7 for a firm with median age. Considering the whole distribution of firm age, we can see that the marginal effects are within a range of 0.5 and 0.7 (except values above 1 for firms above the upper 1 percent percentile range). Accordingly, a change in the statutory corporate tax rate of 10 percentage points is associated with an increase in the debt ratio by about 5 to 7 percentage points. Although our empirical model is not directly comparable to previous research, this marginal effect seems broadly in line with the evidence presented there. For instance, Gordon and Lee (2001), focusing on a panel of U.S. firms to analyze the differential impact of taxation on debt financing of small and large firms, find a slightly lower marginal effect of about 0.35. In a similar study, Gordon and Lee (2007) estimate a marginal effect of corporate taxation of 0.47.[13]

**Robustness:** We analyze the sensitivity of our results (i) by using different definitions of the debt ratio, (ii) by focusing on alternative tax rate concepts, and (iii) by restricting our sample in various ways (e.g., by excluding highly leveraged firms). In all robustness checks, we refer to the specification with the average corporate tax rate between 1999 and 2004 as reported in the last column of Table 2. The results of the sensitivity analysis are depicted in Table 4. For the sake of brevity, we only report the variables of interest ($\tau$, $A$, $A^2$ and $\tau \cdot A$) along with the sample size and the $R^2$.

In the first set of robustness experiments, we use alternative definitions of the debt ratio based on three sub-components of total liabilities, i.e., (i) short-term liabilities, (ii) total liabilities excluding trade accounts, and (iii) long-

[13] Huizinga, Laeven and Nicodéme (2008), focusing on international debt shifting of multinational firms using the (small) AMADEUS database (around 18,000 firms), estimate a marginal effect of domestic corporate taxation of about 0.25.

Table 4: Robustness

| | $\tau$ | $A$ | $A^2$ | $\tau$·A | Obs. | $R^2$ |
|---|---|---|---|---|---|---|
| **(i) Definition of the debt ratio** | | | | | | |
| Total debt ratio (basic regression from Table 2) | 0.628 *** | −0.872 *** | 0.003 *** | 0.010 *** | 390,546 | 0.442 |
| | (0.014) | (0.028) | (0.0002) | (0.001) | | |
| Short-term debt ratio | 0.213 *** | −0.546 *** | 0.002 *** | 0.004 *** | 390,546 | 0.351 |
| | (0.013) | (0.025) | (0.0002) | (0.001) | | |
| Total debt ratio excluding trade credits | 0.915 *** | −0.629 *** | 0.002 *** | 0.006 *** | 390,546 | 0.372 |
| | (0.014) | (0.025) | (0.0002) | (0.001) | | |
| Long-term debt ratio | 0.432 *** | −0.177 *** | 0.0003 ** | 0.003 *** | 390,546 | 0.193 |
| | (0.001) | (0.025) | (0.0001) | (0.001) | | |
| **(ii) Marginal tax rates as proposed by Graham (1996)** | | | | | | |
| MCTR1 | 0.174 *** | −0.525 *** | 0.002 *** | 0.0008 *** | 405,373 | 0.428 |
| | (0.005) | (0.016) | (0.0002) | (0.0002) | | |
| MCTR2 | 0.256 *** | −0.540 *** | 0.002 *** | 0.001 *** | 405,373 | 0.431 |
| | (0.007) | (0.016) | (0.0002) | (0.0003) | | |
| MCTR3 | 0.322 *** | −0.527 *** | 0.002 *** | 0.0009 *** | 405,373 | 0.431 |
| | (0.007) | (0.015) | (0.0002) | (0.0003) | | |
| MCTR4 | 0.307 *** | −0.550 *** | 0.002 *** | 0.002 *** | 405,373 | 0.432 |
| | (0.008) | (0.016) | (0.0002) | (0.0004) | | |
| MCTR5 | 0.286 *** | −0.516 *** | 0.002 *** | −0.0007 *** | 405,373 | 0.432 |
| | (0.006) | (0.016) | (0.0002) | (0.0002) | | |
| MCTR5[a)] | 0.555 *** | −1.120 *** | 0.003 *** | 0.014 *** | 316,782 | 0.294 |
| | (0.015) | (0.033) | (0.0002) | (0.001) | | |
| **(iii) Sample restrictions** | | | | | | |
| Firms with $b \leq 100$ percent | 0.653 *** | −1.049 *** | 0.003 *** | 0.012 *** | 361,584 | 0.176 |
| | (0.014) | (0.030) | (0.0003) | (0.001) | | |
| Firms with $A \leq 150$ | 0.551 *** | −1.189 *** | 0.006 *** | 0.013 *** | 405,132 | 0.441 |
| | (0.012) | (0.018) | (0.0001) | (0.001) | | |
| Firms with $A \leq 50$ | 0.435 *** | −1.750 *** | 0.010 *** | 0.023 *** | 391,361 | 0.441 |
| | (0.014) | (0.028) | (0.0003) | (0.001) | | |
| Countries with more than 500 firms | 0.555 *** | −0.912 *** | 0.003 *** | 0.011 *** | 405,114 | 0.438 |
| | (0.013) | (0.027) | (0.0002) | (0.001) | | |
| NACE 2-digit industries with more than 5,000 firms | 0.562 *** | −0.905 *** | 0.003 *** | 0.011 *** | 397,128 | 0.439 |
| | (0.013) | (0.027) | (0.0002) | (0.001) | | |

**Notes:** White (1980) robust standard errors in parentheses. ***Significant at 1%, **Significant at 5%, *Significant at 10%.
[a)] Sample restricted to observations with positive EBIT.
MCTR1: $\tau = 0$ if EBIT $\leq 0$ in 2 or more years, $\tau =$ SCTR otherwise.
MCTR2: $\tau = 0$ if EBIT $\leq 0$ in 3 or more years, $\tau =$ SCTR otherwise.
MCTR3: For each year separately, we set $\tau_t = 0$ if the annual EBIT $\leq 0$, otherwise $\tau_t =$ SCTR. Then, we calculate the average corporate tax rate as $\tau = \bar{\tau}_t$
MCTR4: $\tau = 0$ if EBIT $\leq 0$ in 4 or more years, $\tau = 0.5$·SCTR if EBIT $\leq 0$ in 2 or 3 years, otherwise $\tau =$ SCTR.
MCTR5: $\tau = 0$ if the sum of EBIT within the sample period is $\leq 0$, and $\tau =$ SCTR otherwise.

term liabilities.[14] The corresponding debt ratios are restricted to the range between zero and 200 percent; in each of the regressions we use exactly the same number of observations (i.e., 390,546 firms). To facilitate a comparison to our earlier results, we also re-estimate the baseline specification from Table 2, but now with the sample of 390,546 firms. The results of this robustness exercise are reported in Table 4. A comparison between the last column of Table 2 and the first row in Table 4 shows that the parameter estimates of the baseline specification remain fairly unchanged when focusing on a sample where all debt ratios are limited to the 0-200 percent range. Then, we rely on short-term debt, i.e., the ratio of current liabilities to total assets. Such a specification has been suggested by Rajan and Zingales (1995) and Gordon and Lee (2001). Not surprisingly (compare the relatively close correlation between the total debt ratio and the short term debt ratio in Table A.3), we conclude that the results regarding our main variables of interest are qualitatively very similar to the ones of the baseline specification. The corporate tax rate enters significantly positive (and somewhat lower than in the original model), firm age exhibits a positive but diminishing impact on debt, and the interaction term between the corporate tax rate and firm age is significantly positive.

Next, we deduct trade credits from total liabilities to re-define the numerator of the debt ratio. Trade credits are typically used by younger firms, especially to cope with short-term liquidity shortages (see Berger and Udell 1998). Again, we find that our results regarding the influence of corporate taxation and firm age on debt financing do not change substantially when relying on the remaining part of total debt. Finally, we focus on long-term debt (see, e.g., Booth, Aivazian, Demirguc-Kunt and Maksimovic 2001). Since firms might not adjust their long-term liabilities immediately on a year-to-year basis, we would expect that firm age is less of importance here. We observe a positive parameter estimate for corporate taxation but a much smaller impact of firm age as compared to the baseline specification, which seems to confirm this expectation. The interaction term between the statutory corporate tax rate and firm age is significantly positive, again.

In the second set of sensitivity analysis, we refer to an alternative definition of the tax measure by taking account of loss-carry forwards. Specifically, following Graham (1996) and Plesko (2003) we define five versions of 'marginal' tax rates (MCTR). The first one, MCTR1, is equal to zero if the EBIT within the observed time period 1999 to 2004 is negative in two or more years. Oth-

[14] In our sample, the short-term debt ratio is around 58 percent (consisting of 10 percent loans, 22 percent trade credits, and the remaining 68 percent other current liabilities), and the long-term debt ratio is around 14 percent.

erwise, MCTR1 is the same as the statutory corporate tax rate. MCTR2 has entry zero if the EBIT is lower than zero in three or more years, and equal to the statutory corporate tax rate else. To compute MCTR3 we account for the year-by-year realizations of the EBIT. In particular, we set $\tau_t$ =SCTR if the EBIT in a given year is positive, and zero else. Then, MCTR3 is calculated as the average of $\tau_t$. In MCTR4, we set the marginal corporate tax rate to equal zero if the EBIT is less than zero in four or more years of the sample period, and equal to 0.5·SCTR if the EBIT is negative in two or three years. Otherwise, MCTR4 is equal to the SCTR (this variant has been proposed by Graham 1996). Finally, we define MCTR5 as equal to zero if the sum of the EBIT over the whole period is negative, and equal to the statutory corporate tax rate else.

In all variants of MCTR, our sample includes exactly the same observations as in Table 2 (i.e., 405,373 firms). Therefore, the estimation results can be directly compared to the ones in the last column of Table 2. We find that the parameter estimates are not strongly varying among the five variants of MCTR. This is not surprising given the fact that the correlations between the MCTRs are relatively high (see Table A.4). Compared to the baseline specification of Table 2 we now observe much lower coefficients for the corporate tax rate and the first power of age. However, this comes not really as a surprise, since we take into account potential tax-loss-carry-forwards. Considering a non-debt-tax-shield which serves as a substitute for tax-deductible interest payments, reduces the impact of corporate taxation on debt financing (see e.g. DeAngelo and Masulis 1980, Gropp 2002 for empirical evidence). Age squared still enters positively with significance levels above the conventional levels. Finally, with the exception of MCTR5 we find a significantly positive interaction term between firm age and the marginal corporate tax rate, which is in line with Proposition 2. Regarding the negative interaction term for MCTR5 one should keep in mind that our sample includes a relatively large number of firms with zero MCTR5 (about 90,000 firms). This might induce a downward bias in the interaction term. Therefore, we re-estimate this equation by only focusing on firms with non-zero marginal tax rates. Applying this sample restriction, we now observe a significantly positive interaction. In sum, the findings for these robustness experiments are qualitatively very similar to the previous ones, which let us conclude that the (joint) influence of corporate taxation and firm age on debt is obviously insensitive to the change in tax rate measures.

In the last series of sensitivity exercises, we exclude potentially influential outliers from the sample. The corresponding results are summarized in the

third block of Table 4. First, we reduce the threshold for the total debt ratio from 200 percent to 100 percent. This reduces the sample by about 44,000 observations. Obviously, the parameter estimates from Table 2 are virtually unchanged (perhaps one exception is the impact of corporate taxation, which is slightly higher now). Second, to assess whether the estimated effects of corporate taxation and firm age are affected by the firm age distribution of the sample (see Figure 3 above), we confine our analysis to firms younger than 150 years (lowering the sample by 246 firms), and, alternatively, to companies younger than 50 years (losing 14,000 firms). It turns out that this does not change the tax parameter substantially. We now observe somewhat higher parameter estimates for firm age ($A$ and $A^2$), and a more pronounced interaction term between firm age and corporate taxation, which translates into a (calculated) turning point of about 49 years (in Table 2, it was around 105 years). Further, as might be suspected by the graphical inspection of Figure 3, the estimate for the quadratic age term is much higher than in the baseline regression. This, in turn, suggests that the non-linear relationship between firm age, corporate taxation and debt is more pronounced when excluding very old firms. All in all, however, the qualitative results regarding the relationship between corporate taxation, firm age and debt are insensitive to these sample restrictions.

Finally, one might suspect that our results are driven by the country and industry coverage. For instance, it is obvious from Table 1 that the sample coverage is relatively weak for some countries (e.g., Cyprus, Malta or Switzerland). Therefore, we drop (i) countries with less than 500 firms (about 260 observations), and (ii) industries with less than 5,000 firms (about 8,000 observations). Again, we obtain almost the same parameter estimates as in the original model.

# 5 Conclusions

This paper analyzes optimal debt financing of firms under corporate taxation, which induces an incentive to increase leverage as a result of the deductibility of interest on debt. The benefits from corporate taxation are dampened by the costs of financial distress arising from increased debt levels. We argue that a firm's leverage might change over the life-cycle of a firm. For example, younger firms exhibit higher debt ratios and find it more difficult to raise external financing sources. This, in turn, suggests that the debt ratios are changing over a firm's life-time, and also that the impact of corporate taxation is age dependent.

We provide a simple two period model with corporate taxation and endogenous financing decisions that allows to derive empirically testable hypotheses regarding the relationship between corporate taxation, firm age and debt financing. We test these hypotheses in a cross section of 405,000 firms from 35 European countries and 126 NACE 3-digit industries. Our empirical findings can be summarized as follows. First, and in line with previous research, we find a positive impact of corporate taxation on a firm's debt ratio, suggesting that the corporate tax system provides an incentive for higher leverage. Second, firm age exerts a negative impact on debt ratios, indicating that older firms are relying less on debt than younger ones. Finally, we observe a significantly positive interaction effect between corporate taxation and firm size. This result implies that the debt ratio of younger firms is much less affected by a cut in corporate tax rates than that of older firms. This, together with a significantly negative coefficient of a quadratic age term, lend support to the view that the effects of corporate taxation on debt financing is changing over the life-time of a firm.

## References


Altman, E. 1968, 'Financial ratios, descriminant analysis, and the prediction of corporate bankruptcy', *Journal of Finance* **23**, 589–609.

Alworth, J. S. and Arachi, G. 2001, 'The effect of taxes on corporate financing decisions: Evidence from a panel of Italien firms', *International Tax and Public Finance* **8**, 353–376.

Beck, T. and Demirguc-Kunt, A. 2006, 'Small and medium-size enterprises: Access to finance as a growth constraint', *Journal of Banking and Finance* **30**, 2931–2943.

Beck, T., Demirguc-Kunt, A. and Maksimovic, V. 2004, 'Financing patterns around the world: Are small firms different?', *World Bank - Working Paper* .

Berger, A. N. and Udell, G. F. 1998, 'The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle', *Journal of Banking and Finance* **22**, 613–673.

Bernanke, B. S., Gertler, M. and Gilchrist, S. 1999, The financial accelerator in a quantitative business cycle framework, *in* J. Taylor and M. Woodford, eds, 'Handbook of Macroeconomics', Vol. 1, Elsevier Science B.V.

Booth, L., Aivazian, V., Demirguc-Kunt, A. and Maksimovic, V. 2001, 'Capital structures in developing countries', *Journal of Finance* **56**, 87–130.

DeAngelo, H. and Masulis, R. W. 1980, 'Optimal capital structure under corporate and personal taxation', *Journal of Financial Economics* **8**, 3–29.

Diamond, D. W. 1991, 'Monitoring and reputation: The choice between bank loans and directly placed debt', *Journal of Political Economy* **99**, 689–721.

Fama, E. F. and French, K. R. 2002, 'Testing trade-off and pecking order predicitions about dividends and debt', *Review of Financial Studies* **15**, 1–33.

Fazzari, S. M., Hubbard, R. G. and Petersen, B. C. 1988, 'Financing constraints and corporate investment', *Brookings Papers on Economic Activity* **1**, 141–206.

Fuest, C., Huber, B. and Nielsen, S. B. 2002, 'Why is the corporate tax rate lower than the personal tax rate? The role of new firms', *Journal of Public Economics* **87**, 157–174.

Gordon, R. H. and Lee, Y. 2001, 'Do taxes affect corporate debt policy? Evidence from U.S. corporate tax return data', *Journal of Public Economics* **82**, 195–224.

Gordon, R. H. and Lee, Y. 2007, 'Interest rates, taxes and corporate financial policies', *National Tax Journal* **60**, 65–84.

Graham, J. R. 1996, 'Proxies for the marginal tax rate', *Journal of Financial Economics* **42**, 187–221.

Graham, J. R. 1999, 'Do personal taxes affect corporate financing decisions?', *Journal of Public Economics* **73**, 147–185.

Graham, J. R. 2003, 'Taxes and corporate finance: A review', *The Review of Financial Studies* **16**, 1075–1129.

Gropp, R. E. 2002, 'Local taxes and capital structure choice', *International Tax and Public Finance* **9**, 51–71.

Huizinga, H., Laeven, L. and Nicodéme, G. 2008, 'Capital structure and international debt shifting', *Journal of Financial Economics* **88**, 80–118.

Jensen, M. C. 1986, 'Agency costs of free cash flow, corporate finance, and take-overs', *American Economic Review* **76**, 323–329.

Keuschnigg, C. 2005, *Öffentliche Finanzen: Einnahmenpolitik*, Mohr Siebeck: Tübingen.

Keuschnigg, C. and Nielsen, S. B. 2002, 'Tax policy, venture capital, and entrepreneurship', *Journal of Public Economics* **87**, 175–203.

Keuschnigg, C. and Nielsen, S. B. 2004, 'Start-ups, venture capitalists, and the capital gains tax', *Journal of Public Economics* **88**, 1011–1042.

MacKie-Mason, J. K. 1990, 'Do taxes affect corporate financing decisions?', *Journal of Finance* **45**, 1471–1493.

Miller, M. H. 1977, 'Debt and taxes', *Journal of Finance* **32**, 261–275.

Modigliani, F. and Miller, M. H. 1958, 'The cost of capital, corporation finance, and the theory of investment', *American Economic Review* **48**, 261–297.

Modigliani, F. and Miller, M. H. 1963, 'Corporate income taxes and the cost of capital: A correction', *American Economic Review* **53**, 433–443.

Myers, S. C. and Majluf, N. S. 1984, 'Corporate financing and investment decisions when firms have information that investors do not have', *Journal of Financial Economics* **13**, 187–221.

Myles, G. D. 1995, *Public Economics*, Cambridge University Press: Cambridge.

Petersen, M. A. and Rajan, R. G. 1994, 'The benefits of lending relationships: Evidence from small business data', *Journal of Finance* **49**, 3–37.

Plesko, G. A. 2003, 'An evaluation of alternative measures of corporate tax rates', *Journal of Accounting and Economics* **35**, 201–226.

Poterba, J. and Summers, L. H. 1985, The economic effects of dividend taxation, *in* E. Altman and M. Subrahmanyam, eds, 'Recent Advance in Corporate Finance', Homewood, IL: Irwin.

Rajan, R. G. and Zingales, L. 1995, 'What do we know about capital structure? Some evidence from international data', *Journal of Finance* **50**, 1421–1460.

Stiglitz, J. E. and Weiss, A. 1981, 'Credit rationing in markets with imperfect information', *American Economic Review* **71**, 393–410.

White, H. 1980, 'A heteroskedastic consistent covariance matrix and a direct test for heteroskedasticity', *Econometrica* **48**, 817–838.

Table A. 1: Variable definitions

| Variable | Description |
|---|---|
| **Debt to asset ratios** | |
| Total debt ratio | Current plus non-current liabilities to total assets (in percent) |
| Short-term debt ratio | Current liabilities to total assets (in percent) |
| Total debt ratio excluding trade credits | Current plus non-current liabilities minus trade credits to total assets (in percent) |
| Long-term debt ratio | Non-current liabilities to total assets (in percent) |
| **Statutory corporate tax rates** | |
| SCTR 1999 | Statutory corporate tax rate in 1999 (in percent) |
| SCTR 2002 | Statutory corporate tax rate in 2002 (in percent) |
| SCTR 2004 | Statutory corporate tax rate in 2004 (in percent) |
| SCTR 1999-2004 | Statutory corporate tax rate, average between 1999 and 2004 (in percent) |
| **Marginal corporate tax rates** | |
| MCTR1 | $\tau = 0$ if EBIT $\leq 0$ in 2 or more years, $\tau =$ SCTR otherwise (in percent) |
| MCTR2 | $\tau = 0$ if EBIT $\leq 0$ in 3 or more years, $\tau =$ SCTR otherwise (in percent) |
| MCTR3 | For each year separately, we set $\tau_t = 0$ if the annual EBIT $\leq 0$, otherwise $\tau_t =$ SCTR<br>Then, we calculate the average corporate tax rate as $\tau = \bar{\tau}_t$ (in percent) |
| MCTR4 | $\tau = 0$ if EBIT $\leq 0$ in 4 or more years, $\tau = 0.5 \cdot$SCTR if EBIT $\leq 0$ in 2 or 3 years,<br>otherwise $\tau =$ SCTR (in percent) |
| MCTR5 | $\tau = 0$ if the sum of EBIT within the sample period is $\leq 0$,<br>and $\tau =$ SCTR otherwise (in percent) |
| **Independent variables** | |
| Firm age | 2006 minus year of incorporation |
| Firm size | Logarithm of sales |
| Asset tangibility | Fixed assets + other fixed assets to total assets (in percent) |
| Return on assets (ROA) | Earnings before interest and taxes (EBIT) to total assets (in percent) |
| Net operating losses (NOL) | Dummy with entry 1 if average profit and loss per period $< 0$, zero else |
| Negative shareholders funds (NSF) | Dummy with entry 1 if average shareholder funds $\leq 0$, zero else |
| $Z$-score | (3.3·earnings before interest and taxes + 1.0·operating revenue +<br>1.4·shareholder funds + 1.2·working capital)/total assets |

Table A. 2: Descriptive statistics

| Variable | Mean | Std. Dev. | Min | Max | Obs.[a)] |
|---|---|---|---|---|---|
| **Debt to asset ratios** | | | | | |
| Debt ratio | 71.89 | 31.20 | 0.00 | 200.00 | 515,741 |
| Short-term debt ratio | 57.60 | 30.59 | 0.00 | 200.00 | 515,741 |
| Total debt ratio excluding trade credits | 60.73 | 33.18 | 0.00 | 200.00 | 515,741 |
| Long-term debt ratio | 14.30 | 19.75 | 0.00 | 200.00 | 515,741 |
| **Statutory corporate tax rates** | | | | | |
| SCTR 1999 | 35.07 | 5.94 | 10.00 | 50.08 | 515,203 |
| SCTR 2002 | 31.94 | 5.64 | 10.00 | 40.30 | 515,741 |
| SCTR 2004 | 31.13 | 5.34 | 12.50 | 37.30 | 515,741 |
| SCTR 1999-2004 | 32.52 | 5.25 | 10.83 | 41.17 | 515,741 |
| **Marginal corporate tax rates** | | | | | |
| MCTR1 | 27.85 | 12.59 | 0.00 | 41.17 | 515,741 |
| MCTR2 | 30.09 | 10.12 | 0.00 | 41.17 | 515,741 |
| MCTR3 | 27.17 | 9.04 | 0.00 | 41.17 | 515,741 |
| MCTR4 | 29.61 | 9.29 | 0.00 | 41.17 | 515,741 |
| MCTR5 | 26.15 | 13.85 | 0.00 | 41.17 | 515,741 |
| **Independent variables** | | | | | |
| Firm age (in years) | 16.91 | 16.06 | 0.00 | 1,018.00 | 515,741 |
| Firm age$^2$ | 543.92 | 2,608.21 | 0.00 | $1.036 \cdot 10^6$ | 515,741 |
| Asset tangibility | 33.64 | 24.24 | 0.00 | 100.00 | 498,187 |
| Firm size (log of sales) | 6.35 | 2.16 | -1.79 | 18.82 | 422,337 |
| Return on assets (ROA) | 7.24 | 53.98 | -15,983.44 | 13,800.86 | 443,198 |
| NOL-dummy | 0.23 | 0.42 | 0.00 | 1.00 | 515,741 |
| NSF-dummy | 0.13 | 0.33 | 0.00 | 1.00 | 515,741 |
| $Z$-score | 2.82 | 23.50 | -1,100.70 | 12,993.81 | 421,903 |
| **Variables used for calculation** | | | | | |
| Operating revenue (in tsd. EUR) | 10,533.24 | 378,685.40 | 0.17 | $150 \cdot 10^6$ | 422,337 |
| Number of employees | 72.10 | 1,877.02 | 1.00 | 757,846.50 | 368,750 |
| Total assets (in tsd. EUR) | 8,556.36 | 387,896.90 | 0.17 | $188 \cdot 10^6$ | 515,741 |
| Fixed assets (in tsd. EUR) | 3,829.59 | 168,037.10 | -2,029.00 | $79 \cdot 10^6$ | 515,727 |
| Other fixed assets (in tsd. EUR) | 1,337.08 | 63,871.77 | $-1.018 \cdot 10^6$ | $19.7 \cdot 10^6$ | 506,368 |
| EBIT (in tsd. EUR) | 490.86 | 20,822.26 | $-1.127 \cdot 10^6$ | $8.004 \cdot 10^6$ | 443,198 |
| Profit/loss per period (in tsd. EUR) | 326.47 | 20,510.27 | $-1.639 \cdot 10^6$ | $7.758 \cdot 10^6$ | 443,693 |

**Notes:** [a)] Number of firms (in 35 countries and 126 NACE 3-digit industries).

Table A. 3: Correlation matrix

| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | Debt ratio | 1.000 | | | | | | | | | | | | |
| (2) | Short term debt ratio | 0.767 | 1.000 | | | | | | | | | | | |
| (3) | Total debt ratio excl. trade credits | 0.170 | 0.116 | 1.000 | | | | | | | | | | |
| (4) | Long term debt ratio | 0.339 | −0.343 | 0.080 | 1.000 | | | | | | | | | |
| (5) | Firm age | −0.214 | −0.185 | −0.043 | −0.044 | 1.000 | | | | | | | | |
| (6) | Firm age$^2$ | −0.119 | −0.106 | −0.020 | −0.024 | 0.832 | 1.000 | | | | | | | |
| (7) | Asset tangibility | −0.020 | −0.265 | 0.360 | 0.018 | 0.007 | 0.021 | 1.000 | | | | | | |
| (8) | Firm size (log of sales) | −0.135 | −0.151 | 0.023 | −0.051 | 0.382 | 0.228 | 0.034 | 1.000 | | | | | |
| (9) | Return on assets (ROA) | −0.272 | −0.176 | −0.141 | −0.042 | −0.044 | −0.024 | −0.100 | 0.003 | 1.000 | | | | |
| (10) | NOL dummy | 0.338 | 0.237 | 0.148 | 0.057 | −0.007 | 0.012 | 0.093 | −0.099 | −0.404 | 1.000 | | | |
| (11) | NSF dummy | 0.595 | 0.481 | 0.167 | 0.110 | −0.139 | −0.062 | −0.004 | −0.259 | −0.223 | 0.366 | 1.000 | | |
| (12) | $Z$-score | −0.085 | −0.004 | −0.119 | 0.366 | −0.025 | −0.013 | −0.136 | 0.008 | 0.362 | −0.141 | −0.062 | 1.000 | |
| (13) | SCTR 99-04 | 0.082 | 0.026 | 0.082 | 0.018 | 0.133 | 0.044 | −0.083 | 0.268 | −0.097 | 0.013 | −0.089 | −0.073 | 1.000 |

Table A. 4: Correlations in tax rates

| | | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|
| (1) | SCTR 99-04 | 1.000 | | | | | |
| (2) | MCTR1 | 0.429 | 1.000 | | | | |
| (3) | MCTR2 | 0.535 | 0.740 | 1.000 | | | |
| (4) | MCTR3 | 0.569 | 0.855 | 0.803 | 1.000 | | |
| (5) | MCTR4 | 0.579 | 0.939 | 0.837 | 0.901 | 1.000 | |
| (6) | MCTR5 | 0.347 | 0.606 | 0.546 | 0.688 | 0.615 | 1.000 |

Table A. 5: Manufacturing firms according to NACE classification

| 2-digit | 3-digit | Name | Obs. |
|---|---|---|---|
| 15 | 150 | Manufacture of food products and beverages | 189 |
| | 151 | Production, processing and preserving of meat and meat products | 10,745 |
| | 152 | Processing and preserving of fish and fish products | 2,454 |
| | 153 | Processing and preserving of fruit and vegetables | 3,313 |
| | 154 | Vegetable and animal oils and fats | 1,401 |
| | 155 | Dairy products | 3,835 |
| | 156 | Grain mill products, starches and starch products | 3,162 |
| | 157 | Prepared animal feeds | 2,205 |
| | 158 | Other food products | 31,327 |
| | 159 | Beverages | 6,973 |
| 16 | 160 | Tobacco products | 269 |
| 17 | 170 | Textiles | 93 |
| | 171 | Preparation and spinning of textile fibres | 2,155 |
| | 172 | Textile weaving | 2,367 |
| | 173 | Finishing of textiles | 2,173 |
| | 174 | Made-up textile articles, except apparel | 4,630 |
| | 175 | Other textiles | 4,064 |
| | 176 | Knitted and crocheted fabrics | 1,047 |
| | 177 | Knitted and crocheted articles | 2,333 |
| 18 | 180 | Wearing apparel; dressing and dyeing of fur | 169 |
| | 181 | Leather clothes | 652 |
| | 182 | Other wearing apparel and accessories | 18,356 |
| | 183 | Dressing and dyeing of fur; manufacture of articles of fur | 541 |
| 19 | 190 | Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear | 19 |
| | 191 | Tanning and dressing of leather | 1,288 |
| | 192 | Luggage, handbags and the like, saddlery and harness | 2,055 |
| | 193 | Footwear | 6,219 |
| 20 | 200 | Wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | 23 |
| | 201 | Sawmilling and planing of wood, impregnation of wood | 10,610 |
| | 202 | Veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards | 1,220 |
| | 203 | Builders' carpentry and joinery | 11,654 |
| | 204 | Wooden containers | 2,257 |
| | 205 | Other products of wood; manufacture of articles of cork, straw and plaiting materials | 6,070 |
| 21 | 210 | Pulp, paper and paper products | 31 |
| | 211 | Pulp, paper and paperboard | 1,350 |
| | 212 | Articles of paper and paperboard | 6,638 |
| 22 | 220 | Publishing, printing and reproduction of recorded media | 113 |
| | 221 | Publishing | 25,682 |
| | 222 | Printing and service activities related to printing | 34,597 |
| | 223 | Reproduction of recorded media | 1,281 |
| 23 | 230 | Coke, refined petroleum products and nuclear fuel | 11 |
| | 231 | Coke oven products | 48 |
| | 232 | Refined petroleum products | 701 |
| | 233 | Processing of nuclear fuel | 40 |
| 24 | 240 | Chemicals and chemical products | 132 |
| | 241 | Basic chemicals | 4,405 |
| | 242 | Pesticides and other agro-chemical products | 350 |
| | 243 | Paints, varnishes and similar coatings, printing ink and mastics | 2,352 |
| | 244 | Pharmaceuticals, medicinal chemicals and botanical products | 2,638 |
| | 245 | Soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations | 3,161 |
| | 246 | Other chemical products | 3,390 |
| | 247 | Man-made fibres | 251 |
| 25 | 250 | Rubber and plastic products | 39 |
| | 251 | Rubber products | 3,005 |
| | 252 | Plastic products | 17,978 |
| 26 | 260 | Other non-metallic mineral products | 68 |
| | 261 | Glass and glass products | 3,863 |
| | 262 | Non-refractory ceramic goods other than for construction purposes; manufacture of refractory ceramic products | 2,388 |
| | 263 | Ceramic tiles and flags | 751 |
| | 264 | Bricks, tiles and construction products, in baked clay | 1,443 |
| | 265 | Cement, lime and plaster | 748 |
| | 266 | Articles of concrete, plaster or cement | 7,879 |
| | 267 | Cutting, shaping and finishing of ornamental and building stone | 5,630 |
| | 268 | Other non-metallic mineral products | 1,401 |
| 27 | 270 | Basic metals | 56 |
| | 271 | Basic iron and steel and of ferro-alloys (ECSC) | 2,250 |
| | 272 | Tubes | 772 |
| | 273 | Other first processing of iron and steel and production of non-ESCS ferro-alloys | 784 |
| | 274 | Basic precious and non-ferrous metals | 1,947 |
| | 275 | Casting of metals | 2,393 |
| 28 | 280 | Fabricated metal products, except machinery and equipment | 153 |
| | 281 | Structural metal products | 27,572 |
| | 282 | Tanks, reservoirs and containers of metal; manufacture of central heating radiators and boilers | 2,203 |

Table A. 5: cont.

| 2-digit | 3-digit | Name | Obs. | 2-digit | 3-digit | Name | Obs. |
|---|---|---|---|---|---|---|---|
| | 283 | Steam generators, except central heating hot water boilers | 2,900 | 33 | 330 | Medical, precision and optical instruments, watches and clocks | 107 |
| | 284 | Forging, pressing, stamping and roll forming of metal; powder metallurgy | 3,664 | | 331 | Medical and surgical equipment and orthopaedic appliances | 7,148 |
| | 285 | Treatment and coating of metals; general mechanical engineering | 29,938 | | 332 | Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment | 5,012 |
| | 286 | Cutlery, tools and general hardware | 6,135 | | 333 | Industrial process control equipment | 2,310 |
| | 287 | Other fabricated metal products | 15,869 | | 334 | Optical instruments and photographic equipment | 1,433 |
| 29 | 290 | Machinery and equipment n.e.c | 596 | | 335 | Watches and clocks | 345 |
| | 291 | Other general purpose machinery | 5,324 | 34 | 340 | Motor vehicles, trailers and semi-trailers | 153 |
| | 292 | Agricultural and forestry machinery | 14,729 | | 341 | Motor vehicles | 1,059 |
| | 293 | Machine-tools | 4,091 | | 342 | Bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers | 2,955 |
| | 294 | Other special purpose machinery | 4,126 | | | | |
| | 295 | Weapons and ammunition | 12,202 | | 343 | Parts and accessories for motor vehicles and their engines | 3,319 |
| | 296 | Domestic appliances n.e.c | 327 | 35 | 350 | Other transport equipment | 20 |
| | 297 | Office machinery and computers | 1,435 | | 351 | Building and repairing of ships and boats | 5,649 |
| 30 | 300 | Office machinery and computers | 3,908 | | 352 | Railway and tramway locomotives and rolling stock | 765 |
| 31 | 310 | Electrical machinery and apparatus n.e.c | 255 | | 353 | Aircraft and spacecraft | 1,100 |
| | 311 | Electric motors, generators and transformers | 2,846 | | 354 | Motorcycles and bicycles | 625 |
| | 312 | Electricity distribution and control apparatus | 2,652 | | 355 | Other transport equipment n.e.c | 476 |
| | 313 | Insulated wire and cable | 986 | 36 | 360 | Furniture; manufacturing n.e.c | 162 |
| | 314 | Accumulators, primary cells and primary batteries | 258 | | 361 | Furniture | 23,619 |
| | 315 | Lighting equipment and electric lamps | 2,486 | | 362 | Jewellery and related articles | 3,890 |
| | 316 | Other electrical equipment n.e.c | 7,169 | | 363 | Musical instruments | 570 |
| 32 | 320 | Radio, television and communication equipment | 13 | | 364 | Sports goods | 1,096 |
| | 321 | Electronic valves and tubes and other electronic components | 3,369 | | 365 | Games and toys | 1,241 |
| | | | | | 366 | Other manufacturing n.e.c | 11,938 |
| | 322 | Television and radio transmitters and apparatus for line telephony and line telegraphy | 2,085 | 37 | 370 | Recycling | 65 |
| | | | | | 371 | Recycling of metal waste and scrap | 3,373 |
| | 323 | Television and radio receivers, sound or video recording or reproducing apparatus and associated goods | 1,356 | | 372 | Recycling of non-metal waste and scrap | 2,946 |

**University of Innsbruck – Working Papers in Economics and Statistics**
Recent papers

2008-09 **Michael Pfaffermayr, Matthias Stöckl and Hannes Winner:** Capital Structure, Corporate Taxation and Firm Age

2008-08 **Jesus Crespo Cuaresma and Andreas Breitenfellner:** Crude Oil Prices and the Euro-Dollar Exchange Rate: A Forecasting Exercise

2008-07 **Matthias Sutter, Stefan Haigner and Martin Kocher:** Choosing the carrot or the stick? – Endogenous institutional choice in social dilemma situations.

2008-06 **Paul A. Raschky and Manijeh Schwindt:** Aid, Catastrophes and the Samaritan's Dilemma.

2008-05 **Marcela Ibanez, Simon Czermak and Matthias Sutter:** Searching for a better deal – On the influence of group decision making, time pressure and gender in a search experiment.

2008-04 **Martin G. Kocher, Ganna Pogrebna and Matthias Sutter:** The Determinants of Managerial Decisions Under Risk.

2008-03 **Jesus Crespo Cuaresma and Tomas Slacik:** On the determinants of currency crises: The role of model uncertainty.

2008-02 **Francesco Feri:** Information, Social Mobility and the Demand for Redistribution.

2008-01 **Gerlinde Fellner and Matthias Sutter:** Causes, consequences, and cures of myopic loss aversion - An experimental investigation. *Revised version forthcoming in Economic Journal.*

---

2007-31 **Andreas Exenberger and Simon Hartmann:** The Dark Side of Globalization. The Vicious Cycle of Exploitation from World Market Integration: Lesson from the Congo.

2007-30 **Andrea M. Leiter and Gerald J. Pruckner:** Proportionality of willingness to pay to small changes in risk - The impact of attitudinal factors in scope tests.

2007-29 **Paul Raschky and Hannelore Weck-Hannemann:** Who is going to save us now? Bureaucrats, Politicians and Risky Tasks.

2007-28 **Harald Oberhofer and Michael Pfaffermayr:** FDI versus Exports. Substitutes or Complements? A Three Nation Model and Empirical Evidence.

2007-27 **Peter Wechselberger, Stefan Lang and Winfried J. Steiner:** Additive models with random scaling factors: applications to modeling price response functions.

2007-26 **Matthias Sutter:** Deception through telling the truth?! Experimental evidence from individuals and teams. *Revised version accepted for publication in The Economic Journal.*

2007-25 **Andrea M. Leiter, Harald Oberhofer and Paul A. Raschky:** Productive disasters? Evidence from European firm level data.

2007-24 **Jesus Crespo Cuaresma:** Forecasting euro exchange rates: How much does model averaging help?

2007-23 **Matthias Sutter, Martin Kocher and Sabine Strauß:** Individuals and teams in UMTS-license auctions.

2007-22 **Jesus Crespo Cuaresma, Adusei Jumah and Sohbet Karbuz:** Modelling and Forecasting Oil Prices: The Role of Asymmetric Cycles.

2007-21 **Uwe Dulleck and Rudolf Kerschbamer:** Experts vs. discounters: Consumer free riding and experts withholding advice in markets for credence goods. *Revised version forthcoming in "International Journal of Industrial Organization".*

2007-20 **Christiane Schwieren and Matthias Sutter:** Trust in cooperation or ability? An experimental study on gender differences*. Revised version published in Economics Letters 99 (2008): 494-497.*

2007-19 **Matthias Sutter and Christina Strassmair:** Communication, cooperation and collusion in team tournaments – An experimental study. *Revised version forthcoming in: Games and Economic Behavior.*

2007-18 **Michael Hanke, Jürgen Huber, Michael Kirchler and Matthias Sutter:** The economic consequences of a Tobin-tax – An experimental analysis.

2007-17 **Michael Pfaffermayr:** Conditional beta- and sigma-convergence in space: A maximum likelihood approach.

2007-16 **Anita Gantner:** Bargaining, search, and outside options. *Published in: Games and Economic Behavior, Vol. 62 (2008), pp. 417-435.*

2007-15 **Sergio Currarini and Francesco Feri:** Bilateral information sharing in oligopoly.

2007-14 **Francesco Feri:** Network formation with endogenous decay.

2007-13 **James B. Davies, Martin Kocher and Matthias Sutter:** Economics research in Canada: A long-run assessment of journal publications. *Revised version published in: Canadian Journal of Economics, Vol. 41 (2008), 22-45.*

2007-12 **Wolfgang Luhan, Martin Kocher and Matthias Sutter:** Group polarization in the team dictator game reconsidered. *Revised version forthcoming in: Experimental Economics.*

2007-11 **Onno Hoffmeister and Reimund Schwarze:** The winding road to industrial safety. Evidence on the effects of environmental liability on accident prevention in Germany.

2007-10 **Jesus Crespo Cuaresma and Tomas Slacik:** An “almost-too-late” warning mechanism for currency crises.

2007-09 **Jesus Crespo Cuaresma, Neil Foster and Johann Scharler:** Barriers to technology adoption, international R&D spillovers and growth.

2007-08 **Andreas Brezger and Stefan Lang:** Simultaneous probability statements for Bayesian P-splines.

2007-07 **Georg Meran and Reimund Schwarze:** Can minimum prices assure the quality of professional services?.

2007-06 **Michal Brzoza-Brzezina and Jesus Crespo Cuaresma:** Mr. Wicksell and the global economy: What drives real interest rates?.

2007-05 **Paul Raschky:** Estimating the effects of risk transfer mechanisms against floods in Europe and U.S.A.: A dynamic panel approach.

2007-04 **Paul Raschky and Hannelore Weck-Hannemann:** Charity hazard - A real hazard to natural disaster insurance. *Revised version forthcoming in: Environmental Hazards.*

2007-03 **Paul Raschky:** The overprotective parent - Bureaucratic agencies and natural hazard management.

2007-02 **Martin Kocher, Todd Cherry, Stephan Kroll, Robert J. Netzer and Matthias Sutter:** Conditional cooperation on three continents.

2007-01 **Martin Kocher, Matthias Sutter and Florian Wakolbinger:** The impact of naïve advice and observational learning in beauty-contest games.

**University of Innsbruck**

**Working Papers in Economics and Statistics**

2008-09

Michael Pfaffermayr, Matthias Stöckl and Hannes Winner

Capital Structure, Corporate Taxation and Firm Age

## Abstract

This paper analyzes the relationship between capital structure, corporate taxation and firm age. We adapt a standard model of optimal capital structure choice under corporate taxation, focusing on the financing and investment decisions a young firm is typically faced with. Our model allows to derive testable hypotheses about the relationship between corporate taxation, a firm's age and its debt to asset ratio. To test these hypotheses empirically, we use a cross-section of 405,000 firms from 35 European countries and 126 NACE 3-digit industries. In line with previous research, we find that a firm's debt ratio increases with the corporate tax rate. Further, we observe that older firms exhibit smaller debt ratios than their younger counterparts. Finally, consistent with our theoretical expectation, we find a positive interaction effect between corporate taxation and firm age, indicating that the impact of corporate taxation on debt is increasing over a firm's life-time.

ISSN 1993-4378 (Print)
ISSN 1993-6885 (Online)