Pfaffermayr, Michael; Stöckl, Matthias; Winner, Hannes

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Capital structure, corporate taxation and firm age


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CAPITAL STRUCTURE, CORPORATE TAXATION AND FIRM AGE

MICHAEL PFAFFERMAYR, MATTHIAS STÖCKL AND HANNES WINNER
WORKING PAPER NO. 2009-04
Capital Structure, Corporate Taxation and Firm Age

Michael Pfaffermayr∗, Matthias Stöckl† and Hannes Winner‡

November 2009

Abstract

This paper analyzes the relationship between corporate taxation, firm age and debt. We adapt a standard model of capital structure choice under corporate taxation, focusing on the financing and investment decisions a firm is typically faced with. Our model suggests that the debt ratio is positively associated with the corporate tax rate, and negatively with firm age. Further, we predict that the tax-induced advantage of debt is more important for older than for younger firms. 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 model, we find a positive interaction 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: Universitätsstrasse 15/3, A-6020 Innsbruck, Austria. E-mail: michael.pfaffermayr@uibk.ac.at

†Department of Economics and Social Sciences, University of Salzburg, Kapitelgasse 5-7, A-5010 Salzburg, Austria. E-mail: matthias.stoeckl@sbg.ac.at

‡Department of Economics and Social Sciences, University of Salzburg, Kapitelgasse 5-7, A-5010 Salzburg, Austria. E-mail: hannes.winner@sbg.ac.at
1 Introduction

Since the seminal work of Modigliani and Miller (1958, 1963) and Miller (1977) a vast number of contributions deals with the optimal financing structure of firms under corporate income taxation (see Graham 2003, for a comprehensive survey). According to this research, 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 are independent of 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, Demirgüç-Kunt and Maksimovic 2008, 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 Demirgüç-Kunt 2006).

Therefore, younger firms typically rely more on debt than older ones (see, Berger and Udell 1998, Gordon and Lee 2001 and Hyytinen and Pajarinen 2007 for empirical evidence). Further, profitable mature firms tend to have more internal funds available from retained earnings. They reduce their reliance on debt, although the costs of external debt financing might decrease with the maturity of a firm. For example, 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. To our knowledge, 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 three-period model of opti-
mal capital structure choice under corporate taxation. The model analyzes the change in the financial structure between these 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 older firms rely less on debt than their younger counterparts. Further, we show that the (positive) impact of corporate taxation on debt reliance 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 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 suggested in the literature (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 three period model (see Auerbach 1979, Poterba and Summers 1985, for a related two-period framework). Investors are assumed to be risk-neutral. They invest in a firm or, alternatively, in a risk-less asset earning a given market interest rate \( r \). We consider two sources of financing, debt and retained earnings. Financing via external equity (i.e., new share issues) is ruled out for simplicity. Capital, \( K_t \), is the only factor of production so that output is given by \( \pi(K_t) \), with the usual assumptions \( \pi'(K_t) > 0, \pi''(K_t) < 0 \). Furthermore, we normalize the output
price to 1. For the sake of brevity and without loss of generality, we ignore economic depreciation and also depreciation for tax purposes. Hence, the current capital stock is equivalent to the sum of past and current investment. Further, we do not consider personal income taxation at the shareholder level.

The timing of investment is as follows: At the end of the founding period 0, the firm invests \( I_0 \) using initial equity \( E_0 \) and/or debt \( B_0 \). Period 1 investment, \( I_1 \), is financed by new debt, \( B_1 - B_0 \), and/or retained earnings. At the end of period 2, the firm is liquidated, outstanding debt is repaid and the remaining assets are paid out to the shareholders.

Let \( b_t = \frac{B_t}{K_t} \) be the debt ratio in period \( t = 0, 1 \), where \( b_t \) is strictly bounded between zero and one. After-tax dividends in period 0, 1 and 2 are given by

\[
\begin{align*}
D_0 &= E_0 + B_0 - I_0 = E_0 - (1 - b_0)I_0 \quad (1) \\
D_1 &= (1 - \tau) \left[ \pi(I_0) - m(b_0)b_0I_0 \right] + b_1 (I_0 + I_1) - b_0 I_0 - I_1 \\
D_2 &= (1 - \tau) \left[ \pi(I_0 + I_1) - m(b_1)b_1(I_0 + I_1) \right] \\
&\quad + I_0 + I_1 - b_1 (I_0 + I_1),
\end{align*}
\]

where \( \tau \) denotes the statutory corporate income tax rate. \( m(b_t) \) represents the interest rate paid on debt, comprising the market interest rate \( r \) and a risk premium that increases with a firm’s debt to asset ratio \( b_t \), 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 Nicodème 2008, among others). This aspect is captured by the assumptions \( m'(b_t) > 0 \) and \( m''(b_t) \geq 0 \). We further assume that the first unit of debt has to pay the market interest rate \( r \), i.e., \( m(0) = r \). Following the previous literature, we assume \( m(b_t) = r + \frac{\gamma t}{2} b_t \) (see, e.g., Huizinga, Laeven and Nicodème 2008 for a similar assumption).

The objective of the firm is to maximize the firm value, which is given by the present value of the dividend stream. Allowing for the possibility that the firm is faced with an equity constraint in period 0 the Lagrangian is defined as

\[
\mathcal{L} = D_0 + \frac{D_1}{1 + r} + \frac{D_2}{(1 + r)^2} + \lambda D_0, \quad (2)
\]

where \( \lambda > 0 \) if \( D_0 = 0 \) and \( \lambda = 0 \) if \( D_0 > 0 \). This constraint is not binding if the initial equity endowment is sufficiently large, so that \( E_0 > I_0 - B_0 \).
Furthermore, we assume that retained earnings in period 1 and 2 are large enough to guarantee $D_1 > 0$ and $D_2 > 0$.

The corresponding first order conditions are

$$\frac{\partial L}{\partial I_0} = b_0 - 1 + \frac{(1-r)[\pi'(I_0) - m_0 b_0] + b_1 - b_0}{1+r} + \frac{(1-r)[\pi'(I_0 + I_1) - m_1 b_1] + 1 - b_1}{(1+r)^2} - \lambda (1 - b_0) = 0$$

$$(3a)$$

$$\frac{\partial L}{\partial I_1} = \frac{b_1 - 1}{1+r} + \frac{(1-r)[\pi'(I_0 + I_1) - m_1 b_1] + 1 - b_1}{(1+r)^2} = 0$$

$$(3b)$$

$$\frac{\partial L}{\partial b_0} = I_0 + \frac{(1-r)[m_0 I_0 - m_0' b_0 I_0] - I_0}{1+r} + \lambda I_0 = 0$$

$$(3c)$$

$$\frac{\partial L}{\partial b_1} = \frac{I_0 + I_1}{1+r} + \frac{(1-r)[m_1(I_0 + I_1) - m_1' b_1(I_0 + I_1)] - (I_0 + I_1)}{(1+r)^2} = 0$$

$$(3d)$$

Re-arranging yields

$$\pi'(I_0) = m_0 b_0 + \frac{r(1-b_0)}{1-r} + \gamma_0 \tilde{\lambda} (1 - b_0)$$

$$(4a)$$

$$\pi'(I_0 + I_1) = m_1 b_1 + \frac{r(1-b_1)}{1-r}$$

$$(4b)$$

$$m_0 + m_0' b_0 = \frac{r}{1-r} + \gamma_0 \tilde{\lambda}$$

$$(4c)$$

$$m_1 + m_1' b_1 = \frac{r}{1-r}$$

$$(4d)$$

with $\tilde{\lambda} = \lambda \frac{1}{\gamma_0} \frac{1+r}{1-r}$. Inserting $m_t = r + \frac{\gamma_t}{2} b_t$ in $(4c)$ and $(4d)$ simplifies the corresponding first order conditions:

$$b_0^* = \frac{\gamma_0}{2} b_1^* + \tilde{\lambda}$$

$$(5a)$$

$$b_1^* = \frac{r}{\gamma_0 (1-r)}.$$ 

$$(5b)$$

According to conditions $(4a)$ and $(4b)$ the firm invests up to the point where the marginal return on investment is equal to its marginal costs. The latter are given by a weighted average of the opportunity costs of internal funds before taxes, $\frac{r}{1-r}$, and the marginal external borrowing costs $m_t(b_t)$. The weights of both components depend on the debt ratio $b_t$. However, if the firm does not possess enough equity initially, period 0 opportunity cost of capital include the additional positive term $\tilde{\lambda}$, so that optimal investment in this period is lower than in the unconstrained case. As a benchmark, we can formulate the following result:

**Under the following conditions, the age of a firm does not affect its debt ratio (i.e., $b_0^* = b_1^*$):**

We only consider cases where $b_t$ is strictly smaller than one. This holds true if $\gamma_t$ is not too low.
(a) The firm is initially not equity constrained ($\lambda = 0$).

(b) The risk premium does not depend on firm age, i.e., $m_0(b_t) = m_1(b_t)$ or $\gamma_1 = \gamma_0$.

(c) The corporate tax rate and the interest rate are constant over time.

In this case, we have $b_0^* = b_1^* = \frac{r(1-\tau)}{\gamma_1}$ and, therefore, $\pi'(I_0) = \pi'(I_0 + I_1)$. In the absence of equity constraints and with time invariant risk premia, the firm neither adjusts its capital stock over time (i.e., $I_1 = 0$) nor does it change its debt to asset ratio ($b_0^* = b_1^*$). Both, investment and debt are initially chosen at their optimal levels. Furthermore, the firm does not have any incentive to finance investment via debt if the corporate tax rate is zero. Then, the marginal return on investment is equal to the market interest rate.

Focusing on deviations from the benchmark case provides three empirically testable hypotheses that establish the relationship between debt, corporate taxation and firm age under more realistic assumptions.

**Hypothesis 1** The debt ratio increases with the statutory corporate tax rate.

This result follows by totally differentiating the first order condition (4d) to obtain $\frac{db_1}{d\tau} = \frac{r(1-\tau)}{(1-\tau)^2} \frac{1}{2m_1' + m_1 b_1} > 0$, since $2m_1' + m_1 b_1 > 0$ by assumption. Under our specific assumption about $m_1$, we obtain $\frac{db_1}{d\tau} = \frac{r}{(1-\tau)^2} \frac{1}{\gamma_1} > 0$. In line with the previous literature, the deductibility of interest payments on debt makes debt financing more attractive (see Modigliani and Miller 1963). However, if the risk premium on debt (as expressed by $\gamma_t$) is relatively high, there is an effective limit to excessive debt financing and it pays to finance investment partly via retained earnings.

To demonstrate the effect of firm age on the debt ratio, we compare $b_1$ with $b_0$:

**Hypothesis 2** The debt ratio is lower for older firms than for younger ones if the firm is equity constrained initially and the risk premium does not decrease too much with age.

From (5) it follows

$$b_0^* > b_1^* \text{ if } \frac{\tilde{\lambda}}{\gamma_0} b_1^* + \tilde{\lambda} > 0. \quad (6)$$

Let us illustrate this result for a young firm with low initial equity (with $E_0 = 0$ at the extreme) and, therefore, with $b_0 = 1$. Since debt financing becomes relatively expensive at high debt ratios, it is optimal for an equity
constraint but profitable firm to start out small and finance additional investments via retained earnings in period 1. Then, \( b^*_1 \) is lower than \( b^*_0 \), suggesting that the debt ratio of an older firm is smaller than for a younger one. On the other hand, assume \( E_0 \) is large enough and the equity constraint is non-binding. Then \( \lambda = 0 \) and the firm chooses the initial debt ratio such that the marginal cost of debt is equal to the market interest rate net of taxes (see equation (4c)). However, given that the risk premium tends to decrease over time for successful firms, it is unlikely that the debt ratio falls as firms grow older under this scenario.

The third hypothesis is concerned with the joint impact of corporate taxation and firm age on debt.

**Hypothesis 3** *The higher the corporate tax rate, the lower the reduction in the debt to asset ratio.*

This hypothesis holds under the assumption that the firm is initially equity constrained, under given initial investment, \( I_0 \), and under \( \gamma_0 = \gamma_1 \). In this case, we have \( \lambda > 0 \), and from \( D_0 = 0 \) we obtain a fixed debt to asset ratio \( b_0 = 1 - \frac{E_0}{I_0} \). Hence, \( \frac{\partial (k_1-k_0)}{\partial \tau} = \frac{1}{\gamma} \frac{1+r}{(1-r)^2} > 0 \). The intuition behind this result is simple. Hypothesis 2 suggests that an older firm has an incentive to rely more on retained earnings and to reduce its target debt ratio. Since corporate taxation constitutes a tax shield, firms choose higher debt ratios at higher corporate tax rates (Hypothesis 1). Therefore, the reduction in debt ratios is less pronounced as corporate tax rates increase.

Empirically, the three hypotheses stated above clearly indicate that one should control for firm age in addition to the corporate tax rate in explaining the capital structure in a cross section of firms. The model predicts a positive relationship between the statutory corporate tax rate and the debt ratio (Hypothesis 1), and a negative one for firm age (i.e., older firms rely less on debt than their younger counterparts; Hypothesis 2). Hypothesis 3 motivates an empirical specification, where firm age is interacted with the corporate tax rate. We expect this interaction term to exhibit a positive sign given a negative age effect and a positive impact of corporate taxes on debt.

### 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).\(^3\) The database includes about 8 million firms be-

\(^3\)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
between 1993 and 2006 and it is available as a panel. However, its major advantage lies in the cross-section rather than the time series variation. For instance, the database exhibits substantial attrition and lots of missing observations, especially in the early years of coverage. Further, missing data are frequently inter- or extrapolated rendering the time variation of the data biased. 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 financing decisions of 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 sub-components of debt, i.e., long-term and short-term debt (e.g., Booth, Aivazian, Demirgüç-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).

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; the variable definitions are laid out in Table A.1). For all three variables together, our sample contains full information about 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

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4In 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).
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.\(^5\)

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 lie 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 fell from 35 percent in 1999 to 31 percent in 2004. Substantial 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 year of a firm’s incorporation.\(^6\) 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 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

\(^5\)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.

\(^6\)The year of incorporation is equal to the year where a firm is founded or a significant reorganization (e.g., change in legal form, acquisitions) has taken place.
Table 1: Average debt ratios, corporate tax rates and firm age per country

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<td>33.55</td>
<td>37.40</td>
<td>19.95</td>
<td>10,523</td>
</tr>
<tr>
<td>Romania</td>
<td>80.86</td>
<td>27.17</td>
<td>38.00</td>
<td>25.00</td>
<td>53,894</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>64.82</td>
<td>29.50</td>
<td>35.00</td>
<td>27.80</td>
<td>7,893</td>
</tr>
<tr>
<td>Serbia and Montenegro</td>
<td>51.77</td>
<td>18.00</td>
<td>20.00</td>
<td>14.00</td>
<td>2,646</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>61.97</td>
<td>27.83</td>
<td>40.00</td>
<td>19.00</td>
<td>1,186</td>
</tr>
<tr>
<td>Spain</td>
<td>74.78</td>
<td>35.05</td>
<td>35.00</td>
<td>13.87</td>
<td>55,471</td>
</tr>
<tr>
<td>Sweden</td>
<td>62.44</td>
<td>28.00</td>
<td>28.00</td>
<td>20.21</td>
<td>23,877</td>
</tr>
<tr>
<td>Switzerland</td>
<td>64.09</td>
<td>24.61</td>
<td>25.04</td>
<td>67.82</td>
<td>4,182</td>
</tr>
<tr>
<td>Ukraine</td>
<td>45.00</td>
<td>29.17</td>
<td>30.00</td>
<td>22.60</td>
<td>4,182</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>71.06</td>
<td>30.00</td>
<td>30.00</td>
<td>17.96</td>
<td>91,379</td>
</tr>
<tr>
<td>Average</td>
<td>71.62</td>
<td>32.34</td>
<td>34.85</td>
<td>30.97</td>
<td>16.81</td>
</tr>
</tbody>
</table>

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).
Figure 1: Average debt ratio per age cohort (stratified sample)

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. 13 firms in the sample are older than 300 years, indicating potentially influential outliers (the oldest firm is 872 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, or about 1 percent of the sample, with zero debt).

Third, and even more importantly, the sheer graphical inspection of Figure 1 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.

The single entries above 300 years are breweries, printing companies and firms from metal processing. In the basic regressions below, 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.
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 in previous research. The econometric specification reads as

\[ b_{i,jk} = \beta_1 \tau_j + \beta_2 A_i + \beta_3 A_i^2 + \beta_4 \tau_j A_i + Z_i \delta + \gamma_k + \epsilon_{i,jk}, \]  

(7)

where \( i, j, \) and \( k \) are firm-, country- and industry indices, respectively. \( b_{i,jk} \) 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 (7): The first two terms capture a possible non-linear (in- or decreasing) impact of firm age on debt (according to Figure 1), 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.\(^8\) From Hypothesis 3 we expect a positive estimate for \( \beta_4 \).

\( \gamma_k \) indicate NACE 3-digit industry fixed effects (overall, we include 126 industry dummies) and \( \epsilon_{i,jk} \) is the remainder error term. \( Z_i \) is a vector of additional firm-specific control variables (including the constant) suggested by the previous empirical literature (Graham 2003 provides an excellent survey). Firstly, it comprises asset tangibility as measured by the share of fixed assets to 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 asset 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

\(^8\)Including a possible interaction term between the corporate tax rate and age squared leaves our estimation results below virtually unchanged. For this reason, and to keep the econometric analysis simple, we decided to leave out this interaction term.
include the size of a firm, defined as the logarithm of sales. 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. Therefore, 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).

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 (earnings before interest and taxes) over total assets (see Fama and French 2002). 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 an effective 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). Financial distress affects debt financing via two channels. First, highly-leveraged firms are more exposed

---

9Since 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.

10We follow Graham (1999) to define the \( Z \)-score as:

\[
Z\text{-score} = 3.3 \cdot \frac{\text{EBIT}}{\text{Total assets}} + 1.0 \cdot \frac{\text{Operating revenue}}{\text{Total assets}} + 1.4 \cdot \frac{\text{Shareholder funds}}{\text{Total assets}} + 1.2 \cdot \frac{\text{Working capital}}{\text{Total assets}}
\]
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 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 (Graham, Lemmon and Schallheim 1998).

**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.\(^{11}\)

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 (7). 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 not sensitive to these variations in tax rates, and, therefore, we refer to the results in column 4 when discussing our empirical findings.

Generally, the model seems well specified. 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 a higher share of fixed assets makes debt financing less attractive in our sample (similar evidence, also based on the AMADEUS database, is provided by Huizinga, Laeven and Nicodémé 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 Majhuf 1984 and the empirical findings in Rajan and Due to data restrictions, we include shareholder funds instead of retained earnings (as in Alworth and Arachi 2001). \(^{11}\)The results from these regressions are virtually the same as for the full sample (i.e., the ones including outliers), but it turns out that the fit of the regressions (in terms of \(R^2\)) improves substantially in the outlier-corrected models. Further, applying median regressions we obtain very similar results as for our outlier-corrected ones. To save space, we do not report the results of the median regressions, but they are available from the authors upon request.

14
Finally, we observe changes from negative to positive, is around 98 years.

...parameters of Table 2, we can see that the firm age, where the influence of age is indicated by the positive parameter estimate on age squared, there is a u-shaped advantage of debt obviously provokes firms to increase their leverage. In line of corporate taxation on debt ratios, as expected from Hypothesis 1. The tax

gabove (see also Graham 1999). The Z-score variable takes the expected negative sign, but is insignificant throughout.

...variables of interest, we find a significantly positive impact of corporate taxation on debt ratios, as expected from Hypothesis 1. The tax advantage of debt obviously provokes firms to increase their leverage. In line with Hypothesis 2, 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 the estimated parameters of Table 2, we can see that the firm age, where the influence of age changes from negative to positive, is around 98 years. Finally, we observe

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

Zingales 1995 and Huizinga, Laeven and Nicodème 2008). Finally, the impact of a firm’s financial situation on debt financing seems decisive. As expected, firms with operating losses reported in their profit and loss account rely 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 from Hypothesis 1. The tax advantage of debt obviously provokes firms to increase their leverage. In line with Hypothesis 2, 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 the estimated parameters of Table 2, we can see that the firm age, where the influence of age changes from negative to positive, is around 98 years. Finally, we observe

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Notes: Constant and industry dummies not reported. White (1980) robust standard errors in parentheses. **Significant at 1%, ***Significant at 5%, *Significant at 10%.
Table 3: Marginal effect of corporate tax rate $\tau$

<table>
<thead>
<tr>
<th>Firm age (99-04)</th>
<th>SCTR in the year(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1999</td>
</tr>
<tr>
<td>Mean</td>
<td>16.60</td>
</tr>
<tr>
<td>Median</td>
<td>13</td>
</tr>
<tr>
<td>Lower 25 percent quartile</td>
<td>8</td>
</tr>
<tr>
<td>Upper 75 percent quartile</td>
<td>20</td>
</tr>
<tr>
<td>Lower 1 percent percentile</td>
<td>2</td>
</tr>
<tr>
<td>Upper 1 percent percentile</td>
<td>82</td>
</tr>
</tbody>
</table>

**Notes:** Marginal effects are calculated from the parameter estimates of Table 2 using $\frac{\partial b}{\partial \tau} = \hat{\beta}_1 + \hat{\beta}_4 A$.

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 Hypothesis 3, 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 (7) 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 0.74 ($\approx 0.566 + 0.011 \cdot 16.60$), 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.\textsuperscript{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

\textsuperscript{13}Huizinga, Laeven and Nicodème (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.
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 (τ, A, A² and τ · A) along with the sample size and the R².

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-term liabilities. 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. 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, Demirgüç-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 of less 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.

\[^{14}\text{In our sample, the short-term debt ratio is around 58 percent (consisting of 10 percent loans, 22 percent trade credits, and the remaining 68 percent other current liabilities), and the long-term debt ratio is around 14 percent.}\]
Table 4: Robustness

<table>
<thead>
<tr>
<th>τ</th>
<th>A</th>
<th>A²</th>
<th>τ*A</th>
<th>Obs</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Definition of the debt ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total debt ratio (basic regression from Table 2)</td>
<td>0.637***</td>
<td>-0.895***</td>
<td>0.003***</td>
<td>0.009***</td>
<td>390,546</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.027)</td>
<td>(0.0001)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Short-term debt ratio</td>
<td>0.216***</td>
<td>-0.559***</td>
<td>0.002***</td>
<td>0.004***</td>
<td>390,546</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.024)</td>
<td>(0.0001)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Total debt ratio excluding trade credits</td>
<td>0.922***</td>
<td>-0.651***</td>
<td>0.002***</td>
<td>0.006***</td>
<td>390,546</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.024)</td>
<td>(0.0001)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Long-term debt ratio</td>
<td>0.425***</td>
<td>-0.226***</td>
<td>0.0006**</td>
<td>0.003***</td>
<td>390,546</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.015)</td>
<td>(0.0001)</td>
<td>(0.0004)</td>
<td></td>
</tr>
<tr>
<td>(ii) Marginal tax rates as proposed by Graham (1996)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCTR1</td>
<td>0.174***</td>
<td>-0.549***</td>
<td>0.003***</td>
<td>0.001***</td>
<td>405,373</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.011)</td>
<td>(0.0001)</td>
<td>(0.0002)</td>
<td></td>
</tr>
<tr>
<td>MCTR2</td>
<td>0.258***</td>
<td>-0.562***</td>
<td>0.003***</td>
<td>0.001***</td>
<td>405,373</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.013)</td>
<td>(0.0001)</td>
<td>(0.0003)</td>
<td></td>
</tr>
<tr>
<td>MCTR3</td>
<td>0.324***</td>
<td>-0.546***</td>
<td>0.003***</td>
<td>0.001***</td>
<td>405,373</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.013)</td>
<td>(0.0001)</td>
<td>(0.0003)</td>
<td></td>
</tr>
<tr>
<td>MCTR4</td>
<td>0.310***</td>
<td>-0.569***</td>
<td>0.003***</td>
<td>0.001***</td>
<td>405,373</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.014)</td>
<td>(0.0001)</td>
<td>(0.0003)</td>
<td></td>
</tr>
<tr>
<td>MCTR5</td>
<td>0.291***</td>
<td>-0.539***</td>
<td>0.003***</td>
<td>-0.001***</td>
<td>405,373</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.011)</td>
<td>(0.0001)</td>
<td>(0.0002)</td>
<td></td>
</tr>
<tr>
<td>MCTR5a</td>
<td>0.562***</td>
<td>-1.103***</td>
<td>0.003***</td>
<td>0.014***</td>
<td>318,782</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.033)</td>
<td>(0.0002)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>(iii) Sample restrictions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firms with b ≤ 100 percent</td>
<td>0.665***</td>
<td>-1.065***</td>
<td>0.003***</td>
<td>0.012***</td>
<td>361,584</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.030)</td>
<td>(0.0001)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Firms with A ≤ 150</td>
<td>0.551***</td>
<td>-1.189***</td>
<td>0.006***</td>
<td>0.013***</td>
<td>405,133</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.019)</td>
<td>(0.0001)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Firms with A ≤ 50</td>
<td>0.435***</td>
<td>-1.750***</td>
<td>0.010***</td>
<td>0.025***</td>
<td>391,362</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.028)</td>
<td>(0.0003)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Countries with more than 500 firms</td>
<td>0.563***</td>
<td>-0.936***</td>
<td>0.003***</td>
<td>0.011***</td>
<td>405,114</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.027)</td>
<td>(0.0001)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>NACE 2-digit industries with more than 5,000 firms</td>
<td>0.570***</td>
<td>-0.930***</td>
<td>0.003***</td>
<td>0.011***</td>
<td>397,128</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.027)</td>
<td>(0.0001)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Domestic firms only (multinationals excluded)</td>
<td>0.533***</td>
<td>-1.094***</td>
<td>0.004***</td>
<td>0.013***</td>
<td>397,029</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.030)</td>
<td>(0.0001)</td>
<td>(0.001)</td>
<td></td>
</tr>
</tbody>
</table>

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 $\tau_i = 0$ if the annual EBIT $\leq 0$, otherwise $\tau_i = SCTR$. Then, we calculate the average corporate tax rate as $\tau = \bar{\tau}_i$.
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, otherwise $\tau = SCTR$.
MCTR5: $\tau = 0$ if the sum of EBIT within the sample period is $\leq 0$, and $\tau = SCTR$ otherwise.
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. Otherwise, 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 $\tau_t = \text{SCTR}$ 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 $0.5 \cdot \text{SCTR}$ 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 do not vary strongly 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 does not really come as a surprise as 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 Hypothesis 3. 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 from these robustness experiments are qualitatively very similar to the previous ones. Therefore, the (joint) influence of corporate taxation and firm age on debt is 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 1 above), we confine our analysis to firms younger than 150 years (lowering the sample by 240 firms), and, alternatively, to companies younger than 50 years (losing 14,011 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 (from the parameter estimates in Table 2 we calculated a value of around 98 years). Further, as might be suspected by the graphical inspection of Figure 1, 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.

Next, we check whether the empirical results are influenced by the sample composition. 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.

Finally, one might suspect that our empirical findings are driven by the existence of multinational firms. Multinational firms are able to reduce tax payments by shifting debt from a low-tax jurisdiction to a high-tax jurisdiction taking advantage of the high-interest deduction in the high-tax jurisdiction (see Desai, Foley and Hines 2004, Huizinga, Laeven and Nicodème 2008, Egger, Eggert, Keuschnigg and Winner 2009, for empirical evidence). To examine
whether the observed relationship between corporate taxation, firm age and debt is sensitive to such debt shifting activities we exclude multinational firms from the dataset. In our sample, a multinational firm is defined as a firm that is owned by a foreign firm (about 8,300 firms). As can be seen from the last line of Table 4, we obtain almost the same parameter estimates as in the baseline specification of Table 2 when focusing on domestic firms only.\footnote{Focusing exclusively on multinational firms, we obtain very similar parameter estimates to those in the full sample. Only for firm age we find a slightly lower, but again a significantly negative coefficient.}

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 three 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 a systematic incentive for higher leverage. Second, firm age exerts a negative impact on debt ratios, indicating that older firms rely less on debt than younger ones. Finally, we observe a significantly positive interaction effect between corporate taxation and firm age. This result implies that the debt ratio of older firms is much more affected by a cut in corporate tax rates than that of younger firms. This, together with a significantly negative coefficient of a quadratic age term, lends support to the view that the effects of corporate taxation on debt financing is changing over the life-time of a firm.
References


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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
<th>Obs. (^{a)})</th>
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<td>200.00</td>
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<td>Short-term debt ratio</td>
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<td>200.00</td>
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</tr>
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<td>Total debt ratio excluding trade credits</td>
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<td>0.00</td>
<td>200.00</td>
<td>515,741</td>
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<td><strong>Statutory corporate tax rates</strong></td>
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<td>35.07</td>
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<td>50.08</td>
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<td>SCTR 2002</td>
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<td>SCTR 2004</td>
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<td>12.50</td>
<td>37.30</td>
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<td>SCTR 1999-2004</td>
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<td>5.25</td>
<td>10.83</td>
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<tr>
<td><strong>Marginal corporate tax rates</strong></td>
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<tr>
<td>MCTR1</td>
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<td>12.59</td>
<td>0.00</td>
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<tr>
<td>MCTR2</td>
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<td>10.12</td>
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</tr>
<tr>
<td>MCTR3</td>
<td>27.17</td>
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<td>0.00</td>
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<td>515,741</td>
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<tr>
<td>MCTR4</td>
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<td>9.29</td>
<td>0.00</td>
<td>41.17</td>
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<td>MCTR5</td>
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<td>13.85</td>
<td>0.00</td>
<td>41.17</td>
<td>515,741</td>
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<tr>
<td><strong>Independent variables</strong></td>
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<td>Firm age (in years)</td>
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<td>872.00</td>
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<td>Firm age(^2)</td>
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<td>Asset tangibility</td>
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<td>6.35</td>
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<td>422,337</td>
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<td>-15,983.44</td>
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<td>NSF-dummy</td>
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<td><strong>Variables used for calculation</strong></td>
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<td>Operating revenue (in tsd. EUR)</td>
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<td>378,685.40</td>
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<td>Number of employees</td>
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<td>1,877.02</td>
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<td>757,846.50</td>
<td>368,750</td>
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<tr>
<td>Total assets (in tsd. EUR)</td>
<td>8,556.36</td>
<td>387,896.90</td>
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<td>188·10^6</td>
<td>515,741</td>
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<td>Fixed assets (in tsd. EUR)</td>
<td>3,829.59</td>
<td>168,037.10</td>
<td>-2,029.00</td>
<td>79·10^6</td>
<td>515,741</td>
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<tr>
<td>Other fixed assets (in tsd. EUR)</td>
<td>1,337.08</td>
<td>63,871.77</td>
<td>-1·10^8</td>
<td>19.7·10^6</td>
<td>506,368</td>
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<tr>
<td>EBIT (in tsd. EUR)</td>
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<td>20,822.26</td>
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<td>8.004·10^6</td>
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<td>Profit/loss per period (in tsd. EUR)</td>
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<td>20,510.27</td>
<td>-1·10^8</td>
<td>7.758·10^6</td>
<td>443,693</td>
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</table>

**Notes:** \(^{a)}\) Number of firms (in 35 countries and 126 NACE 3-digit industries).
Table A. 3: Correlation matrix

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<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
<th>(13)</th>
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<tr>
<td>(1) Debt ratio</td>
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<td>(2) Short term debt ratio</td>
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<tr>
<td>(3) Total debt ratio excl. trade credits</td>
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<td>0.116</td>
<td>1.000</td>
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<tr>
<td>(4) Long term debt ratio</td>
<td>0.339</td>
<td>-0.343</td>
<td>0.080</td>
<td>1.000</td>
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<tr>
<td>(5) Firm age</td>
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<td>-0.184</td>
<td>-0.043</td>
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<tr>
<td>(6) Firm age^2</td>
<td>-0.120</td>
<td>-0.107</td>
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<td>-0.024</td>
<td>0.846</td>
<td>1.000</td>
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<tr>
<td>(7) Asset tangibility</td>
<td>-0.020</td>
<td>-0.265</td>
<td>0.360</td>
<td>0.018</td>
<td>0.007</td>
<td>0.021</td>
<td>1.000</td>
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<td>(8) Firm size (log of sales)</td>
<td>-0.135</td>
<td>-0.151</td>
<td>0.023</td>
<td>-0.051</td>
<td>0.382</td>
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<td>(9) Return on assets (ROA)</td>
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<td>-0.176</td>
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<td>-0.042</td>
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<td>(10) NOL dummy</td>
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<td>(11) NSF dummy</td>
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<td>-0.223</td>
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<td>(12) Z-score</td>
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<td>-0.119</td>
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<td>-0.025</td>
<td>-0.013</td>
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<td>(13) SCTR 99-04</td>
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<td>0.026</td>
<td>0.082</td>
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<td>0.044</td>
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<td>-0.089</td>
<td>-0.073</td>
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<td>Correlations in tax rates</td>
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