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Death and Taxes
Does Taxation Matter for Firm Survival?

by Serhan Cevik and Fedor Miryugin

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Death and Taxes: Does Taxation Matter for Firm Survival?

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Abstract

This paper investigates the impact of taxation on firm survival, using hazard models and a large-scale panel dataset on over 4 million nonfinancial firms from 21 countries over the period 1995–2015. We find ample evidence that a lower level of effective marginal tax rate improves firms' survival chances. This result is not only statistically but also economically important and remains robust when we partition the sample into country subgroups. The effect of taxation on firms' survival probability is found to exhibit a non-linear pattern and be stronger in developing countries than advanced economies. These findings have important policy implications for the design of corporate tax systems. The challenge is not simply reducing the statutory tax rate, but to level the playing field for all firms by rationalizing differentiated tax treatments across sectors, asset types and sources of financing.

JEL Classification Numbers: D22, D24, O3, O4,

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I. INTRODUCTION

Corporate dynamism is critical for the vitality and sustainability of competitiveness, innovation and growth. While creative destruction—through firm entry and exit—is essential for economic progress, establishing a conducive ecosystem for firm survival is also necessary for sustainable private sector development and socioeconomic cohesion. There is an extensive literature identifying firm-level characteristics (such as size, age, indebtedness, and productivity) as well as macroeconomic conditions and institutional features as key contributing factors to growth and survival probability among firms (Evans, 1987; Hall, 1987; Audretsch, 1991; Audretsch and Mahmood, 1995; Ericson and Pakes, 1995; Agarwal, 1997; Zingales, 1998; Agarwal and Audretsch, 2001; Agarwal and Gort, 2002; Bond and others, 2003; Bunn and Redwood, 2003; Clementi and Hopenhayn, 2006; Bridges and Guariglia, 2008; Musso and Schiavo, 2008; Byrne, Spaliara, and Tsoukas, 2016). To the best of our knowledge, however, there is no paper analyzing the impact of taxation on firms' survival prospects. While corporate income taxes are expected to lower firms' capital investment and productivity by raising the user cost of capital, distorting factor prices and reducing after-tax return on investment, taxation also provides resources for public infrastructure investments and the proper functioning of government institutions, which are key to a firm's success. As shown by Barro (1990), Aghion and others (2016), and Cevik and Miryugin (2018), the overall impact of taxation on firm performance depends on the relative weight of these two opposing effects, which can vary with the composition and efficiency of taxation and government spending.

The objective of this paper is to shed light on how taxation affects the probability of firm survival across countries. According to the Orbis database maintained by Bureau van Dijk, the average failure rate among nonfinancial firms from 167 countries is 3.5 percent of active firms during the 1995-2015 period. While the average failure rate of 4 percent in advanced economies is almost double the average failure rate among developing countries, there appears to be a convergence in failure rates over the past decade. In this paper, we focus on how taxation affects the survival prospects of nonfinancial firms, using hazard models and a comprehensive dataset covering over 4 million nonfinancial firms from 21 countries with a total of 21.5 million firm-year observations over the period 1995–2015. As the main explanatory variable of interest, we estimate the effective marginal tax rate (EMTR) for each firm, rather than using the statutory corporate income tax (CIT) rate, as the appropriate measure of the tax burden on firms.[1] The firm-specific EMTR encapsulates not only the differences in the overall tax burden across countries, but also the discriminatory nature of tax regimes across sectors and types of firms.

We find ample evidence that a lower level of effective marginal tax rate increases survival probability among nonfinancial firms. To obtain a granular analysis of firm survival across countries and over time, we control for a plethora of firm characteristics, such as age, size, profitability, capital intensity, leverage and total factor productivity (TFP), as well as systematic

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[1]Devereux and Griffith (2002) provide a comprehensive discussion of backward-looking effective rates, which are inherently prone to endogeneity inducing biased estimation results.

differences across sectors and countries. We find that the tax burden—measured by the firm-specific EMTR—exerts an adverse effect on companies' survival prospects. In other words, a lower level of EMTR increases the survival probability among firms in our sample. This finding is not only statistically but also economically important and remains robust when we partition the sample into country subgroups. We run the estimation on separate samples and find that the effect of taxation on firm survival is significantly greater in developing countries than advanced economies. Furthermore, digging deeper into the tax sensitivity of firm survival, we uncover a nonlinear relationship between the firm-specific EMTR and the probability of corporate failure, which implies that taxation becomes a detriment to firm survival at higher levels. With regards to the impact of other firm characteristics, we obtain results that are in line with previous research and see that survival probability differs depending on firm age and size, with older and larger firms experiencing a lower risk of failure. Focusing on the financial health, we find that the probability of failure diminishes with the degree of profitability but increases with the level of indebtedness. Similarly, in relation to firm structure and performance, we observe that capital intensity and TFP play a significant role in reducing the probability of failure.

Tax systems can be designed better to improve efficiency and boost investment that foster innovation and job creation. The firm-level estimates presented in this paper demonstrate that taxation clearly has a significant effect on the pattern of firm failures across advanced and developing countries. This finding has important policy implications for the design of tax systems. A coherent and fair approach to taxation is important to reduce legal uncertainty and distortions in resource allocation faced by firms. Tax policy and administration should therefore aim to cut the costs of compliance, facilitate entrepreneurship and innovation, and encourage alternative sources of financing by particularly addressing the corporate debt bias. In this context, the EMTR holds a special key by influencing firms' investment decisions and the probability of survival over time. For policymakers, the challenge is not simply reducing the statutory CIT rate, but to level the playing field for all firms by rationalizing differentiated tax treatments across sectors, capital asset types and sources of financing.

The remainder of the paper is organized as follows. Section II describes the data sources, explains the calculation of firm-specific variables used in the analysis, and presents summary statistics and stylized facts. Section III explains the empirical methodology. Section IV presents the econometric results, including various robustness checks. Section V concludes and discusses policy implications.

II. Data Overview and Estimating EMTR and TFP

The primary dataset consists of annual observations on a total of more than 4 million nonfinancial firms from 21 countries during the 1995-2015 period. We obtain harmonized firm-level financial data, including balance sheets and income statements, from the Orbis database. Unlike other administrative firm-level databases, Orbis provides a comparable coverage of both public (listed) and private (non-listed) firms including small and medium-sized enterprises in a broad universe of developed and developing countries. The complete Orbis sample consists of more than 200 million firm annual observations from over 100 countries around the world. However, similar to any other large-scale micro dataset, the Orbis data require careful management to ensure consistency and comparability across firms and countries and over time. First, we select countries with sufficient number of observations by setting a threshold of 10,000 annual observations per country. Second, following the data cleaning principles suggested by Gal (2013) and Kalemli-Ozcan and others (2015), we filter out firms with negative values of total assets, employment, operating revenues, and short-term loans and long-term debt in any given year. Third, we restrict the dataset to the sample of firms and countries for which we have information to compute the measures of EMTR and TFP as described below. Fourth, to minimize the effect of extreme outliers, we exclude 1 percent of observations on both tails of the distribution of variables. After these steps, we obtain an unbalanced panel of 4,026,648 unique firms from 21 countries (14 advanced and 7 developing) with a total of 21,450,725 firm-year observations over the period from 1995 to 2015.[2]

We follow a commonly-used EMTR approach to estimate a forward-looking measure of the effective tax burden at the firm level.[3] The firm-specific EMTR framework is based on the user cost of capital concept as developed by Hall and Jorgenson (1967), Auerbach (1983), and King and Fullerton (1984). According to Devereux and Griffith (1998; 2003), the EMTR is the difference between the expected pre-tax (gross) rate of return ($\tilde{p}$) and the expected post-tax (net) rate of return on a marginal investment (*r*), divided by the pretax rate of return:

$$EMTR = \frac{\tilde{p} - r}{\tilde{p}}$$

The EMTR is therefore a consolidated indicator of the various tax factors that affect the cost of capital relative to a normal rate of return. The expected pre-tax rate of return ($\tilde{p}$) is the minimum rate of return of a new investment project (*I*) that covers the acquisition cost (*Q*) and the economic rate of depreciation (δ), allowing the firm to pay tax obligations and funding costs.

$$\tilde{p} = \frac{I}{Q} - \delta$$

The expected post-tax rate of return (*r*), on the other hand, is equivalent to the nominal market interest rate (*i*) minus the inflation rate (*π*), both of which are assumed to be common across firms in a given country and time. When there is no tax, $\tilde{p}$ is equal *r*, and the *EMTR* is zero. With taxation, however, the expected pre-tax rate of return ($\tilde{p}$) diverges from the expected after-tax rate of return (*r*), thereby requiring the firm to generate additional profits to cover for not only for funding costs but also for tax obligations. If the EMTR is the same across different sectors and

[2] The list of countries in our sample and the numbers of firms and firm-year observations per country are provided Appendix Table A1. The classification of countries is according to the IMF's World Economic Outlook (WEO) database as of September 2018.

[3] Egger and others (2009) provide comprehensive guidance on computing EMTRs at the firm level, which is applied recently by Benedek and others (2017) in the context of estimating the impact of tax incentives on firm size in a panel of four European countries.

firm characteristics, then all firms face the same effective tax rate. However, when the tax code allows for changes in tax rates and allowances according to sector- and firm-level differences, the EMTR shows considerable variation across firms in a given country and over time.

The estimation of firm-specific EMTRs requires a combination of firm-level information and country-level factors including the key features of the tax system. We calculate firm-level EMTRs using company-specific information and a set of parameters including the statutory CIT rate, depreciation rules, inflation, the nominal interest rate, and the real before-tax return on equity in each country, which are assumed to be constant across all firms. Following Egger and others (2009), we assume that the key parameters are as follows: $\tilde{p}$ = 0.2, r = 0.05 and π = 0.02, and use different rates of economic depreciation (δ) for different types of assets: 0.1225 for machinery; 0.0361 for buildings; 0 for land and inventories; and 0.15 for intangible assets.[4]

We estimate a firm-level measure of TFP to incorporate the impact of efficiency differences across enterprises on the likelihood of firm survival. TFP is an indicator of the efficiency with which capital and labor are used in a production process. As such, it plays a significant role in analyzing economic fluctuations at the macro level, as well as assessing differences across sectors and firms. Firm-specific TFP is expressed as the residual from the standard Cobb-Douglas production function with capital and labor as inputs and an underlying assumption of constant returns to scale as given by:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \mu_i + \mu_t + \varepsilon_{it}$$

in which y_{it} is the logarithm of real gross output for firm i at time t; k_{it} and l_{it} denote the logarithms of real capital stock and labor, respectively; μ_i and μ_t stand for firm and time fixed effects, respectively, to capture permanent differences across firms and aggerate changes to common to all firms; and ε_{it} is the residual representing the amount of output that cannot be explained by the use of inputs. To compute the real capital stock, we follow the perpetual inventory method detailed in Gal (2013) and define the capital stock, k_{it}, as the book value of fixed tangible assets, and depreciation, δ_{it}, as reported in a firm's accounts. Accordingly, the real capital stock is calculated by:

$$k_{it} = k_{it-1}(1 - \delta_{it}) + I_{it}$$

where $I_{it}$is net fixed investment in real terms, using industry-specific price deflators. To mitigate the risk of obtaining biased TFP estimates with the ordinary least squares (OLS) method, however, we utilize the algorithm proposed by Levinsohn and Petrin (2003) and use intermediate inputs, energy or material costs, as proxies to solve the simultaneity problem. Hence, the production function is expressed in the following form with an additional term:

[4] While inflation and interest rates tend to vary across countries, the macroeconomic parameters used in the analysis are consistent with country-level observations for advanced and developing countries in the sample.

$$y_{it} = \beta_o + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \mu_i + \mu_t + \varepsilon_{it} = \beta_l l_{it} + \varphi_{it}(k_{it}, m_{it}) + \mu_i + \mu_t$$

In the first stage of the estimation, $\hat{\beta}_l$ is estimated by the OLS model and a third order approximation in k_{it} and m_{it} substituted for $\varphi_{it}(k_{it}, m_{it})$. In the second stage, $\widehat{\omega_{it}}$ is estimated for all values of $\beta_k{}^*$ and $\beta_m{}^*$, according to the formula:

$$\widehat{\omega_{it}} = \widehat{\varphi_{it}} - \beta_k{}^* k_{it} - \beta_m{}^* m_{it}$$

Then, the residual of the following equation is computed and interacted with two instruments, which are real capital stock and material costs:

$$\widehat{\eta_{it} + \xi_{it}} = y_{it} - \hat{\beta}_l l_{it} - \beta_k{}^* k_{it} - \beta_m{}^* m_{it} - E[\omega_{it} | \widehat{\omega_{it}} - 1]$$

Capital stock in the current period is assumed to be not correlated with the contemporaneous productivity shock, as it is mostly driven by an investment decision made in the previous period, which yields to the first moment condition. The second moment condition is obtained through the fact that the material costs from the previous level are uncorrelated with the current shock.

Table 1 displays the distribution of nonfinancial firms across 10 sector groups over the period spanning from 1995 to 2015. Our sample of firms is unevenly distributed across 21 countries and 10 nonfinancial sectors grouped according to the statistical classification of economic activities based on the *Nomenclature des Activités Économiques dans la Communauté Européenne* (NACE). The substantial majority is concentrated in Europe, accounting for 95 percent of nonfinancial firms covered in our sample. It is important to note that the number of firms covered in the Orbis database varies from one year to another, increasing considerably after 2000. In terms of sectoral coverage, the dataset is based on the NACE classification of economic activities and covers nonfinancial sectors excluding agriculture, public administration and defense, activities of extraterritorial organizations and bodies, and activities of households as employers and for own use. Most of the firms in our sample operate in the wholesale and retail trade sector, accounting for about 31 percent of observations, followed by services grouped together with 25 percent, manufacturing with 18 percent, and construction with 17 percent.

Table 1. Distribution of Firms Across Sectors

Economic Sector	Number of Firms	Percent
Accommodation and Food Services	338,592	8.4
Construction	699,047	17.4
Information Technology	157,500	3.9
Manufacturing	710,620	17.7
Mining	10,885	0.3
Professional and Administrative Activities	503,135	12.5
Real Estate	148,467	3.7
Transportation and Storage	192,739	4.8
Utilities	33,920	0.8
Wholesale and Retail Trade	1,231,743	30.6
Total	**4,026,648**	**100.0**

Table 2 presents descriptive statistics of all variables for the entire sample as well as subgroups of advanced and developing countries. Along with the firm-specific EMTR and TFP measures, we include several key firm characteristics, such as age (measured by the log of years since inception), size (measured as the log of total assets), profitability (measured by the ratio of profits after tax to total assets), capital intensity (measured by capital per worker), and leverage (defined as short-term and long-term debt over total assets). The nominal firm-level variables obtained from the Orbis database are deflated using industry-specific deflators drawn from the OECD STAN database for advanced economies and the UN National Accounts database for developing countries. As described above, the real capital stock is calculated using the perpetual inventory method, as the sum of previous period real fixed assets *minus* depreciation *plus* real fixed investment in the current period. As presented in Table 2, there are considerable variations in firm characteristics, including the EMTR, and macroeconomic features over the sample period from 1995 to 2015. In particular, the variance in the EMTR reflect differences in the composition of assets and source of financing at the firm level.

Table 2. Summary Statistics

Variable	*All*			*Advanced*			*Developing*		
	Obs.	*Mean*	*Std. Dev.*	*Obs.*	*Mean*	*Std. Dev.*	*Obs.*	*Mean*	*Std. Dev.*
Firm Characteristics									
Age [log]	20.91 ml	2.14	0.95	18.23 ml	2.21	0.95	2.68 ml	1.68	0.87
Size [log]	21.39 ml	13.55	2.33	18.49 ml	13.61	2.33	2.90 ml	13.17	2.33
Profitability	20.64 ml	0.01	0.21	17.84 ml	0.01	0.16	2.80 ml	0.01	0.40
Capital Intensity	21.45 ml	10.19	2.20	18.54 ml	10.15	2.19	2.91 ml	10.41	2.26
Leverage	17.02 ml	0.18	0.22	15.32 ml	0.18	0.23	1.70 ml	0.10	0.19
TFP [log]	21.45 ml	7.20	1.12	18.54 ml	7.19	1.11	2.91 ml	7.26	1.17
EMTR	16.39 ml	0.28	0.07	14.82 ml	0.29	0.06	1.57 ml	0.20	0.07

Source: Orbis; authors' calculation.

III. ECONOMERTIC METHODOLOGY

We focus on the impact of taxation on firms' survival prospects in a large panel of 4,026,648 firms from 21 countries over the period 1995-2015. We trace the span of survival for each firm over the sample period and define the survival function as the probability of failure between time t and $t+1$ divided by the probability of surviving at least until t, for a given set of covariates. In line with the literature, we consider a firm as failed in a given year when its status is that of receivership, liquidation, or dissolved (Bunn and Redwood, 2003; Bridges and Guariglia, 2008; Helmers and Rogers, 2010). The observation period in this analysis takes into account both left truncation and right censoring since firms may remain in operation beyond the sample period. We use the year of first appearance in the dataset as the time at which a firm becomes at risk of failure and exclude observations when a firm drops out of the database. The survival function for firm i at any point of time $t>0$ and $t=1, \ldots, T$ is assumed to take the proportional hazard form:

$$\theta_{it} = \theta(t) \cdot X_{it}'\beta$$

where $\theta(t)$ is the baseline hazard function and X_{it} is a series of time-varying covariates summarizing observed differences among firms (Cox, 1972; Cox and Oakes, 1984; Audretsch and Mahmood, 1995; Kleinbaum and Klein, 2005). In a panel setting, the discrete time formulation of the probability of failure is given by a complementary log-log model such as:

$$h_t(X_{it}) = 1 - \exp\{-\exp\big(X_{it}'t\beta + \theta(t)\big)\}$$

in which $h_t(X_{it})$ is the hazard rate at time t for firm i, $\theta(t)$ is the baseline hazard function, and X_{it} comprises a vector of firm characteristics. This discrete time version of the Cox proportional hazard model can be extended to account for unobserved but systematic differences among firms by describing unobserved heterogeneity by a random variable μ_i independent of X_{it}:

$$h_t(X_{it}) = 1 - \exp\{-\exp\big(X_{it}'\beta + \theta(t)\big) + \mu_i\}$$

where μ_i denotes an unobserved firm-specific error term with zero mean, uncorrelated with the *X*s. The complementary log-log model allows us to capture the exact time of corporate failures and deal with the potential right-censoring bias and the endogeneity problem arising from simultaneity between the dependent and explanatory variables. Since our dataset is on an annual basis, the complementary log-log model is also more appropriate compared to the standard Cox model.

Our main explanatory variable of interest is the firm-specific measure of the effective corporate tax burden. Focusing on the impact of corporate taxation on firms' survival prospects, we control for main firm characteristics comprising age, size, profitability, leverage, capital intensity, and productivity. We include sector and country fixed effects to account for unobserved time-invariant heterogeneity. This model can be estimated using standard random effects panel data methods for a binary dependent variable, assuming that the distribution of μ_i is normal. Robust standard errors are clustered at the firm level to account for the fact that observations pertaining to a firm are correlated and thus do not contain as much information as unclustered errors.

IV. EMPIRICIAL RESULTS

The estimation results, presented in Table 3, show that the corporate tax burden has a significant effect on firms' survival prospects. All variables included in the model have the expected sign with a high degree of statistical significance. Regarding the main variable of interest, we find that the coefficient on the corporate tax burden—measured by the firm-specific EMTR—exerts a positive and highly significant effect on the probability of failure. In other words, a lower level of effective marginal tax rate increases the survival probability among nonfinancial firms in our sample. This finding is not only statistically but also economically important and remains robust when we partition the sample into country subgroups. We run the estimation on separate samples and find that the effect of taxation on firm survival is significantly greater in developing countries than advanced economies. We dig deeper into the tax sensitivity of firm survival and discover a nonlinear relationship between the firm-specific EMTR and the probability of corporate failure. These results, presented in Table 4, show that the coefficient on EMTR turns negative when we include its squared value in the model along with other control variables. The coefficient on the EMTR squared, on the other hand, is highly significant and positive with greater economic magnitude. This implies that taxation becomes a detriment to firm survival at higher levels. While this pattern of nonlinear interactions remains intact for firms in advanced economies, the picture is completely different for firms in developing countries where the coefficients on EMTR and its squared term have the opposite values. This could be due to the limited number of observations—267,249 firms from developing countries compared to almost 2.3 million from advanced economies. More importantly, however, we suspect that bankruptcy procedures that tend to tend to take an exorbitant amount of time in developing countries with inefficient bureaucracy and weak rule of law may distort the relationship between the tax burden and firm survival.

Table 3. Firm Survival—Baseline Estimations

Variables	All Countries	Advanced	Emerging
Dependent variable: Probability of failure			
Age	-0.297***	-0.296***	-0.214***
	[0.002]	[0.002]	[0.008]
Size	-0.035***	-0.044***	0.054***
	[0.002]	[0.002]	[0.005]
Profitability	-1.494***	-1.803***	-0.741***
	[0.017]	[0.023]	[0.013]
Capital Intensity	-0.089***	-0.095***	-0.061***
	[0.001]	[0.001]	[0.004]
TFP	-0.130***	-0.088***	-0.418***
	[0.003]	[0.003]	[0.007]
Leverage	0.401***	0.361***	0.143***
	[0.008]	[0.009]	[0.028]
EMTR	3.951***	3.943***	3.927***
	[0.097]	[0.113]	[0.404]
# of observations	12,877,294	11,719,946	1,157,348
# of firms	2,555,686	2,288,437	267,249
# of failures	446,983	412,702	34,281
Fixed effects	Yes	Yes	Yes
Wald test	85,784	82,950	12,343
Log-likelihood	-4,435,071	-4,147,730	-281,918

Note: Standard errors clustered at the firm level are displayed in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Pertaining to the impact of firm characteristics, we obtain results in line with previous research in this area. First, the probability of firm survival increases with age and size, as indicated by the negative and statistically significant coefficients. Older and larger firms are better positioned to weather shocks compared to younger and smaller enterprises. However, while age has the similar effect on the incidence of corporate failure across all countries, firm size appears to have the opposite effect in the case of developing countries. These findings may reflect that the latter are likely to face a higher degree of asymmetric information problems and consequently a higher degree of financial constraints, especially in countries with undeveloped financial systems. Second, firms' survival prospects are greatly dependent on the financial health as measured by profitability and leverage. The probability of failure diminishes with the degree of profitability but increases with the level of indebtedness. Both results are particularly more pronounced among nonfinancial firms in advanced economies. Third, in relation to firm structure and performance, we find that capital intensity and TFP play a significant role in reducing the hazard of failure among nonfinancial firms. These results, consistent across all countries, capture the contribution of greater scale economies and efficiency gains.

Table 4. Firm Survival—Nonlinear Effects of Taxation

Variables	All Countries	Advanced	Emerging
Dependent variable: Probability of failure			
Control variables	Yes	Yes	Yes
EMTR	-5.913***	-6.976***	4.064***
	[0.436]	[0.354]	[0.802]
$EMTR^2$	20.122***	22.182***	-0.242
	[0.904]	[0.626]	[1.576]
# of observations	12,877,294	11,719,946	1,157,348
# of firms	2,555,686	2,288,437	267,249
# of failures	446,983	412,702	34,281
Fixed effects	Yes	Yes	Yes
Wald test	86,177	84,900	12,363
Log-likelihood	-4,434,475	-4,147,067	-281,918

Note: Standard errors clustered at the firm level are displayed in brackets. *** p<0.01, ** p<0.05, * p<0.1.

We conduct several robustness checks to verify our findings, and to attain a more nuanced picture of how taxation affects the incidence of corporate failure. Having identified a significant connection between the tax burden and firm survival, we explore more in detail whether the pattern and magnitude of this relationship differ when we differentiate between types of firms.

- First, we classify a firm as young (or old) in a given year if its age falls into the bottom (or top) half of the age distribution of all firms operating in the same industry in that year, and, as presented in Table 5, find that the magnitude of the coefficient on EMTR for old firms is almost five times greater than that for young firms. In other words, taxation has a significantly greater effect on the probability of failure as firms age over time.

- Second, we split the sample into small and large firms by classifying companies with total assets in the lowest quartile as small and those in the highest quartile as large and, as displayed in Table 5, find that the tax burden has a greater adverse impact on firm survival among large firms than smaller enterprises and relative to the baseline coefficient estimate.

- Third, estimating the probability of firm failure at the sectoral level, we observe a significant degree of heterogeneity in the impact of taxation. As presented in Table 6, while the coefficient on the firm-specific EMTR is consistently positive and statistically significant across all sectors (except real estate), its magnitude varies from the minimum of 1.6 for accommodation and food services to the maximum of 8.7 for information technology and manufacturing. These results indicate that the corporate tax burden has a greater impact on the survival prospects of firms operating in capital intensive sectors such as information technology and manufacturing.

- Fourth, we introduce a personal income tax (PIT) rate to control for its potential impact, since employees may gain from a more favorable rate by moving their earnings into or from the corporate tax base. These results, presented in Appendix Table A2, show that the effect of EMTR on firm survival remains negative and significant even when we include the PIT rate as an additional control variable.

Table 5. Firm Survival—Effects of Age and Size

Variables	Young	Old	Small	Large
Dependent variable: Probability of failure				
Age	-0.285*** [0.004]	-0.187*** [0.006]	-0.216*** [0.003]	-0.378*** [0.004]
Size	-0.016*** [0.002]	-0.055*** [0.002]	-0.125*** [0.005]	0.079*** [0.005]
Profitability	-1.455*** [0.015]	-1.562*** [0.018]	-1.089*** [0.012]	-4.698*** [0.045]
Capital Intensity	-0.094*** [0.002]	-0.082*** [0.002]	-0.048*** [0.002]	-0.087*** [0.003]
TFP	-0.081*** [0.004]	-0.184*** [0.004]	-0.154*** [0.005]	-0.023*** [0.006]
Leverage	0.318*** [0.010]	0.519*** [0.012]	0.267*** [0.011]	0.526*** [0.017]
EMTR	1.458*** [0.149]	6.494*** [0.149]	3.472*** [0.185]	4.132*** [0.192]
# of observations	5,394,715	7,482,579	2,344,254	3,662,299
# of firms	1,707,355	1,371,568	879,179	739,288
# of failures	235,760	211,223	126,153	92,031
Fixed effects	Yes	Yes	Yes	Yes
Wald test	37,803	29,729	23,731	25,719
Log-likelihood	-2,141,818	-1,989,740	-1,055,296	-790,808

Note: Standard errors clustered at the firm level are displayed in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Firm Survival—Estimations by Sector

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable: Probability of failure								
Age	-0.383***	-0.338***	-0.379***	-0.243***	-0.338***	-0.319***	-0.278***	-0.244***	-0.285***
	[0.007]	[0.005]	[0.012]	[0.004]	[0.007]	[0.012]	[0.010]	[0.027]	[0.004]
Size	-0.119***	-0.004	-0.020***	-0.026***	0.009**	0.025***	-0.052***	0.020	-0.032***
	[0.006]	[0.004]	[0.007]	[0.004]	[0.005]	[0.008]	[0.009]	[0.019]	[0.003]
Profitability	-1.044***	-1.689***	-1.298***	-1.897***	-1.302***	-1.088***	-1.448***	-1.257***	-1.449***
	[0.027]	[0.040]	[0.076]	[0.051]	[0.036]	[0.064]	[0.079]	[0.096]	[0.036]
Capital Intensity	-0.063***	-0.105***	-0.012*	-0.102***	-0.043***	-0.127***	-0.118***	-0.050***	-0.088***
	[0.005]	[0.003]	[0.007]	[0.004]	[0.004]	[0.006]	[0.006]	[0.017]	[0.002]
TFP	-0.357***	0.049***	0.015	-0.270***	-0.063***	-0.042***	-0.018*	-0.103***	-0.301***
	[0.012]	[0.007]	[0.013]	[0.010]	[0.007]	[0.010]	[0.010]	[0.035]	[0.008]
Leverage	0.155***	0.608***	0.335***	0.453***	0.186***	0.192***	0.282***	0.219**	0.395***
	[0.018]	[0.020]	[0.046]	[0.020]	[0.028]	[0.044]	[0.041]	[0.105]	[0.014]
EMTR	1.551***	1.224***	8.701***	8.667***	5.681***	-0.055	7.928***	3.183***	3.145***
	[0.252]	[0.267]	[0.744]	[0.259]	[0.336]	[0.387]	[0.497]	[1.201]	[0.167]
# of observations	869,025	2,135,058	414,096	2,972,510	1,181,842	369,748	591,338	110,736	4,232,941
# of firms	201,373	449,297	93,164	498,552	278,009	89,263	117,346	20,704	807,978
# of failures	34,970	89,114	15,634	91,824	38,850	12,721	18,001	2,547	143,322
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald test	13,026	18,487	2,254	19,227	5,208	2,809	3,832	372	33,019
Log-likelihood	-329,812	-902,116	-129,581	-928,259	-361,147	-103,316	-153,248	-16,892	-1,505,110

Note: Standard errors clustered at the firm level are displayed in brackets. *** p<0.01, ** p<0.05, * p<0.1. The columns represent the following sectors: (1) Accommodation and food services, (2) Construction, (3) Information technology, (4) Manufacturing, (5) Professional and administrative activities, (6) Real estate, (7) Transportation and storage, (8) Utilities, (9) Wholesale and retail trade. The mining sector is excluded due to the small number of firm-year observations.

- Fifth, we estimate the probability of firm survival using alternative methodologies, including accelerated failure time (AFT) models. As opposed to Cox proportional hazard model, in which covariates have a uniform shift effect on the survival curve, the AFT models allow covariates to have a multiplicative effect on the survival time (Orbe and others, 2002; Patel and others, 2006; Ali and others, 2015). These findings, presented in Appendix Table A2, are consistent with our baseline findings.

- Lastly, we estimate the multilevel mixed-effects parametric survival model with both fixed effects and random effects, which is not possible in the Cox and AFT models because of computational limitations. These results, also presented in Appendix Table A2, are in line with the baseline findings (based on the Cox proportional hazard model) and other robustness checks.

V. CONCLUSION

This paper is to shed light on how taxation affects the probability of firm survival across countries and over time. There is a vast and growing literature on corporate failures, but no paper has analyzed the quantitative effect of tax burden on firms' survival prospects in a broad panel of advanced and developing countries. In this paper, we analyze the probability of failure among more than 4 million nonfinancial firms from 21 countries during the period 1995–2015, using a Cox proportional hazard model and controlling for firm characteristics and systematic differences across sectors and countries. The results indicate that the corporate tax burden—as measured by the firm-specific EMTR—exerts a highly significant adverse effect on companies' survival prospects with a non-linear pattern. Put differently, a lower level of EMTR increases the survival probability among nonfinancial firms in our sample. This finding is not only statistically but also economically important and remains robust when we partition the sample into country subgroups. We run the estimation on separate samples and find that the adverse effects of taxation on firms' survival prospects appears stronger in developing countries than advanced economies, but data constraints limit the extent of the analysis.

We provide robust evidence indicating that the impact of taxation on firm survival becomes detrimental at higher levels. Digging deeper into the tax sensitivity of firm survival, we uncover a nonlinear relationship between the firm-specific EMTR and the probability of corporate failure, which implies that taxation becomes a detriment to firm survival at higher levels. With regards to the impact of other firm characteristics, we obtain results that are in line with previous research and see that survival probability differs depending on firm age and size, with older and larger firms experiencing a lower risk of failure. Focusing on the financial health, we find that the probability of failure diminishes with the degree of profitability but increases with the level of indebtedness. Similarly, concerning firm structure and performance, we document that capital intensity and TFP play a significant role in reducing the probability of failure among over 4 million nonfinancial firms in the sample.

Well-designed tax systems can enhance efficiency and encourage investment that foster innovation and job creation. The empirical analysis presented in this paper demonstrate that taxation unmistakably plays an important role in determining the pattern of failures among nonfinancial firms across advanced and developing countries. This finding has important policy implications for the design of tax systems, since the firm-specific EMTR encapsulates not only the differences in the overall tax burden across countries, but also the discriminatory nature of tax regimes across sectors and types of firms. A coherent and fair approach to business taxation is important to reduce legal uncertainty and distortions in resource allocation faced by firms. Reforms in tax policy and revenue administration should therefore be designed to cut the costs of compliance, facilitate entrepreneurship and innovation, and encourage alternative sources of financing by particularly addressing the corporate debt bias. In this context, the EMTR holds a special key by influencing firms' investment decisions and the probability of survival over time, especially in capital intensive sectors of the economy. Importantly, the challenge for policymakers is not simply reducing the statutory CIT rate, but to level the playing field for all firms by rationalizing differentiated tax treatments across sectors, capital asset types and sources of financing.[5]

[5]As argued in IMF (2017), the complete elimination of differences in tax treatments across firms is not feasible or desirable, as tax policy should aim to influence resource allocation when firms ignore externalities such as excessive carbon emissions or underinvestment in research and development.

REFERENCES

Agarwal, R., 1997, "Survival of firms Over the Product Life Cycle," Southern Economic Journal, Vol. 63, pp. 571–584.

Agarwal, R., and D. Audretsch, 2001, "Does Entry Size Matter? The Impact of the Life Cycle and Technology on Firm Survival," *Journal of Industrial Economics*, Vol. 49, pp. 21–43.

Agarwal, R., and M. Gort, 2002, "Firm and Product Life Cycles and Firm Survival," *American Economic Review*, Vol. 92, pp. 184–190.

Aghion, P., Akcigit, U., Cage, J. and Kerr, W. 2016, "Taxation, Corruption, and Growth," *European Economic Review*, Vol. 86, pp. 24–51.

Ali, Z., M. Hosseini, M. Mahmoodi, K. Mohammad, H. Zeraati, and K. Naieni, 2015, "A Comparison Between Accelerated Failure-Time and Cox Proportional Hazard Models in Analyzing the Survival of Gastric Cancer Patients," *Iranian Journal of Public Health*, Vol. 44, p.1095-1102.

Audretsch, D., 1991, "New-Firm Survival and the Technological Regime," *Review of Economics and Statistics*, Vol. 60, pp. 441-450.

Audretsch, D., and T. Mahmood, 1995, "New Firm Survival: New Results Using a Hazard Function," *Review of Economics and Statistics*, Vol. 72, pp. 97-103.

Auerbach, A., 1983, "Taxation, Corporate Financial Policy, and the Cost of Capital," *Journal of Economic Literature*, Vol. 21, pp. 905-940.

Barro, R., 1990, "Government Spending in a Simple Model of Endogenous Growth," *Journal of Political Economy*, Vol. 98, pp. 103–126.

Benedek, D., N. Budina, P. Deb, B. Gracia, S. Saksonovs, and A. Shabunina, 2017, "The Right Kind of Help? Tax Incentives for Staying Small," IMF Working Paper No. 17/139 (Washington, DC: International Monetary Fund).

Bond, S., J. Elston, J. Mairesse, and B. Mulkay, 2003, "Financial Factors and Investment in Belgium, France, Germany, and the United Kingdom: A Comparison Using Company Panel Data," *Review of Economics and Statistics*, Vol. 85, pp. 153–165.

Bridges, S., and A. Guariglia, 2008, "Financial Constraints, Global Engagement, and Firm Survival in the U.K.: Evidence from Micro Data," *Scottish Journal of Political Economy*, Vol. 55, pp. 444-464.

Bunn, P., and V. Redwood, 2003, "Company Accounts Based Modelling of Business Failures and the Implications for Financial Stability," Bank of England Working Paper No. 210 (London: Bank of England).

Byrne, J., M. Spaliara, and S. Tsoukas, 2016, "Firm Survival, Uncertainty, and Financial Frictions: Is There a Financial Uncertainty Accelerator?" *Economic Inquiry*, Vol. 54, pp. 375–390.

Cevik, S., and F. Miryugin, 2018, "Does Taxation Stifle Corporate Investment? Firm-Level Evidence from ASEAN Countries," *Australian Economic Review*, Vol. 51, pp. 1-17.

Chirinko, R., S. Fazzari, and A. Meyer, 1999, "How Responsive is Business Capital to User Cost? An Exploration with Micro Data," *Journal of Public Economics*, Vol. 74, pp. 53-80.

Clementi, L. and H. Hopenhayn, 2006, "A Theory of Financing Constraints and Firm Dynamics," *Quarterly Journal of Economics*, Vol. 54, pp. 229–265.

Cox, D., 1972, "Regression Models and Life Tables," *Journal of the Royal Statistical Society*, Vol. 34, pp. 187-202.

Cox, D., and D. Oakes, 1984, *Analysis of Survival Data* (London: Chapman and Hall).

Devereux, M., and R. Griffith, 1998, "The Taxation of Discrete Investment Choices," IFS Working Paper No. 98/16 (London: Institute for Fiscal Studies).

Devereux, M., and R. Griffith, 2003, "Evaluating Tax Policy for Location Decisions," *International Tax and Public Finance*, Vol. 10, pp. 107-126.

Egger, P., S. Loretz, M. Pfaffermayr, and H. Winter, 2009, "Firm-Specific Forward-Looking Effective Tax Rates," *International Tax and Public Finance*, Vol. 16, pp. 850-870.

Evans, D., 1987, "The Relationship Between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries," *Journal of Industrial Economics*, Vol. 35, pp. 567-581.

Gal, P., 2013, "Measuring Total Factor Productivity at the Firm Level Using OECD-ORBIS," OECD Economics Department Working Paper No. 1049 (Paris: Organization for Economic Co-operation and Development).

Gal, P., and A. Hijzen, 2016, "The Short-term Impact of Product Market Reforms: A Cross-Country Firm-level Analysis," IMF Working Paper No. 16/116 (Washington, DC: International Monetary Fund).

Gilchrist, S., and E. Zakrajsek, 2007, "Investment and the Cost of Capital: New Evidence from the Corporate Bond Market," NBER Working Paper No. 1317 (Cambridge, MA: National Bureau of Economic Research).

Hall, B., 1987, "The Relationship Between Firm Size and Firm Growth in the US Manufacturing Sector," *Journal of Industrial Economics*, Vol. 35, pp. 583–606.

Hall, R., and D. Jorgenson, 1967, "Tax Policy and Investment Behavior," *American Economic Review*, Vol. 57, pp. 391-414.

Hayashi, F., 1982, "Tobin's Marginal and Average Q: A Neoclassical Interpretation," *Econometrica*, Vol. 50, pp. 213-224.

Helmers, C., and M. Rogers, 2010, "Innovation and the Survival of New Firms in the UK," *Review of Industrial Organization*, Vol. 36, pp. 227-248.

Hubbard, G., 1998, "Capital Market Imperfections and Investment," *Journal of Economic Literature*, Vol. 36, pp. 193-225.

International Monetary Fund, 2017, "Upgrading the Tax System to Boost Productivity," Fiscal Monitor, Chapter II, April 2017 (Washington, DC: International Monetary Fund).

Kalemli-Ozcan, S., L. Laeven, and D. Moreno, 2015, "Debt Overhang in Europe: Evidence from Firm-Bank-Sovereign Linkages," University of Maryland Working Paper (College Park, MD: University of Maryland).

Kalemli-Ozcan, S., B. Sorensen, C. Villegas-Sanchez, V. Volosovych, and S. Yesiltas, 2015, "How to Construct Nationally Representative Firm Level Data from the ORBIS Global Database," NBER Working Papers No. 21558 (Cambridge, MA: National Bureau of Economic Research).

King, M., and D. Fullerton, 1984, *The Taxation of Income from Capital* (Chicago: University of Chicago Press).

Kleinbaum, D., and M. Klein, 2005, *Survival Analysis: A Self-Learning Text* (New York: Springer).

Levinsohn, J., and A. Petrin, 2003, "Estimating Production Functions Using Inputs to Control for Unobservables," *Review of Economic Studies,* Vol. 70, pp. 317-341.

Mata, J., and P. Portugal, 1994, "Life Duration of New Firms," *Journal of Industrial Economics*, Vol. 42, pp. 227-245.

Musso, P., and S. Schiavo, 2008, "The Impact of Financial Constraints on Firm Survival and Growth," *Journal of Evolutionary Economics*, Vol. 15, pp. 135-149.

Orbe, J., E. Ferreira, and V. Núñez-Antón, 2002, "Comparing Proportional Hazards and Accelerated Failure Time Models for Survival Analysis," *Statistics in Medicine*, Vol. 21, pp. 3493-3510.

Patel, K., Kay, R. and Rowell, L., 2006, "Comparing Proportional Hazards and Accelerated Failure Time Models: An Application in Influenza," *Pharmaceutical Statistics: The Journal of Applied Statistics in the Pharmaceutical Industry*, Vol. 5, pp. 213-224.

Ribeiro, P., S. Menghinello, and K. De Backer, 2010, "The OECD ORBIS Database: Responding to the Need for Firm-Level Micro-Data in the OECD," OECD Statistics Working Papers, No. 2010/01 (Paris: Organization for Economic Co-operation and Development).

Schaller, H., 2006, "Estimating the Long-Run User Cost Elasticity," *Journal of Monetary Economics*, Vol. 53, pp. 725-736.

Summers, L., 1981, "Taxation and Corporate Investment: A Q-Theory Approach," *Brookings Papers on Economic Activity*, Vol. 12, pp. 67-127.

Tobin, J., 1969, "A General Equilibrium Approach to Monetary Theory," *Journal of Money, Credit and Banking*, Vol. 1, pp. 15-29.

Zingales, L., 1998, "Survival of the Fittest or the Fattest? Exit and Financing in Trucking Industry," *Journal of Finance*, Vol. 53, pp. 905-938.

Appendix Table A1. List of Countries

Country	Number of firms	Percent of total number of firms	Number of observations	Percent of total number of observations
Advanced Economies				
Belgium	22,340	0.6	173,927	0.8
Czech Republic	100,705	2.5	582,179	2.7
Estonia	35,130	0.9	238,723	1.1
Finland	87,472	2.2	527,078	2.5
France	739,297	18.4	3,755,091	17.5
Germany	43,556	1.1	163,211	0.8
Italy	774,463	19.2	4,186,215	19.5
Korea	190,408	4.7	680,180	3.2
Norway	76,930	1.9	111,179	0.5
Portugal	261,315	6.5	1,383,457	6.5
Slovak Republic	66,949	1.7	339,876	1.6
Slovenia	37,940	0.9	166,070	0.8
Spain	831,494	20.7	5,285,465	24.6
Sweden	142,390	3.5	949,769	4.4
Subtotal	**3,410,389**	**84.7**	**18,542,420**	**86.4**
Emerging Economies				
Bulgaria	59,108	1.5	248,636	1.2
Croatia	83,238	2.1	592,858	2.8
Hungary	18,899	0.5	59,009	0.3
Poland	42,045	1.0	119,216	0.6
Romania	296,735	7.4	1,444,237	6.7
Serbia	53,171	1.3	244,295	1.1
Ukraine	63,063	1.6	200,054	0.9
Subtotal	**616,259**	**15.3**	**2,908,305**	**13.6**
Total	**4,026,648**	**100.0**	**21,450,725**	**100.0**

Source: Orbis; authors' calculation.

Appendix Table A2. Robustness Checks

Variables	Alternative Models			Additional Controls	
	Gompertz (PH)	Exponential (PH/AFT)	Log-logistic (AFT)	PIT	Mixed Effects
Age	-0.396***	-0.306***	-0.427***	-0.267***	-0.188***
	[0.003]	[0.002]	[0.002]	[0.003]	[0.002]
Size	0.053***	0.046***	0.064***	0.017***	0.016***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.008]
Profitability	-1.397***	-1.413***	-1.762***	-1.448***	-1.689***
	[0.029]	[0.030]	[0.008]	[0.015]	[0.007]
Capital Intensity	-0.112***	-0.103***	-0.088***	-0.098***	-0.088***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
TFP	-0.160***	-0.155***	-0.092***	-0.196***	-0.168***
	[0.003]	[0.003]	[0.002]	[0.002]	[0.002]
Leverage	0.188***	0.189***	0.108***	0.240***	0.389***
	[0.011]	[0.010]	[0.006]	[0.008]	[0.007]
EMTR	9.366***	7.986***	8.560***	7.072***	5.578***
	[0.105]	[0.058]	[0.058]	[0.067]	[0.030]
PIT rate				0.032***	
				[0.000]	
# of observations	11,639,304	11,639,304	11,639,304	11,401,501	11,639,304
# of firms	2,380,710	2,380,710	2,380,710	2,297,867	2,380,710
# of failures	667,550	667,550	667,550	429,747	667,550
Cluster	Firm	Firm	Firm	Firm	
Wald test	111,685	170,362	335,391	116,671	253,034
Log-likelihood	-1,761,534	-1,770,586	-1,721,012	-4,202,494	-4,055,095

Note: Standard errors are displayed in brackets. *** p<0.01, ** p<0.05, * p<0.1. PH denotes the proportional hazards model; AFT denotes the accelerated failure time model.