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Survival and the ergodicity of corporate profitability*

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Abstract

The cross-sectional variation in corporate profitability has occupied research across fields as diverse as strategic management, industrial organization, finance, and accounting. Prior work suggests that corporate idiosyncrasies are important determinants of profitability, but it disagrees on the quantitative importance of particular effects. This paper shows that corporate specificities become irrelevant in the long run because profitability is ergodic conditional on survival, leading to a uniform, time-invariant regularity in profitability that applies across firms. Conditional on survival, we cannot reject the hypothesis that corporations are on average equally profitable and also experience equally volatile fluctuations in their profitability, irrespective of their individual characteristics. Since the same is not true for shorter-lived firms, even for more than twenty years after entry, we can reconcile our findings with an extensive literature that studies profitability in heterogeneous samples of surviving and shorter-lived firms. Our findings provide a new benchmark for long-term performance in competitive environments, and offer a novel perspective by highlighting a robust commonality instead of specificities.

JEL classifications: C14, L10, D21, E10.
Keywords: Performance, dynamic competition, corporate strategy, stochastic differential equation.

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1 Introduction

We revisit the longstanding debate on how corporate idiosyncrasies affect profitability, finding that idiosyncrasies correlate with profitability for shorter-lived firms but surprisingly have no impact on surviving firms, whose profitability is ergodic. Here ergodicity refers to the notion that we cannot statistically distinguish the moments of the cross-sectional distribution of survivors' return on assets (ROA) from the moments of their individual ROA time series. Not only do survivors exhibit the same profitability on average, they also experience equally volatile fluctuations in their profitability. Our findings thus depart from an extensive literature across fields as diverse as strategic management, industrial organization, finance, and accounting that investigates the dynamics and cross-sectional properties of corporate profitability. The literature observes that various idiosyncrasies have a systematic influence on profitability and imply persistent cross-sectional variation in corporate ROA, in particular year, industry, business-unit, and corporate-parent effects. We argue here that the influence of such effects disappears after about two and a half decades of survival, revealing an almost universal regularity that is invariant over time and across firms.

Since the perpetual flux of companies into and out of the market obscures this regularity in corporate profitability, our empirical analysis emphasizes the destinies of surviving corporations to uncover it. In spite of the fact that few corporations survive the proverbial gales of creative destruction for more than a couple of decades (Fama and French, 2004), creative destruction apparently occurs more in name than in substance because transfers of ownership are responsible for the vast majority of corporate 'mortality,' while bankruptcy and liquidation historically account for merely eight percent of corporate deaths (Daepp et al., 2015). This leads to a striking continuity in corporate capital over time and renders surviving firms as worthwhile objects of economic investigation. Moreover, according to the granular hypothesis (Acemoglu et al., 2012; Gabaix, 2011), long-lived corporations are relevant for understanding how sizable economy-wide fluctuations can arise from idiosyncratic shocks to the largest and most interconnected firms in the economy. Concerns of survivorship bias, however, have traditionally prevented exclusive interest in the subset of long-lived firms, and so far we know surprisingly little about the granular capital that has accumulated over time in surviving corporations.[1] To fill this void, Alfarano et al. (2012) and Mundt et al. (2016) have studied the distributional

[1] As far as corporate survival is concerned, the contested questions have typically revolved around whether executives prioritize the maximization of profits over survival or whether they even care for corporate survival. Recent contributions show that survival is both of theoretical and empirical relevance. Dutta and Radner (1999) demonstrate under reasonably weak assumptions that profit-maximizing corporations will go bankrupt almost surely in finite time such that over longer horizons none of the surviving firms could have been maximizing profits, while Oprea (2014) shows in a closely related experimental setup that individual subjects exhibit a widespread bias towards survival even after controlling for standard risk aversion.

and temporal properties of survivors' ROA, finding both to be remarkably stable over time and across firms.

The present paper makes three additional contributions. First, we discuss the origin of this stability, which lies in the ergodicity of corporate ROA. Using a heterogeneous sample of firms across nearly all industries of the US economy, we motivate the ergodic hypothesis by showing that firm-specific estimates of average profitability and volatility converge to the cross-sectional expectation and dispersion of ROA when survival time becomes sufficiently large. The ergodic hypothesis entails a fundamental change in the modeling of corporate profitability because it implies that the cross-sectional moments of a given year reflect survivors' individual destinies over time, such that a dynamic characterization of corporate profitability can be replaced with a simpler probabilistic description that is time-invariant (see Peters, 2019, for a recent discussion of ergodicity and the historical disregard for it in most economic models). Actually, we are not aware of other economic or financial observables that exhibit this peculiar property. It is well-known, for example, that the volatility of firm growth rates depends on firm size (Bottazzi and Secchi, 2003; Stanley et al., 1996), even for surviving firms (Mundt et al., 2016), suggesting that time series moments of growth rates vary systematically across companies and thus do not coincide with cross-sectional moments. The corporate ROA is a distinctive ratio that transforms the (non-ergodic) level of operating income into an ergodic observable when dividing by (non-ergodic) total assets, indicating its importance for the system of competitive firms as it leads to an almost universal, time-independent regularity. A corollary to the ergodic hypothesis is that the evolution of survivors' ROA is reasonably well captured by one and the same stochastic differential equation (SDE), first introduced in Alfarano et al. (2012). We interpret this SDE as a reduced-form model of competition in the classical sense of a perpetual reallocation of capital in search of abnormal profits, ultimately resulting in a constant dispersion of ROA around a systemic rate of return.

Second, we provide an empirical assessment of the ergodic hypothesis and test its stark and unexpected implication that corporate idiosyncrasies are irrelevant for the time evolution of surviving corporations' profitability. Our results support the coincidence of cross-sectional and individual time series distributions of ROA and testify to a uniform long run rate of profit and, even more unexpectedly, an almost uniform volatility in surviving capital.

Third, we reconcile our findings with previous work by investigating whether the profitability of shorter-lived firms is also independent of idiosyncrasies. Contrary to long-lived firms, dependencies between profitability and corporate characteristics do exist for shorter-lived firms, explaining the different views in the extant literature (reviewed in A.1) that usually considers heterogeneous mixtures of surviving and shorter-lived firms.

2 Data

Our data are taken from Datastream Worldscope and consist of 5,313 publicly traded US companies. The unbalanced sample covers the period 1980-2012 and includes companies from around six hundred (4-digit) SIC industries, merely excluding banking corporations because their balance sheets differ structurally from other industries, which reduces the sample size by less than one percent to 5,266 firms, with a total of 75,692 firm-year observations. Depending on the year, the number of firms in the sample varies between 543 in 1980 and 4,249 in 2008, with an average of 2,293 observations per year. Considering the individual time series, the average firm remains in the surveyed population for approximately 14 years, and 498 firms in the sample survive over the entire period 1980-2012. While these firms represent 9.5% of firms in the sample, they account on average for 72% of total assets, 75% of market capitalization, and 74% of employment in the sample.

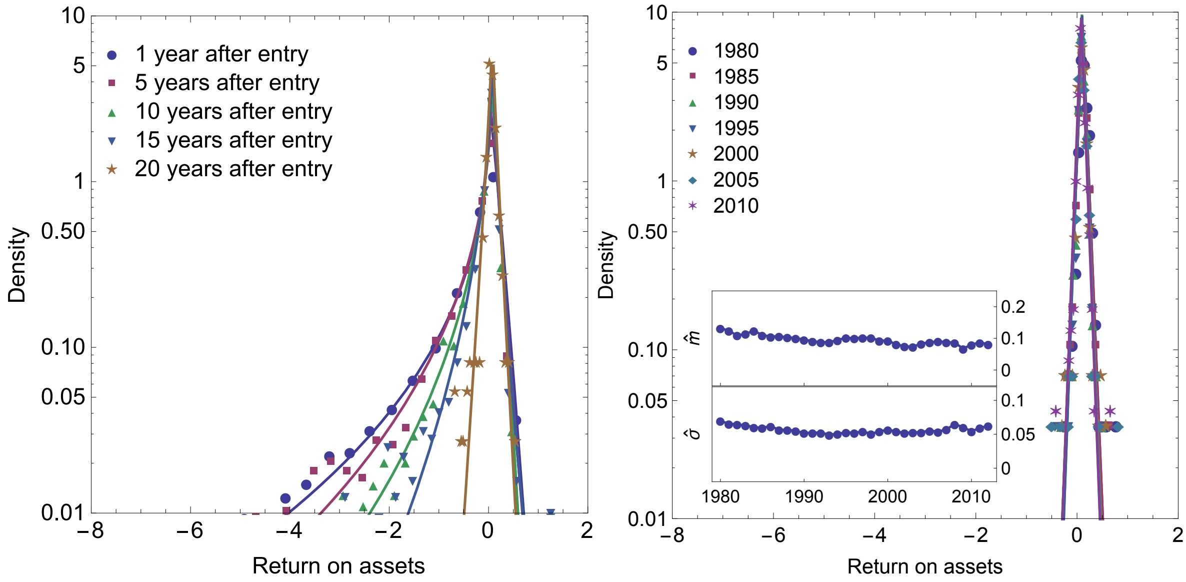
At the center of our investigation are annual corporate profit rates, measured by the ratio of operating income to total assets in a given year, and henceforth denoted by $x \in \mathbb{R}$. Regarding individual corporate characteristics, we retrieve additional variables including common equity, total liabilities consisting of long-term and short-term debt, sales, number of employees, and stock market prices. To investigate the effect of industry concentration on corporate profitability, we employ 4-digit SIC codes.

While concerns of survivorship bias have obstructed exclusive interest in long-lived firms, the explicit focus on surviving (and mostly granular) capital is a major novelty in the present study. The sample period includes different phases of the business cycle and even several crises, so our results should not be driven by the choice of sample period. In addition to surviving corporations, the sample also includes a large number of shorter-lived firms with heterogeneous lifespans, and we will argue that sample heterogeneity is crucial for understanding the divergent views between our study and prior work. Finally, the sample covers a wide range of different industries and provides a rather comprehensive view of the US economy.

3 Motivation of the ergodic hypothesis

This section discusses the ergodic hypothesis for the profitability of surviving companies that motivates our reduced-form model in Section 4. Ergodicity implies that the individual estimates of average profitability and volatility over time are identical across firms and coincide with the ensemble moments at any point in time, pointing to a common and time-invariant law of motion governing the profitability of surviving firms.

To motivate the ergodic hypothesis, we study our data from a time series and a cross-sectional perspective, focusing on the role of survival for the observed regularities. The two perspectives provide complementary views on the profitability of companies.



(a) Entering firms

(b) Surviving firms

Figure 1: Cross-sectional ROA distribution for entrants (a) and surviving companies (b). Solid lines in (a) represent a fit with an asymmetric exponential power distribution (Bottazzi and Secchi, 2011), while the distributions in (b) are fitted with the symmetric Laplace in Eq. (1). Parameter estimates of the latter are shown in the inset of panel (b).

While the cross-sectional ROA distribution defines the space of possible outcomes and their respective probabilities at a given point in time, the ROA time series is more relevant for stakeholders as it captures individual destinies over time. Only under ergodicity can we employ the cross-sectional distribution in a given year to draw inferences on individual trajectories because both perspectives are then equivalent. If the time series moments vary across firms and potentially relate systematically to firms' individual characteristics, the cross-sectional moments would not represent individual destinies and lead to a non-ergodic system.

First we consider the cross-sectional properties of corporate profitability in Fig. 1 and compare the results for entrants (panel a) and survivors (panel b). The cross-sectional ROA distribution for entering firms exhibits a leptokurtic left tail that prevails for more than twenty years after entry. The tail thins out considerably and the distribution becomes more symmetric as firms continue to survive, implying that the space of possible ROA outcomes depends on survival time. The cross-sectional distribution for the 498 companies that survive over the entire sample period 1980-2012 is symmetric and reasonably approximated by the Laplace distribution

$$L(x;m,\sigma) = \frac{1}{2\sigma}\exp\left(-\left|\frac{x-m}{\sigma}\right|\right), \tag{1}$$

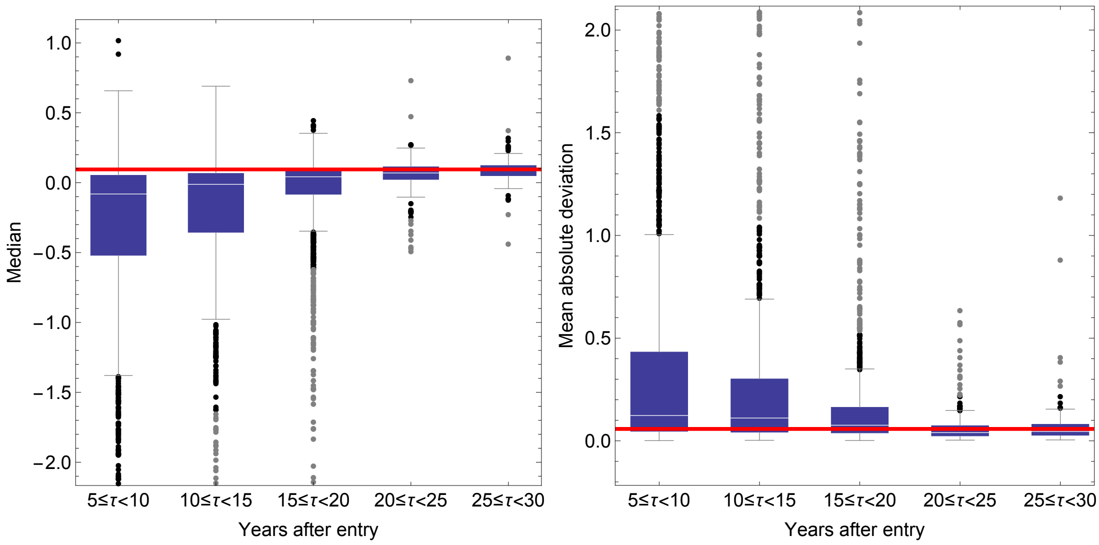


Figure 2: Box plots of time series median and mean absolute deviation from the median as a function of years after entry. The red horizontal lines represent the phenomenological values $\hat{m} = 0.0947 \pm 0.0005$ (left) and $\hat{\sigma} = 0.0581 \pm 0.0005$ (right) obtained from the pooled cross-sectional profit rate distribution for surviving firms.

which exhibits a linear tent-shape on semi-logarithmic scale.[2] To illustrate the time stability of this empirical regularity conditional on survival, Fig. 1 (b) shows the distribution for seven different years of the sample period, and also reports the annual maximum likelihood (ML) estimates of the Laplace location parameter m and the scale parameter σ for all years from 1980 to 2012. The ML estimators correspond to the sample median and the sample mean absolute deviation from the median (see, e.g., Kotz et al., 2001). Since both the functional form and the parametrization of this distribution are stable over time, the different annual distributions virtually collapse upon the same curve as in Fig. 1 (b), suggesting that the state space is invariant conditional on survival. We thus pool the ROA realizations of all surviving firms across all years and obtain parameter estimates $\hat{m} = 0.0947 \pm 0.0005$ and $\hat{\sigma} = 0.0581 \pm 0.0005$, henceforth referred to as the phenomenological values of the location and scale parameters, so the cross-sectional median ROA of surviving corporations is around 9.5% per year with a cross-sectional mean absolute deviation of around 5.8% per year.

A complementary perspective to the cross-sectional analysis in Fig. 1 is provided in Fig. 2, which shows estimates of the median and the mean absolute deviation obtained from individual time series as a function of the survival time, say $\tau = \{1, 5, 10, 15, 20\}$ years after entry. Our main point here is that for increasing survival times the individual time series moments are not only less dispersed across firms but also converge to the phenomenological values obtained from the cross-sectional distribution, shown as red lines in Fig. 2. While consistent with the ergodic hypothesis, this finding is at odds with the

[2] Prior work confirmed the Laplacian shape of the cross-sectional ROA distribution based on different goodness-of-fit tests (see, e.g., Alfarano et al., 2012; Mundt et al., 2020).

idea that average profitability and volatility depend systematically on industry and firm-level specificities. The latter would imply that firm-specific moments converge to different long-run values and that the cross-sectional distribution of ROA is not representative of individual time series.[3] In contrast, new firms exhibit substantial variation in their time series moments over the first twenty years of their lifespan, indicating that ergodicity only applies to the profitability of surviving corporations.

Building on these empirical regularities, the next section reviews a model for the evolution of survivors' ROA that is consistent with the ergodicity of profitability.

4 Reduced-form model

This section reviews a relatively general model of survivors' profitability, originally proposed by Alfarano et al. (2012). The model encodes the reduced-form dynamics of profitability through a mean-reverting stochastic differential equation (SDE) with a stationary Laplace density, built on the classical idea that competition tends to equalize ROA. As we will see momentarily, the ergodic hypothesis implies a specific parametrization of the SDE, prescribing a common central tendency and volatility for all surviving firms irrespective of their individual characteristics.

The number of stochastic processes that have the Laplace distribution in Eq. (1) as its stationary density is in principle infinite. Heeding the dictum of parsimony and relying on a considerable analytical apparatus that is in place for SDEs, Alfarano et al. (2012) construct the following nonlinear SDE for the time evolution of ROA $\{X_t\}_{t=0}^{T}$ for firm i

$$dX_t = -\frac{D_i}{2\sigma_i}\,\mathrm{sgn}(X_t - m_i)dt + \sqrt{D_i}\,dW_t \tag{2}$$

such that it results in a stationary Laplace density. Eq. (2) defines a regular diffusion on the real line around the measure of central tendency m_i with dispersion σ_i, where the constant diffusion function $\sqrt{D_i}$ that scales the Wiener increments dW_t determines how rapidly the process fluctuates. From an economic viewpoint, the process can be interpreted as a reduced-form model of dynamic competition in the classical sense of a perpetual reallocation of capital in search of abnormal profits, which leads to a tendency for profit rate equalization that is captured by the mean-reverting first term. The functional form of the stationary Laplace in Eq. (2) implies that the systematic drift toward average profitability is constant and equal to $D_i/2\sigma_i$, while its sign depends on the difference between current and average profitability via the signum function. The stochastic innovations from the diffusion function in the second term can be interpreted as idiosyn-

[3] Using an almost identical dataset, Livan et al. (2014) show that cross-sectional correlations in the profitability of surviving corporations are negligible. This rules out the alternative interpretation that the remarkable homogeneity in survivors' time series moments is merely an artifact of cross-sectional correlations.

cratic corporate efforts in the competitive process. The idiosyncratic noise level D_i shows up in both the deterministic drift and the random diffusion function, indicating that idiosyncratic efforts and the tendency for profit rate equalization are intertwined aspects of the same competitive mechanism. For survivors, the idiosyncratic noise D_i does not affect the stationary outcome in Eq. (1), yet it is crucial for the competitive mechanism because eliminating the noise (by setting $D_i = 0$) removes the mean-reverting tendency in the drift function. Moreover, D_i also determines the time scale of fluctuations around the average profitability m_i.

Under ergodicity, the functional form of the cross-sectional and time series distributions must be the same (here stationary Laplace) and the firm-specific parameters m_i and σ_i in Eq. (2) representing the individual time series of firm i must be consistent with the cross-sectional parameters m and σ from the ensemble distribution in Eq. (1). So we close the model by assuming that cross-sectional and time series moments are identical, i.e. $m_i = m$ and $\sigma_i = \sigma \; \forall i = 1, \ldots, N$. This follows from the ergodic hypothesis, and leaves D_i as the only source of idiosyncratic variation in the time evolution of profitability.[4]

5 Testing the ergodic hypothesis

To assess the empirical validity of the ergodic hypothesis, we test whether annual cross-sectional and individual time series distributions of corporate ROA are indeed statistically indistinguishable conditional on survival. We employ the two-sample Kolmogorov-Smirnov (KS hereafter) test because it does not depend on the functional form and particular parametrization of the distributions under scrutiny. The persistence and mean-reversion in corporate profitability lead to significant autocorrelations, so the standard critical values of the KS test need to be modified because they are highly sensitive to serially correlated data (Weiss, 1978). To address this problem, we compute firm-specific critical values from Monte Carlo simulations of our reduced-form model that account for individual autocorrelations in ROA through the drift function (see section A.2 in the Online Appendix for details).

We then compute the KS statistics for all pairs of firm time series and annual cross-sectional distributions from 1980 to 2012. Under ergodicity, a rejection of the null hypothesis for a time series and the cross-sectional distribution of a given year implies rejections for that time series and all annual cross-sectional distributions. Put differently,

[4]Note that stationarity of a process does not imply ergodicity, as a simple counterexample illustrates. For instance, Eq. (2) would not be consistent with an ergodic system if the ROA time series of n firms, indexed by i, were samples from different stationary Laplace distributions with firm-specific parameters m_i and σ_i. In this case the ROA time series of each firm will have its respective stationary Laplace distribution, but the system will be non-ergodic because the cross-sectional distribution depends on the distribution of m_i and σ_i, and is thus not representative of either of the n firms.

firms that are rejected in a given year should be rejected in all other years as well. Conversely, firms that are not rejected in a given year should never be rejected. Thus we expect that 5% of firms are rejected under the ergodic hypothesis for all years considering a significance level of 5%. Empirically, we detect some deviations from this idealized scenario. In fact, we observe that 34 out of 498 firms (or 6.8%) are rejected for more than 30 years.[5]

A rejection of the null hypothesis either stems from statistical fluctuations or from 'true' violations of ergodicity. To distinguish between the two cases, we identify companies whose empirical realization of the KS statistic exceeds the maximum statistic in the respective Monte Carlo simulations.[6] This procedure identifies 9 firms among the 34 that are inconsistent with the ergodic hypothesis, yet their destinies provide some additional insights into the competitive process and the capital reallocation mechanism. For instance, two of these firms operate below $\hat{m}$ with a negative median ROA for the period 1980-2012, namely Comprehensive Care and Intelligent Systems. So it is not surprising that the former did not survive for much longer, filing for bankruptcy in 2020. An example for a deviation in the opposite direction is St. Jude Medical, which operated systematically above $\hat{m}$ and was acquired by another surviving corporation, Abbott Laboratories, in 2017. Texas Pacific Land and Great Northern Iron (GNI) are peculiar insofar as they are trusts pursuing non-scalable businesses that are largely sheltered from competition, leading to profit margins that exceed the sample average by almost one order of magnitude. GNI ceased to be a going concern in 2015, and its assets have been acquired by (a subsidiary of) the surviving corporation Conoco Phillips. The remaining four companies are Hecla Mining, Advanced Micro Devices, Deluxe Corporation, and Gap Inc.[7] These 9 'outliers' nevertheless provide anecdotes of how the market tends to eliminate long-run deviations from ergodicity through the process of capital reallocation, indicating the vital importance of classical competition for the remarkable stability in corporate profitability.

6 Testing an economic implication of ergodicity

The ergodic hypothesis implies that corporate idiosyncrasies do not affect average profitability and volatility conditional on survival. We test this implication by analyzing how or whether the median and mean absolute deviation of ROA time series relate to

[5]Note that this procedure is not overly sensitive to a different choice of this threshold. For example, we count 51 (or 10.2%) firms with more than 25 rejections.

[6]The maximum statistic exceeds the 95% quantile of the simulated null distribution by a factor 1.02-2.76, depending on the diffusion coefficient.

[7]While a detailed analysis of the few peculiar survivors that appear non-ergodic is beyond the scope of this article, it is perhaps still instructive to note that they oftentimes engage in sequences of very large acquisitions and divestments with substantial effects on asset turnover or, as in the case of Hecla, benefit from silver short squeezes and are exposed to the extremely volatile environment of speculative mining.

financial and industrial characteristics such as industry concentration, size, sales growth, market share, leverage, productivity, or market valuation. The reason why we concentrate on these particular variables is that they have been the most prevalent in prior studies of profitability (see, e.g., the meta-analysis by Capon et al., 1990, in addition to the studies in A.1). The extant literature, by avoiding survivorship bias, has found systematic influences of corporate idiosyncrasies on profitability, so our diverging views on the (ir)relevance of firm idiosyncrasies for profitability should originate from differences in sample composition.

Consequently, we group firms into three subsamples such that the first group contains 1804 firms that remain in the population for 10 to 17 years, the second group of 837 firms for 18-25 years, and the third group with 720 firms for 26 or more years. Then we compute the median ROA and the mean absolute deviation in ROA for every individual time series and regress each on their respective firm and industry characteristics. Since the functional form of the regression relationships is not obvious a priori, we employ a nonparametric multivariate procedure.[8]

The results in Fig. 3 (for average ROA) and Fig. 4 (for ROA volatility) suggest that corporate idiosyncrasies indeed correlate with the profitability of shorter-lived firms; for example, shorter-lived companies that are large or exhibit high productivity tend to be more profitable on average, and also exhibit less volatile fluctuations. The influence of these specificities is increasingly vanishing, however, as the system approaches the ergodic regime for increasing survival times.[9] Thus survivors cannot do better but also must not do worse than their competitors, both in terms of their average profitability and the volatility of their ROA series. A notable exception among the considered idiosyncrasies is of course Tobin's q, in line with the well-known dichotomy between 'real' variables and financial market valuations.

7 Discussion

Our findings have consequences for managers, investors, and society at large, and lead to new and as of yet unresolved questions. Survival confers a certain privilege, apparently metabolizing capital through its accumulation and competitive reallocation in a way that leaves no room for the risk-return tradeoff we have grown accustomed to. Our approach certainly has important limitations as well, since it cannot predict survival, nor can it predict what will happen to young, small, or private firms. Managers of both incumbent and new firms might none the less want to understand how various idiosyncrasies affect

[8]Online appendix A.3 provides technical details of the procedure for the Nadaraya-Watson estimator. A complementary analysis using partial correlation coefficients instead of the nonparametric regressions reported here is in appendix A.4.

[9]This is also true if we study profitability as a function of the change in firm size from 1980 to 2012, as suggested by one of the referees.

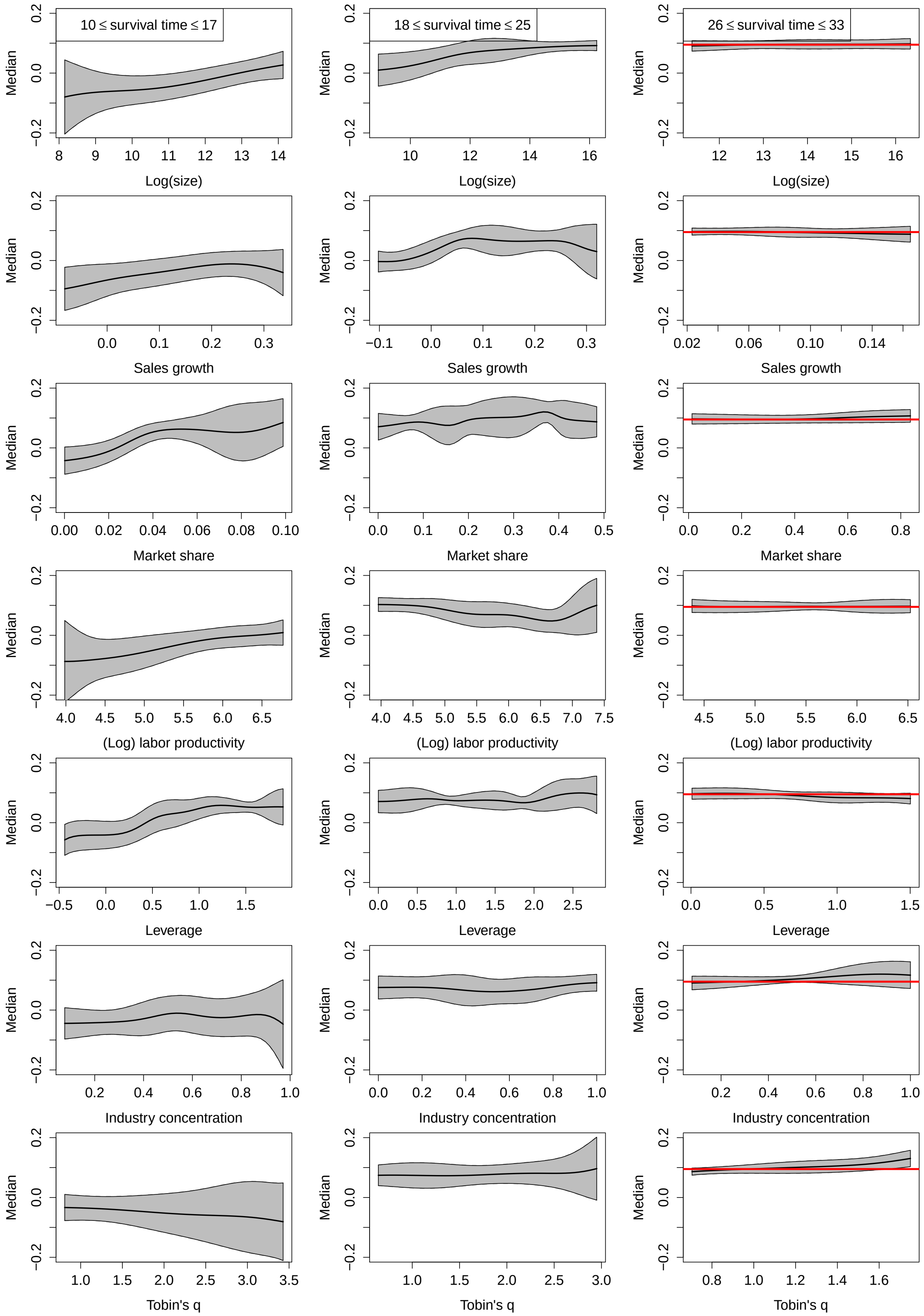


Figure 3: Partial nonparametric regression plots (outcome vs. one covariate, holding all other covariates constant at their median value) for the median profit rate, conditional on the number of years that firms survive in the sample. The left panel shows firms with 10 up to 17 observations, the middle panel those with 18 up to 25, and the right panel those with more than 25 observations. 95% confidence bands are adjusted for multiple testing using the Bonferroni method. The independent variables are (the time series median of) firm size (sales), growth of sales, market share (on a 4-digit SIC level), labor productivity (sales per employee), leverage (the ratio of the sum of short-term und long-term debt to common equity), the Herfindahl industry concentration measure, and Tobin's q (the ratio of the sum of book value of debt and the market value of equity to total assets). The red horizontal line shows the phenomenological value of the location parameter.

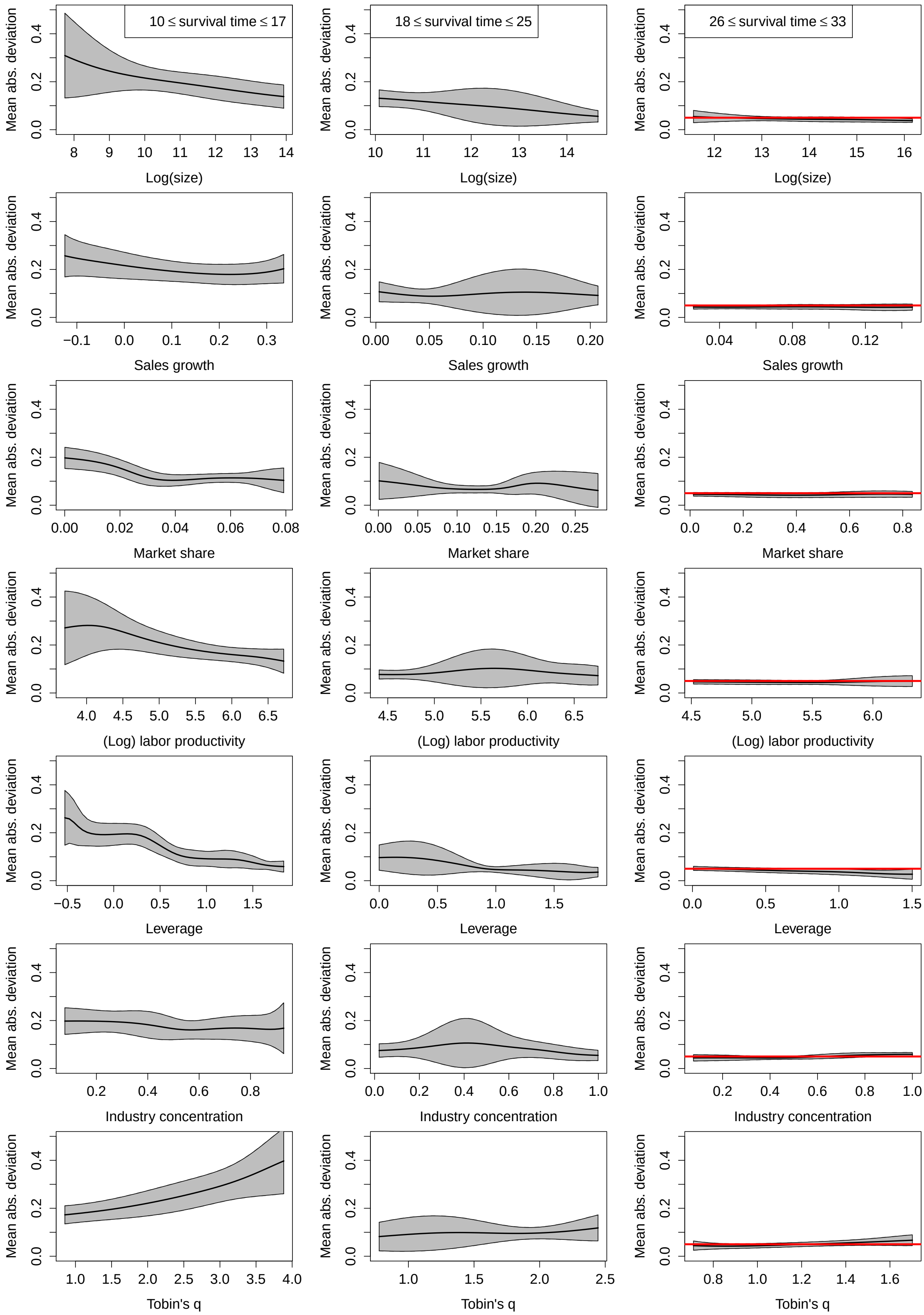


Figure 4: Partial nonparametric regression plots for the mean absolute deviation of profit rates, conditional on the number of years that firms survive in the sample. The red horizontal line illustrates the phenomenological value of the dispersion parameter.

the probability to survive rather than how they affect profitability itself. On the other hand, the stability we observe in surviving capital covers more recent decades of data and it remains to be seen whether the ergodic hypothesis also applies over the entire period of corporate capitalism, dating back to the middle of the 19th century.

With this caveat in mind, investors will notice that the annual average profitability of surviving firms coincides with the long term annual return to the S&P500, but the historical volatility of annual financial returns is almost an order of magnitude higher compared to the volatility of real returns produced by surviving corporations. Viewed from this perspective, financial volatility seems to be the premium that investors have to pay for the liquidity and divisibility of financial investment relative to the frictions and commitment that real activity necessitates. Some investors still care more about abnormal returns over shorter time scales than about the average annualized return to a broadly diversified portfolio of survivors. Returns to shorter-lived firms, however, are non-ergodic and subject to the conventional risk-return tradeoff, and in such scenarios Peters (2019) argues that investors should optimize the growth rate of wealth through the Kelly criterion, by reducing leverage, and by increasing capital buffers as means to overcome the problem of time irreversibility in non-ergodic settings. Similarly for management, Dutta and Radner (1999) show that the maximization of shareholder value almost surely leads to bankruptcy of the company because the maximizing manager undervalues the insuring effect of retained earnings that provide a buffer against future losses. They advocate a more conservative policy that focuses directly on survival, with payouts below the shareholder value maximizing optimum to increase the probability of survival. While a growing body of literature has already investigated how industry or firm characteristics impact the probability of survival (see, e.g., Agarwal and Gort, 1996, 2002; Bayus and Agarwal, 2007), our findings nevertheless provide a new perspective for research into strategic mechanisms that increase the probability of survival as they quantify the reward that prolonged survival confers.

The operationalization of our results for long investment horizons is straightforward since ETFs on a broad index like, say, the S&P500 are rebalanced periodically, passively yielding a portfolio that comes close to a portfolio of survivors by construction, albeit forgoing the large abnormal returns of successful dynamic newcomers by construction as well. On the other hand, the operationalization of the Kelly formula in a non-ergodic investment universe is far from trivial because both the edge and the odds, or in other words the payoff and the probabilities of winning and losing, are prone to serious calibration errors in financial markets, and it is rather difficult to identify an edge in the first place. Our results also show that abnormally large returns cannot scale beyond a certain survival time, rendering investment in a portfolio of survivors through ETFs a low-cost, feasible, and scalable long term financial strategy.

The most pressing issue in the eyes of the public is probably whether the stability in surviving capital has socio-political, environmental, or economic costs attached to it. Put differently, does the stability in survivors' profitability entail considerable fluctuations and adjustments in other parts of the economy? Eeckhout (2021) argues in his recent book that corporations have significantly increased their market power over the period we study here, and he provides an unsettling account of economic developments and policies that have been 'pro-business' rather than 'pro-market', with suppressed wages across the board as an important means in generating or maintaining corporate profits. A historical perspective on ROA over the entire period of corporate capitalism, including different crises periods and regimes of antitrust enforcement, would certainly be helpful in deciding on this issue in the ergodicity context, provided one can compile an appropriate historical dataset going back to the middle of the 19th century.

From a formal perspective, an important open point is how surviving capital can be ergodic in an otherwise non-ergodic economy? While survival is a necessary condition for ergodicity, it is not sufficient since survivors could in principle exhibit different profit rate trajectories, which would make surviving capital non-ergodic. We conjecture that it is survival combined with the classical process of capital reallocation that lead to ergodic ROA properties because the destinies of 'outliers' in Section 5 suggest that the market tends to eliminate persistent deviations from this long run regularity, either by bankruptcy and liquidation or by mergers and acquisitions. On a more constructive level, our approach may help to identify companies that are potential takeover targets or are threatened by bankruptcy. Another immediate application of this regularity is forecasting (Mundt et al., 2020), with the important qualification that the evidently superior forecasting performance of our process is conditional on survival and thus limited in practice.

Finally, our investigation shows that the profitability of entering companies is non-ergodic and correlated with firm characteristics, even for more than 25 years after entry, implying that firm-specific patterns in profitability prevail in the short and medium run, and thus obviously merit the extensive consideration they have received in the literature, especially because the survival time of the average US corporation is below 25 years and has markedly decreased over the last 70 years (Foster and Kaplan, 2001). After all, stakeholders still might want to realize that prolonged survival apparently prevents sustained deviations from the systemic rate of profit and its volatility.

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A Online appendix

A.1 Corporate idiosyncrasies and profitability in the literature

Our investigation of the dynamics and cross-sectional properties of corporate profitability relates to various strands of the literature studying the determinants of performance. The classical industrial organization perspective, which dates back at least to Bain (1951, 1956) and Mason (1949), argues that structural industry characteristics lead to persistent profit rate variation across firms. According to the so-called structure-conduct-performance paradigm (SCP), firms operating in industries with high seller concentration, economies of scale, and significant entry and exit barriers will be more profitable on average than companies in more atomistic industries due to weaker rivalry or tacit collusion. An opposing view emphasizes inter-firm differences in size and productive efficiency to explain intra-industry variation in profitability (Demsetz, 1973; Stigler, 1963). Like the SCP paradigm, this approach predicts a positive correlation between concentration and profitability, however arguing that disproportionally productive firms grow faster than their competitors and thus have larger market shares, enjoy excess profitability, and increase concentration.

The management literature emphasizes resources, strategies, capabilities and the role of competitive positioning to explain differential performance. Resource-based theories (see, e.g., Barney, 1991; Barney et al., 2011; Barney, 2001; Levinthal, 1995; Peteraf, 1993; Teece, 2007; Wernerfelt, 1984), for instance, argue that sustainable competitive advantages may arise from the possession of organizational, financial, technological, or intellectual resources which are valuable, rare, and imperfectly imitable by competitors.

Consequently, excess profitability can be interpreted as a Ricardian rent obtained from the exploitation of such resources, and the persistence of cross-sectional variation in profitability depends on isolation mechanisms that allow to exclude other firms from such resources. Persistent cross-sectional variation in profitability has also been attributed to corporate-parent and business effects. The former arise when the profitability of a firm is determined by its pattern of diversification, while the latter refer to a variety of factors that influence strategy and organization (McGahan and Porter, 2003).

Also finance and accounting hold that financial idiosyncrasies have a defining effect on corporate profitability (e.g., Fairfield et al., 2009; Fama and French, 2000), generally arguing that the risk aversion of capital providers should lead to an equilibrium structure of ROA where higher average returns are a compensation for investors' willingness to bear additional risk.

The quantitative importance of business, corporate-parent, industry, and year effects on profitability has been under scrutiny in several studies (see, e.g., Bowman and Helfat, 2001; Goddard et al., 2009; McGahan and Porter, 2002; Misangyi et al., 2006; Ruefli and Wiggins, 2003; Rumelt, 1991; Schmalensee, 1985), yielding different conclusions about the relative contribution of such effects. Against this background, the main contribution of the present study is to show empirically that the profitability of *surviving* corporations is not affected by such idiosyncrasies and apparently obeys a common and time-invariant regularity.

A.2 Kolmogorov-Smirnov test

To perform the KS test, we have to compute new critical values accounting for the firm-specific persistency in the ROA time series. The standard critical value of the KS test (which amounts to 1.358 at the 5% level) is valid only for non-correlated data. We compute correlation-adjusted critical values by employing a Monte Carlo simulation of our reduced-form model. The crucial parameter is D_i in Eq. (2), which governs the characteristic decay time of the autocorrelation, say, τ_c and therefore the degree of persistency in the time series: the higher D_i, the smaller is τ_c (cf. Mundt et al., 2016).

We estimate the parameter D_i from the ROA time series of each surviving firm i from $\hat{D}_i = \langle(\Delta X_{t,i})^2\rangle$, where $\langle\cdot\rangle$ denotes the average over time. For each of these estimates, we then simulate 1000 time paths of the process in Eq. (2) with the same length as the empirical data and common location and scale parameters that match the phenomenological values, i.e. $m_i = \hat{m}$ and $\sigma_i = \hat{\sigma}$ $\forall i$. This specific parametrization ensures that time series and cross-sectional distributions are by construction the same, consistent with the ergodic hypothesis. Then we measure the maximum distance between the cumulative distribution function (CDF) of each of these simulated time paths and the CDF of synthetic cross-sectional data, given by independent draws from the Laplace

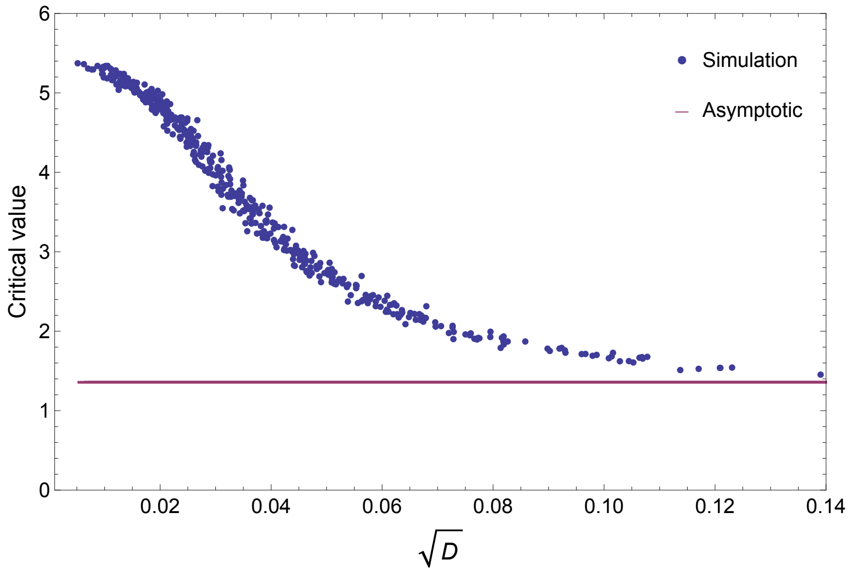

Figure 5: Critical value of the Kolmogorov-Smirnov test as a function of (the square root of) the diffusion coefficient. Blue dots represent the simulated critical values, while the violet line illustrates the asymptotic critical value at the 5% level, which is approximately 1.358.

distribution parametrized with the phenomenological values. This yields a distribution of test statistics for each D_i. The critical value for firm i at the 5% level is obtained as the 95% quantile of this sampling distribution. The dependence of the critical value on the diffusion coefficient is illustrated in Fig. 5. Note that for large values of D_i, i.e. short τ_c, the critical value converges asymptotically to the standard KS critical value, corroborating the plausibility of our simulation procedure.

A.3 Nonparametric regression

To analyze the relation between the median or mean absolute deviation of a ROA time series (Y) and individual firm characteristics in the p-dimensional vector of explanatory variables $\mathbf{Z} = (Z_1, \ldots, Z_p)'$, we consider the conditional expectation of either one of the two 'moments'

$$E[Y|\mathbf{Z}] = g(\mathbf{Z}), \tag{3}$$

where $g(\cdot)$ is an unknown, smooth function to be estimated. We fit this function using the multivariate generalization of the Nadaraya-Watson estimator (see Härdle et al., 2004, Section 4.5)

$$\hat{g}_{\mathbf{h}}(\mathbf{z}) = \frac{\sum_{i=1}^{n} \mathcal{K}_{\mathbf{h}}(\mathbf{Z}_i - \mathbf{z}) Y_i}{\sum_{i=1}^{n} \mathcal{K}_{\mathbf{h}}(\mathbf{Z}_i - \mathbf{z})}, \tag{4}$$

which is a weighted average of observed responses near the target point, with weights given by kernel functions $\mathcal{K}$. Here $\mathcal{K}$ is a multivariate kernel function in the p-dimensional space, operationalized as the product of Gaussian kernels

$$K_{h_j}(Z_{i,j} - z_j) = \frac{1}{\sqrt{2\pi}} \exp\left\{ -\frac{1}{2} \left(\frac{Z_{i,j} - z_j}{h_j} \right)^2 \right\}, \tag{5}$$

with h_j the bandwidth parameter for explanatory variable $j = 1, \ldots, p$. To choose a bandwith, we employ the multivariate generalization of Silverman's (1986) rule

$$h_j = \left(\frac{4}{p+2} \right)^{1/(p+4)} n^{-1/(p+4)} \psi_j \tag{6}$$

(see Härdle et al., 2004, p. 73), where n denotes sample size, and ψ is a measure of spread. To improve robustness against outliers, we estimate ψ as the minimum of the sample standard deviation and the (normalized) interquartile range, i.e. the difference between the 75% and 25% percentile

$$\hat{\psi}_j = \min\left\{ \frac{1}{n-1} \sum_{i=1}^{n} (z_{i,j} - \bar{z}_j)^2, IQR/1.34 \right\}. \tag{7}$$

We assess the uncertainty of the regression function using 50 pointwise confidence intervals based on bootstrapped standard errors. These intervals are adjusted for multiple testing using the Bonferroni method. For better visibility, we draw continuous bands around the 50 error pointwise confidence intervals in the graphical representation of the regression results.

A.4 Correlation tests

To measure the dependence between the ROA time series 'moments' (median and mean absolute deviation) and the different firm characteristics as a function of the survival time, we estimate partial correlations and compare them across age cohorts. Akin to the design of the multivariate regression and the partial regression plots in Figures 3 and 4 in the main text, partial correlations enable us to quantify the association between two variables (e.g., median ROA and sales growth) while eliminating the confounding effect of the other variables (e.g., firm size, market share, etc.) on this correlation. Among the available correlation measures, we opt for the Spearman rank correlation because it does not assume a linear dependence and thus complements the nonparametric regressions considered in Section 6. To obtain the most undiluted view on survivors' profitability based on the available data, we additionally consider the group of 498 survivors by itself and correspondingly adapt the third group to include firms that have a survival time of 26-32 (instead of 33) years. Since ergodicity is an asymptotic property we expect finite size effects, yet the comparison between the four cohorts should still be informative in the sense that it should illustrate the tendency of survivors' profitability to become independent of idiosyncrasies.

Let $\mathbf{X} = \{x_1, x_2, \dots, x_k\}$ denote a vector of ranks of variables. Then the partial Spearman rank correlation denoted $\rho_{i,j|S}$ of x_i and x_j given the remaining variables $\mathbf{X}_S = \mathbf{X} \backslash \{x_i, x_j\}$ as controls is computed as

$$\rho_{i,j|S} = -\frac{d_{i,j}}{\sqrt{d_{ii}}\sqrt{d_{jj}}}, \tag{8}$$

where $d_{i,j}$ is the element in row i and column j of the inverse of the variance-covariance matrix of $\mathbf{X}$ (Whittaker, 1990, pp. 143-144). The test statistic for Spearman's partial rank correlation test is

$$t_{i,j|S} = \rho_{i,j|S} \sqrt{\frac{n-2-g}{1-\rho_{i,j|S}^2}}, \tag{9}$$

where n is sample size and g denotes the number of controlled variables, and the p-value is computed from

$$p = 2\Phi(-|t_{i,j|S}|, n-2-g) \tag{10}$$

with $\Phi(\cdot)$ Student's t distribution with $n-2-g$ degrees of freedom (see, e.g., Sheskin (2003), pp. 1061-1078.; Conover (1999), pp. 327-328).

Table 1 reports the estimated partial correlation coefficients between the ROA median (panel A) and mean absolute deviation (panel B) and each of the seven explanatory variables, controlling for the influence of the other six. We observe a tendency for the correlations to become weaker and insignificant for increasing survival times, corroborating the partial regression results shown in Figures 3 and 4. Since market valuations are not a control variable for management, we cannot exclude significant feedback from particular profitability trajectories into market valuations. Regarding the other ('real') variables, we still observe a weak correlation between profitability and firm size for survivors, but these correlations are small and depend on few firms. For example, eliminating merely the smallest three firms leads to insignificant correlations between ROA volatility and firm size. The only real variable that exhibits a significant (negative) partial correlation with ROA volatility is leverage, reflecting the well-known behavior of firms with volatile earnings to reduce leverage in order to minimize the probability of bankruptcy.

Table 1: Partial Spearman rank correlations for the median and mean absolute deviation of ROA.

Variable	Survival time			
	10-17 years	18-25 years	26-32 years	33 years
Panel A: Median				
Size	0.27***	0.11***	−0.04	0.09*
Growth in sales	0.08***	0.12***	0.17**	0.01
Market share	0.32***	0.35***	0.27***	0.07
Productivity	0.11***	−0.02	−0.05	−0.06
Leverage	0.07***	−0.07*	−0.10	−0.05
Concentration	0	−0.01	0.02	0.06
Tobin's q	−0.08***	0.14***	0.40***	0.62***
Panel B: Mean absolute deviation				
Size	−0.32***	−0.29***	−0.17**	−0.08*
Growth in sales	0.02	−0.08**	−0.04	0.03
Market share	−0.10***	−0.10***	−0.04	−0.01
Productivity	−0.11***	−0.05	0.01	0.05
Leverage	−0.24***	−0.25***	−0.37***	−0.37***
Concentration	0.09***	0.04	−0.03	0
Tobin's q	0.52***	0.53***	0.31***	0.24***

Note: Statistical significance at the 1%, 5%, and 10% level is designated by ***, ** and *, respectively.

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