The Black Swan Problem: The Role of Capital, Liquidity and Operating Flexibility

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Abstract

How firms cope with tail risk is an under researched problem in the literature on corporate risk management. This paper presents stylized facts on the nature of revenue shocks based on 65 years worth of Compustat data. We define a Black Swan as an unexpected year-on-year drop in revenue between 30-90%. The rate of Black Swans has increased markedly since the 1970s and there are more pronounced cyclical peaks in the three most recent decades. We also examine the role of three general determinants of firms' ability to absorb Black Swans: equity capital, liquidity, and operating flexibility. The conclusion to emerge from this analysis is that the deciding factor in mediating the effects of revenue shocks on employment is liquidity. Cash reserves and cash margins make firms less fragile, but neither equity capital nor operating flexibility robustly buffer against Black Swans.

Key words: Revenue risk, Financial constraints, Black swan, Financial slack

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1. Introduction

Uncertainty about future performance is an inherent part of doing business, which calls on managers to engage in various forms of risk management. Tail risk, i.e. low probability-high impact events, presents a particular challenge to management teams. Apart from their fundamental unpredictability, humans suffer from cognitive limitations that impair our ability to visualize and prepare for extreme events, a phenomenon referred to as "Black Swans" (Taleb, 2007). Using derivative and insurance markets to transfer exposures to tail risk offers an effective solution only in certain narrow circumstances, as transferring general revenue or profitability risk is not possible.

In the presence of non-insurable tail risk, firms might decide to keep a loss-absorbing buffer of financial resources. A cushion of equity capital and liquidity gives firms a means to survive and continue to execute their strategy when faced with sharp declines in performance (e.g. Nocco and Stulz, 2006; Alviniussen and Jankensgård, 2009). Liquidity, in our usage of the term, comprises cash and its equivalents, but also cash margins, which is the cash the firm is able to generate per unit of revenue. These internal resources can be crucial due to capital market frictions that make raising new external financing unfeasible in many circumstances, difficulties often compounded by the weakened state following a negative shock to performance (e.g. the debt overhang problem in Myers, 1977). Another very general mechanism for coping with tail risk is flexibility, which implies the possibility to exit unattractive positions or change modes of operation at low cost. Operating flexibility implies higher resilience to shocks, suggesting that it is functionally equivalent to buffers of financial resources. Operating flexibility has many dimensions, but one aspect of it is that it increases the more variable and easily adjustable the firm's cost base is. This makes it largely the inverse of what the literature has referred to as 'operating leverage': the proportion of costs that is quasi-fixed in the short- to medium term (Lev, 1984; Mandelker and Rhee, 1984; Reinartz and Schmid, 2016).

The dilemma – the Black Swan-problem – faced by firms is that these general risk management strategies reduce the return on equity in the vast majority of scenarios in which no tail risk materializes. In fact, firms are frequently lambasted for maintaining large and "unproductive" cash balances and for having "inefficient" balance sheets (implying under-utilization of debt). Given

that strategies for increasing corporate resilience are costly, it is important to know how effective they are in coping with tail risk. Which of the various forms of buffers are, according to the data, better at absorbing shocks to performance? Which of them are conducive to lower fragility in a worst-case scenario? The question is essentially one of "risk capital", i.e. how to provide for resources that allow the firm to survive and continue to execute its strategy in a worst-case scenario (Alviniussen and Jankensgård, 2009). In shaping a response to the Black Swan-problem, it is also helpful to have data on the frequency at which such events can be assumed to occur and their distribution across industries.

In this paper, we address the question of firms' resilience to tail risk by examining how shocks to the corporate top line (revenue) impacts the bottom line (number of employees). We define a Revenue Black Swan as an unexpected year-on-year drop in revenue between 30-90% (in the interest of brevity we henceforth refer to this simply as a "Black Swan") and construe firm fragility in terms of a comparably large sensitivity of employment numbers to such revenue shocks. These are substantial shocks in that a third or more of the firm's business volume disappears over the course of a year. To ensure they are not driven by corporate events such as disposals of assets, we only count firm year observations where asset sales do not exceed 5% of total assets. To carry out this investigation, we gather Compustat data for US firms stretching back to 1955, incorporating all industries except financial and utility.

We report a number of stylized facts on revenue shocks over 65 years. Consistent with the popular view that uncertainty has been growing over time, the incidence of Black Swans is considerably higher in the latter part of the sample period. Up to the mid 1970's, the average rate of Black Swans was 1.2%, whereas in the 2000s it is 6.1%. Further underscoring this trend, four out of the five highest Swan-years are observed after 2000. This rise occurs despite an increase over time in the average size of publicly listed firms in the US (small firms are disproportionately affected by Swans). While to some extent the rising incidence of Swans reflects a change in the sample composition towards more technology-intense firms, we observe an increase in all industries investigated. Black Swans are, to a fair degree, transitory events in the sense that the afflicted firm sees a rebound in its fortunes in the following year (40%). Only a very small percentage of firms

hit by a Black Swan enters bankruptcy (1%) or is liquidated (0.7%). However, in a substantial minority of cases (14%) another Black Swan follows, a serial correlation that suggests a severely impaired business model in this subset of firms.

Our multivariate analysis, incorporating over 160,000 firm-year observations, suggests that liquidity is most effective in making firms less fragile and insulating them from the effects of tail risk events. We run firm fixed-effect regressions on the log of employees that include a dummy variable that flags whether a Black Swan has occurred in a particular year. Furthermore, we add the requirement of 2 prior years of positive revenue growth to ensure these events are unexpected. The results indicate that end-of-year employment is on average 17% lower in firm-years in which a Black Swan occurs compared to non-Black Swan years. The buffer variables – equity ratio, cash reserves, cash margin, and operating flexibility – are then interacted with the Black Swan-dummy to get an indication of the extent to which they act as "shock-absorbers". Cash reserves is, by a wide margin, the variable that most robustly reduces the sensitivity of employment to revenue shocks. Being in the top third in terms of cash reserves decreases fragility by 32%. This conclusion holds when we change the setting to investigate cyclical Black Swans, i.e. years in which the Swan-rate spikes due to economy-wide recessions, and transient Black Swans, i.e. those shocks that are followed by a rebound and therefore temporary in nature. Cash margins are also associated with lower fragility, albeit not to the same extent as cash reserves.

It is puzzling that equity capital is not associated with a statistically verifiable reduction in fragility. Several other studies have found evidence supporting the view that highly leveraged firms are more vulnerable to negative shocks to performance (Chodorow-Reich, 2014; Friedrich and Zator, 2020; Giroud and Mueller, 2016). One thing that can partly explain the different conclusion in the present investigation is that we include cash reserves and cash margins, which are lacking in most other studies. Furthermore, creditors, while holding the trigger, simultaneously function as liquidity providers in times of crises (Kashyap et al., 2002), and have incentives to keep firms going through periodic stress to protect their notional. Caballero et al. (2008) point to the practice of lending to otherwise insolvent companies, the so-called "zombie firms", thereby preventing the normal competitive outcome of shedding jobs and losing market share. Firms with

more debt in the balance sheet may instead adjust to shocks primarily through cuts in investment spending, as violations of debt covenants (or a high risk thereof) frequently limit firms' ability to uphold investment spending (Chava and Roberts, 2008).

This study contributes primarily to the literature on risk capital. Risk capital has been conceptualized in various ways. Nocco and Stulz (2006) define it in terms of the equity capital associated with a certain probability of financial distress. Alternatively, it is envisioned as the equity capital consistent with a targeted probability of insolvency, defined as a situation where the value of a firm's assets falls below the value of debt (referred to as "economic capital", see Klaassen and Eeghen, 2009). Alviniussen and Jankensgård (2009) instead propose to define risk capital in terms of a buffer of existing and conditional sources of liquidity to uphold cash commitments in a worst-case scenario. Yet others have looked at risk capital through the lens of interactions between solvency and liquidity risk (Cont et al., 2020). Our contribution to this literature is to provide broad-sample evidence regarding which elements of risk capital absorb tail risk most effectively. The managerial implication of our result is to emphasize financial strategies that support the provision of liquidity in worse-than-expected scenarios, and to maintain cost efficiency in good times to maximize the risk-absorbing buffer from cash margins.

Our results also contribute to the literature on the impact of financial resources on private sector employment. One conclusion to emerge from this literature is that firms tend to engage in "labor hoarding", which is to say preserving the workforce following a negative shock to performance. The reasons for such hoarding is generally that firms may anticipate a rebound in growth and want to avoid adjustment costs in the form of severance pay and training (Anderson et al., 2003). As noted, our findings run contrary to one of the other main conclusions to emerge from this research, namely that leverage constrains labor hoarding when there is an exogenous shock to performance (Baurle et al., 2018; Chodorow-Reich, 2014; Giroud and Mueller, 2016). Potential reasons for the different conclusions is that these studies focus on relatively narrow sectors of the economy, and that they do not control for cash reserves and cash margins in their empirical tests. Using a broad sample spanning 50 years, and using a firm-fixed effects framework that controls for cash reserves and cash margins, the proportion of debt financing does not appear to be a decisive factor in mediating the

effect of revenue shocks on employment.

2. Hypotheses

In this section, we outline several empirical predictions based on the literature. Our main interest lies in risk capital and the four buffer variables that make it up discussed in the introduction: equity capital, cash reserves, cash margins, and operating flexibility. However, we also look into two other related claims that have been put forth by commentators: that the world is getting riskier and that large firms are more fragile.

Common wisdom holds that risk is on the rise. Proponents of this view often cite accelerating technological change, increased inter-connectedness, globalization, and the consequences of climate change as some of the main factors behind this development. Consulting firm PwC, for example, presents this as something close to an established fact: "The world is getting riskier. Organizations are increasingly vulnerable as business becomes more complex, virtual and interdependent."[1] If the world is getting more uncertain, or riskier, this can manifest itself in a variety of ways. One such indicator could be the rate of large and negative shocks to firms' revenue, or Black Swans in our terminology. Therefore:

H1: *The rate of Black Swans is increasing over time*

In his book "Antifragility: Things that Gain from Disorder", (Taleb, 2012) makes a conjecture about the relation between size and fragility, claiming essentially that size is conducive to fragility. Taken literally, the claim suggests that we should expect fragility, here defined as the sensitivity of the number of employees to large revenue shocks, to be an increasing function of size[2]

H2: *The impact of Black Swans on the number of employees increases with firm size*

[1] gc-enterprise-resilience.pdf (pwc.com)

[2] Taleb's assertion with respect to size is not developed into a coherent thesis, but he states that "size hurts you at times of stress. It is not a good idea to be large during difficult times" (p. 279) and that "fragility comes from size" (p. 282).

As discussed in the introduction, one way to absorb losses and reduce the impact of performance shocks is to keep a buffer of highly liquid assets such as cash. Such readily available cash reserves provide a means to meet ongoing cash commitments without having to make costly adjustments. The literature analyzing firm's cash policy cites the "pre-cautionary savings" motive for liquidity as one of the key benefits of cash holdings (Opler et al., 1999) and that this benefit is greater when firms are in a weak state (Pinkowitz and Williamson, 2003). Operating assets do not function as a buffer in this sense because they are generally illiquid and may need, in the case of a large and unexpected shock, to be sold at a discount to fair value in a so-called asset fire sale (Shleifer and Vishny, 1992). That is, liquidating operating assets in response to a shock to performance is a negative consequence of variability and not a convenient way to handle performance shortfalls.

H3: *The impact of Black Swans on the number of employees decreases with cash reserves*

In a similar way to cash, a positive cash margin, construed in terms of the amount of cash generated per unit of revenue, provides a way to absorb revenue shocks. For obvious reasons, the wider the firm's margins, the more of a drop in revenue it can handle without running into difficulties in serving cash obligations that could imply costly adjustments to operations. Internally generated cash has been extensively explored in the literature on corporate investment, which attributes a role to it in light of capital market imperfections that create a cost wedge between external and internal sources of funding (Fazzari et al., 1988). Since the cash margin is a pre-capital expenditure concept, the implication is that investment spending can be cut in response to revenue shocks, thus making it less likely that core activities need to be scaled back.

H4: *The impact of Black Swans on the number of employees decreases with cash margins*

According to the corporate finance literature, another factor that determines a firm's resilience to performance shocks is the extent to which it has financed its assets with equity (e.g. Stulz,

1996). Debt implies a higher level of fixed cash commitments in the form of interest payments and repayments of the notional. The increased threat of bankruptcy that comes from these fixed commitments is liable to produce a more forceful adjustment in response to shocks in performance. On top of this, high levels of debt amplify certain well-known contracting problems in financial markets, rendering it difficult to get financing on attractive terms to sustain operations (e.g. Myers, 1977). Equity in contrast, implies no cash commitments on which the firm could default and no contractual notional to be repaid.

H5: *The impact of Black Swans on the number of employees decreases with the extent of equity financing*

A general strategy for managing risk is flexibility in terms of making an exit from a position that has become unattractive. Risk is reduced to the extent company can scale its operations up or down in response to fluctuations in demand without incurring any substantial adjustment costs. Conversely, the more fixed a firm's costs are in the short-to-medium term, the higher its so-called operating leverage and therefore risk (Mandelker and Rhee, 1984). There is therefore a sense in which flexibility in adjusting operating costs is functionally equivalent to financial buffers like cash reserves and equity capital, and therefore included in our conceptualization of risk capital. If a firm easily can exit or scale down its costs when faced with a decline in revenue, the fewer financial resources it needs for any given risk it is willing to tolerate. Indeed, the literature emphasizes that there is a substitution effect between financial and operating leverage. Chen et al. (2019), for example, likens certain operating costs to the coupon-payments of a fixed-rate bond, noting that they must be serviced also in financial distress. These considerations lead us to the argument that the higher the proportion of costs that is made up of elements that can be scaled relatively easily, such as raw material expenses and purchases of semi-finished goods, the less sensitive the number of employees will be to shocks to revenue. Therefore:

H6: *The impact of Black Swans on the number of employees decreases with operating flexibility*

3. Sample, empirical design, and variables

3.1. Sample

The sample used in this study comprises all firms in the Compustat North America database. For the part of the descriptive analysis that focuses on revenue, we use data going back to the first year in which Compustat contains observations with reliable consistency (1955). For the multivariate analyses including variables from other sections of the financial statements, we restrict the sample to 1970 in order to ensure reasonable comparability over time and exclude financial and utility firms as they tend to face high levels of regulation. In addition to requiring valid observations for variables in our baseline model, firm-year observations are excluded if they meet any of the following criteria: a) revenue is zero or below, b) total assets are zero or below, c) asset sales exceed 5% of total assets d) decline in revenue exceeds 90%.[3]

3.2. Empirical design

Whereas hypotheses 1 and 2 are addressed in the descriptive part of the paper (section 4), hypotheses 3-6 are tested in a multivariate regression framework in section 5. The empirical model (Eq. 1) relates the log of the number of employees to Black Swans whilst controlling for a number of firm characteristics that are likely to be systematically related to the number of employees. The right-hand side includes the buffer-variables discussed in Section 2: the equity ratio, cash reserves, cash margins, and operating flexibility. To test the hypotheses (Eq. 2), each buffer-variable is interacted with the Black Swan-dummy. The model contains firm fixed effects, such that the impact of a Swan is measured relative to each firm's baseline level. The error terms are clustered at the firm level. An important consideration is whether the shocks, as captured by the Black Swan variable, are unexpected or not. Whereas a recession in the economy may be considered exogenous to any given firm, the same is not necessarily true of general revenue shocks. Firms may alter their policies in anticipation of a future shock that has become sufficiently likely. To reduce concerns

[3]Reasons for excluding these most extreme cases of revenue declines are detailed in section 3.3 below

about endogeneity, we lag the independent variables two years, and in the multivariate setting we also require positive revenue growth in the two years leading up to the Black Swan. Therefore, the shock arrives on the back of two consecutive years of growth. This puts some distance between the measurement and the event, and mitigates any tendency that the shock was anticipated or even engineered by the firm. Another concern is that a reduction in revenue exceeding our threshold of 30% that may be driven by asset sales, which would count as a false positive. For this reason, we exclude firm-years in which there is a divestment of assets exceeding 5% of total assets. Equation 1 represents our baseline regression model while Equation 2 adds cross-product terms of the buffers and the *Black swan* dummy variable:

$$\begin{aligned} log(Employees) =& \alpha_i + \alpha_t + \beta_1 Q_{t-2} + \beta_2 Tangibility_{t-2} + \beta_3 Cash\ margin_{t-2} + \beta_4 OP\ flexibility_{t-2} + \\ & \beta_5 Cash_{t-2} + \beta_6 Equity\ ratio_{t-2} + \beta_7 Black\ swan \end{aligned} \tag{1}$$

$$\begin{aligned} log(Employees) =& \alpha_i + \alpha_t + \beta_1 Q_{t-2} + \beta_2 Tangibility_{t-2} + \beta_3 Cash\ margin_{t-2} + \beta_4 OP\ flexibility_{t-2} + \\ & \beta_5 Cash_{t-2} + \beta_6 Equity\ ratio_{t-2} + \beta_7 Black\ swan + \\ & \beta_8 Black\ swan \times Cash\ margin_{t-2} + \beta_9 Black\ swan \times OP\ flexibility_{t-2} \\ & \beta_1 0 Black\ swan \times Cash_{t-2} + \beta_1 1 Black\ swan \times Equity\ ratio_{t-2} \end{aligned} \tag{2}$$

where $log(Employees)$ is the natural logarithm of firm employees, Q is Tobin's Q, $Tangibility$ is firm asset tangibility, and $Cash\ margin$, $Operating\ flexibility$, $Cash\ reserves$, and $Equity\ ratio$, are financial buffers (variables are explicitly defined and further discussed in next section). α_i and α_t are firm and time fixed effects, respectively.

Under the null that buffers of resources do not matter to employment numbers when a Black Swan occurs, these interaction terms would be jointly insignificant. An overall lack of significance in these interaction terms would suggest that any adjustment to the workforce is an orderly and economically justifiable response to changing circumstances. This point is similar in spirit to Fazzari et al. (1988), who investigate the sensitivity of investment to changes in cash flow. Their

claim is that financial constraints cannot be directly observed, but may be possible to infer from differences in observed investment-cash flow sensitivities. Likewise, firm fragility is not directly observable, but may be inferred from differences in the observed employment-revenue sensitivities. That is, it can reasonably be ascertained that if buffers do matter, we should observe excessive cuts to the workforce made when then they are absent or too low. Cuts that occur for lack of buffers have a "fire-cut" aspect to them and thus come with an economic cost because they are forced rather than orderly and motivated by fundamentals (compare the argument for asset fire sales in Shleifer and Vishny, 1992). After all, employees are often claimed to be a firm's most valuable resource. What is more, there are significant costs involved in terms of severance pay and training (in case of later rehiring), suggesting that firms have strong incentives to avoid cuts that are damaging to its long term prospects. As a result, they tend to engage in a practice referred to as "labor hoarding" (Anderson et al., 2003).

Unlike shocks that are exogenous to the economic system, like a pandemic, Black Swans as defined in this paper do not distinguish between shocks imposed from the outside and those that result from a failing business model. Risk capital that safeguard against performance tail risk should properly speaking not address the latter. Rather, it should buffer against temporary declines in performance in fundamentally viable businesses. For these reasons, we carry out further investigations that involve only years with significant spikes in the rate of Black Swans, reflecting economy-wide forces that create pressure in the corporate sector ("Cyclical Black Swans"). We also distinguish between Swans from which the firm rebounds in the following years and those that appear to impair the firm's performance more permanently. It should not be viewed as a "failure" of risk capital if it does not shield the firm's workforce against what is effectively a new and lower volume of business activity. Therefore, we analyze separately Swans that are considered temporary on the basis of whether they are followed by a rebound or not ("Transient Black Swans").

3.3. Varible descriptions and definitions

Black Swan is a binary variable that takes the value one if the year-on-year drop in revenue is between 30-90% and zero otherwise. That is, it flags a one if a firm loses a third of its revenue or more, which is in most circumstances a very severe shortfall in revenue. We do not include decreases

larger than 90% for two reasons. Firstly, there is a clear over-representation of observations in that part of the outcome distribution. The general pattern is that revenue shocks get progressively more infrequent the further out in the tail one moves, however this changes once one reaches the 90th percentile. This suggests that there is a fair amount of noise contained in that part of the distribution, and that many of these outcomes are driven by irregularities e.g. related to corporate restructurings rather than by demand shortfalls. Secondly, shortfalls in excess of 90% are too extreme: a near-total wipeout of business activity may not be a very interesting case to consider.

Log_Employees is the log of the number of employees (EMP). *Revenue*, *SGA* and *COGS* are defined as annual sales (REVT), selling, general, and administrative expenses (XSGA) and cost of goods sold (COGS), respectively. Size is the log of total assets (AT). Asset tangibility is the ratio of property, plant, and equipment (PPENT) to total assets (AT). Tobin's Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is the number of shares outstanding times share price (PRCC_F x CSHOC).

We define four variables related to risk capital that capture a firm's robustness to Black Swan events: *Equity ratio*, *Cash reserves*, *Cash margin*, and *Operating flexibility*. *Equity ratio* is defined as one minus total liabilities divided by total assets (1-LT/AT). This formulation is preferred because we want, for ease of exposition, a buffer-interpretation for all four moderating factors. By this, we mean a variable that has the following interpretation: the higher the value it takes, the more resilient the firm is presumed to be (according to the hypotheses presented in Section 2). The results reported throughout the paper are not sensitive to using alternative definitions such as leverage (short and long term debt over assets) and gearing (short and long term debt over book equity). We define *Cash reserves* as cash and cash equivalents divided by total assets (CHE/AT). *Cash margin* is computed as Revenue/(SGA+COGS). Cash margins indicate the extent to which the firm is able to generate cash flows from the core elements of its operations. Both capital expenditure and R&D expenses are excluded from the measure, which means that investment is essentially considered a buffer with respect to number of employees. That is, faced with a sharp downturn in business activity (revenue), a firm can choose to defer its spending on new projects in

order to preserve its current operations thus mitigating the impact on the number of employees. *Operating flexibility* is defined as COGS/SGA. Following Chen et al. (2019), we view COGS as a more flexible cost element than SGA. According to these authors, studies investigating firms' cost behavior tend to find a substantial stickiness for SGA, meaning that it is slower to adjust downward compared to how it responds to increases in business activity. For COGS, however, there is little or no systematic evidence of stickiness. For our purposes, COGS over SGA is an imperfect proxy since COGS also contains a labor expense-item in addition to the purchase of raw materials and semi-finished goods (i.e. staff expenses directly related to the productions of goods). What really buffers the number of employees is the extent to which a firm's cost structure is dominated by aspects that are predominantly variable in nature such as the aforementioned purchases. However, Compustat does not present a sufficiently detailed breakdown to back out these labor expenses. All ratios are winsorized at the 1st and 99th percentiles to minimize the possible distorting effects of outliers.

3.4. Sample description

Table 1 reports the descriptive statistics of the variable used in this study and Table 2 their correlations. *Log_Employees* is strongly correlated with several variables, notably size (the log of assets). The correlation is 0.82 between these variables. In fact, number of employees and assets are two measures that alternatively are used as a proxy for firm size in the literature (for a discussion of different measures of firm size see Dang and Yang (2017)). This makes including size measured as the log of assets in the multivariate regression problematic, which is why we instead gauge the impact of size in a separate analysis instead (section 4).

[INSERT TABLE 1 ABOUT HERE]

[INSERT TABLE 2 ABOUT HERE]

Our main variable of interest, Black Swan, is computed based on percentage changes in revenue.

The development of aggregate revenue over time (the sum of revenue of all firms included in the sample) is illustrated in Figure (1), divided into positive and negative observations. Aggregate revenue is growing steadily over the sample period, except for a leveling out that began in the late 2000s. The total number of firms in the sample has been on a decreasing trend since the late 1990s, however, suggesting that more and more revenue is concentrated in the hands of larger firms. This is the same thing as saying that the median size of firms is going up since around the year 2000, which we also verify. Furthermore, an increasing number of firms report negative revenue growth overtime. In the first five years of the sample period (1970-1974) the ratio of negative to positive revenue growth is 20%, a stark contrast to the 62% seen in final five years of the sample (2016-2020).

[INSERT FIGURE 1 ABOUT HERE]

4. Stylized facts about Black Swans

This section outlines various stylized facts pertaining to the main variable of the study, defined as a year-on-year decline in revenue between 30-90%. Figure 2 depicts the development over time in the yearly mean value of revenue drops, which is to say the proportion of firms that experience a 30-90% fall in yearly revenue.[4] In addition to the definition with 30-90%, the graph shows the trend using a 50-90% as thresholds, representing an event even further out in the tail of the distribution (these firms lose over half of their revenue relative to the preceding year). Figure 2 is consistent with the popular notion that uncertainty is increasing over time (Hypothesis 1). Both measures show a marked increase. The mean Black Swan rate between 1955 and 1975 is 1.2%, whereas the corresponding number in the 2000-2020 period is 6.1%. Sharp spikes in the rate of Black Swan seems to occur with greater frequency in the latter part of the sample. In fact, four out of the five years with the highest Swan rate are found in the 2000s.

[4]Note that Figures 2-4 include all such observations, and consequently do not apply the requirement that they occur following two years of positive growth. This is to show the frequency of such shocks for the entire sample. In the multivariate analysis in section 5, in contrast, this filter is employed to reduce concerns about endogeneity.

[INSERT FIGURE 2 ABOUT HERE]

Two objections may be raised against the interpretation that Figure 2 bears out the hypothesis that uncertainty is increasing over time. The first is that the trend merely reflects a change in the sample composition towards more technology-intense firms for which uncertainty is inherently higher. The second is that the Compustat database contains an ever larger share of small and risky firms that use more accessible public equity markets as a means to fund growth. Both objections have some merit, but it is important to see that, as already noted, the median size of firms is actually increasing, a trend that has accelerated in the last 10-15 years reflecting merger-driven consolidation. Furthermore, the increasing revenue shock-rate is present in all industries included in the study (Figure 3).

[INSERT FIGURE 3 ABOUT HERE]

The over-representation of small firms is clear from Table 3, which partitions the sample into terciles according to size (differences in fragility are addressed in Table 6). The smallest third accounts for over half of all Black Swans. Presumably, this reflects such firms' being more dependent on the success of a limited number of innovations and product lines. Large firms, in contrast, tend to have a more established market presence with some proven successes in the product mix at any given point.

[INSERT TABLE 3 ABOUT HERE]

Table 4 shows the Black Swan-rates per industry, and juxtaposes them with the median values of each of the buffer variables. The industries are arranged, in descending order, according to their respective Swan rate. The industry with the highest incidence of Swans is Oil, gas, and coal extraction. Interestingly, firms in this industry generally do not hold substantial cash reserves

as a buffer against this tail risk. Instead, they have one of the highest cash margins, reflecting the fact that their main cost element is capital expenditure (many firms operate with low or negative EBIT-margins, see e.g. Andrén and Jankensgård, 2015). This configuration suggests that the primary strategy for absorbing tail risk in this industry are reductions in capital expenditure. Relying on capex-cuts is consistent with the theory in Froot et al. (1993) because the value of investment opportunities in commodity-producing industries tend to co-vary with the product price that drives revenue. Furthermore, oil and gas producers are known to engage in extensive hedging using financial derivatives, which yield substantial cash payoffs in industry recessions (Jankensgård and Moursli, 2020). The industry with the second-highest Swan-rate, Business Equipment, has less access to strategic hedging and may not see its investment opportunities co-move with revenue to the same extent. In keeping with these observations, this industry relies more on cash reserves as a means of absorbing tail risk outcomes.

[INSERT TABLE 4 ABOUT HERE]

One venue that can be explored in order to learn more about the implications of Black Swans is to study revenue performance in the year following a Swan. An important question is to what extent Black Swans are transient phenomena from firms quickly rebound. From a risk capital-perspective, this makes a difference, because such buffers are primarily meant to protect against costly disruptions in the value-creation process that result from temporary shocks to performance. That is, the task of risk capital is not to keep going indefinitely a firm that has seen its business model fundamentally impaired. As a first step in mapping out this issue, Figure 4 details what happens in the year following a Swan. Firstly, we distinguish between firms that exit the sample and those that remain. Exit happens for a variety of reasons, such as bankruptcy, liquidation, and mergers. The majority, however, live to fight another day (76%). Secondly, we separate the surviving firms between those that revert to positive revenue growth (40%) and those that continue to experience a decline in revenue (36%). Of the firms returning to positive revenue growth, 14.5% of the Black Swan total bounce back to at least 75% of previous revenue levels ("Rebound").

Figure 4 shows that subsequent revenue declines are found in 36% of the cases, just 4% less than those firms with post-swan positive revenue growth. Thirdly, we analyze the extent to which a Swan is followed by another similar drop. This is the question of whether Black Swans are serially correlated. According to Figure 4, such a consecutive Swan occurs in 14% of Swan-years. In unreported logit-regressions, we confirm that experiencing a Swan increases the likelihood of a Swan in the following year by about 5% (statistically significant at the 1%-level). We will come back to the issue of transient and cyclical Swans in section 5 where we carry out drill-downs using the information in Figure 4.

[INSERT FIGURE 4 ABOUT HERE]

5. Multivariate analysis

In this section, we carry out multivariate analysis with the logarithm of employees as dependent variable. Our interest lies in the sensitivity of employment numbers to Black Swans and how that relation is moderated by risk capital. The sensitivity is by itself not an indicator of fragility, but, as previously discussed, a plausible case can be made that differences between groups are indicative of differences in fragility.

A potential concern is that large and negative revenue shocks may be expected, and in this sense, firms may utilize buffer resources in preemptive fashion in an attempt to navigate the effects these significant declines in revenue have on business activity. While no empirical study can fully rule out endogeneity concerns, we address this issue, as noted earlier, by requiring Black Swans to be preceded by two consecutive years of positive revenue growth in the regression models. In this manner, the Black Swans are highly likely to be unexpected, arriving on the back of two years of positive performance, which makes for a sharper test of the hypotheses in the multivariate setting.

Table 5 reports the unconditional impact of a Black Swan on *Log_Employees* (Model 1) and the impact conditional on the Swan taking place in the 2000s (Model 2). The purpose of the latter model is to gauge whether fragility has increased over time, matching the increase in the

frequency of Swans reported in section 4. On average, holding other factors affecting employment constant, years in which a Black Swan occurs are associated with 17% lower end-of-year employment compared to non-Swan years. Model 2 indicates that there is no statistically significant difference post-2000, suggesting firms' sensitivity to revenue shocks has not changed materially over time.

[INSERT TABLE 5 ABOUT HERE]

In section 4, we found that the frequency of Swans is higher among small firms. We now turn to investigating the role of size in determining firm fragility, to which end we split the sample into terciles according to size and re-estimate the baseline model for each subsample. The results are reported in Table 6. Among the smallest tercile, the difference in end-of-year employment is almost 22% between Swan-years versus non-Swan-years, whereas the corresponding difference in the largest cohort is 17%. However, Model 4, where we include a binary variable representing the highest tercile, shows that the sensitivity to revenue shocks of larger peers is not statistically different from the other ones. The coefficient is negative (-0.042) but does not reach the statistical threshold. Taleb's conjecture that larger firms are more fragile thus is not supported by the data (Hypothesis 2).

[INSERT TABLE 6 ABOUT HERE]

Next, we consider whether risk capital determines the employment-Swan sensitivity (Table 7). We interact each of the four buffer-variables with the Black Swan-dummy, first separately (Models 2-5) and finally together (Model 6). The results strongly suggest that Cash reserves is the most important variable in lowering firm fragility to Black Swans. The positive coefficient on the interaction term between Cash reserves and Black Swan totally offsets the negative effect of the latter variable on employment, suggesting that the sensitivity of employment to revenue shocks is primarily high in those firms with low level of Cash reserves. Cash margins are also significant in moderating Black Swans, with the expected positive sign, but neither Equity ratio nor Op

Flexibility are significant at conventional levels. In unreported regressions, we test alternative definitions for both these variables, as well as examine the effect of the highest cash holders in the sample, however the conclusions are unaffected. Further tests break down the sample into industries and sub-periods, yet the Equity ratio reaches statistical significance in none of them.[5]

[INSERT TABLE 7 ABOUT HERE]

6. Extensions and robustness

In the following section, we provide robustness checks that further validate our findings. First, as tail risk has not been clearly defined, we show that our results are invariant to the specific threshold of revenue decrease used to identify Black Swan. Second, we show that the importance of cash reserves holds when we consider transient as well as cyclical Black Swans. Finally, we challenge our findings by introducing some changes in the sample selection as well as in the econometric specifications.

6.1. Alternative thresholds to identify a Black Swan

Table 8 examines whether results are sensitive to alternative definitions of a Black Swan since tail risk has no clear definition. Our lower threshold of 30% is meant to capture a rare and very severe decline in revenue from one year to the next. We presume that most firms are likely to consider unexpectedly losing a third of their sales a drastic impact on their business. In Table 8, we raise and lower this threshold to consider both more and less extreme tail risk events (revenue drop between 20-90%, 40-90%, 50-90%). Moreover, we split our original 30-90% revenue decrease range into two sub-ranges to identify "mild" Black Swans (when a revenue shortfall is between 30-60%) and "severe" Black Swans (when a revenue shortfall is more extreme and between 60-90%).

[5] We carry out many tests in addition to industry and sub-periods, such as re-estimating Eq. 1 after first dividing the sample into thirds based on size and Tobin's Q. In none of the sub-samples does the Equity ratio come out significant. We also explore various definitions of leverage, such as including only interest-bearing debt, but the conclusion is the same in all these exercises. Leverage simply does not seem to be a powerful mediator of the employment-Swan sensitivity.

Again, recall that this comes on the back of two years of positive revenue growth and that firms carrying out large disposals of assets have been filtered out. Table 8 informs us that going further out the tail, or changing the definition of a Black Swan in general, does not change the conclusion: cash reserves are still the most important moderator of firm fragility. The effect is particularly relevant in the case of a "severe" Black Swan.

[INSERT TABLE 8 ABOUT HERE]

6.2. Transient and cyclical Black Swans

An important aspect to consider is that the implications of a Swan-event may be different depending on whether it reflects a temporary shock or is indicative of an impaired business model. Risk capital, strictly speaking, is only supposed to absorb transient shocks of firms that are still viable, thereby shielding them from costly disruptions to the execution of their strategy. To investigate this further, we classify firms that experience a Swan and experience positive revenue growth in the year following into a new dummy variable, Rebound. Of course, such an ex-post identification is problematic for various reasons. However, it is not entirely unreasonable to assume that managers making decisions about whether to retain employees or not had a fairly clear idea whether the shock was permanent or not. Table 9 shows that risk capital does buffer against revenue shocks when they are transient (Model 2). When firms do not recover, having more risk capital does not help the outcome. In these cases, any adjustment to the workforce is more likely to be a necessary and economically motivated response to new and less favorable circumstances. Consistent with expectations, then, cash reserves and cash margins only absorb shocks in firms that experience transient Swans. Surprisingly, the equity ratio has a negative sign in this regression. In Model 1, we find similar results when we restrict the sample to the ten years with the largest spike in the mean of Black Swan. These are generally years in which there is an economy-wide recession, such as the bursting of the IT-bubble (2001) or the financial crisis (2009). Also for cyclical Swans, cash reserves stand out as the source of risk capital that is most effective in reducing firm fragility.

[INSERT TABLE 9 ABOUT HERE]

6.3. Other robustness checks

Table 10 contains additional robustness tests. Model 1 adds back all the observations for which asset sales exceed 5% of total assets. The reason is that causality may also go the other way: rather than asset sales triggering revenue decreases, firms that experience a large revenue shock may resort to asset sales as a way to generate the necessary liquidity. Model 2 introduces industry-year fixed effects to further account for time-varying differences in economic activity across industries and take any industry trends into consideration. In Model 3, in the spirit of Khwaja and Mian (2008), we regress the change in the log employees number as a result of the Black Swan on the risk capital measures two years before the Black Swan. More specifically, our dependent variable is now the log-difference between the mean of the number of employees three years before the Black Swan and the mean of the number of employees three years after the Black Swan. Analyzing the log-change serves to further alleviate any concerns about endogeneity. Moreover, it allows us to restrict the analysis around the Black Swan and to observe the firm for a reasonable period (3 years) after the event. Finally, Model 4 acknowledges that the composition of debt liabilities can shape the corporate response to a Black Swan by adding the ratio of short term debt to long term debt. Almeida et al. (2009) show that there was a significant decline in economic activity in firms with a large portion of their debt coming due at the onset of the financial crisis in the late 2000s, which introduces an omitted-variable concern. All robustness checks in Table 10, however, confirm that cash reserves is the single most important moderator of the employment-Swan sensitivity.

[INSERT TABLE 10 ABOUT HERE]

7. Conclusions

The Black Swan-problem that motivates this paper is that committing resources to risk capital in order to deal with tail risk reduces return on equity in the vast number of scenarios in which

such risks do not materialize. This makes it pertinent to understand which sources of risk capital are effective in absorbing tail risk, construed in this paper as large, negative, and unexpected revenue shocks ("Black Swans"). Risk capital is here broadly conceptualized as any buffer that helps absorb and mitigate the impact of such revenue shocks, thereby allowing firms to avoid negative consequences to its strategy execution. Our proxy for strategy execution in this paper is the number of employees, on the premise that differences in the employment-Swan sensitivity is an indicator of the extent to which firm must make deep and costly adjustments to its strategy. Excessive cuts in the number of employees suggest that the firm is acting defensively out of a weak position, which risk capital can moderate.

Out of the elements of risk capital investigated in this study, cash reserves stand out in terms of their ability to buffer against Black Swans. Cash reserves are associated with a statistically and economically significant reduction in firm fragility, measured in terms of a decrease in the employment-Swan sensitivity. Cash margins are also associated with a lower fragility, albeit not as robustly so as cash reserves. Overall, liquidity-based sources of risk capital fare best when it comes to absorbing tail risk.

Contrary to expectations, the equity ratio did not prove to be a reliable indicator of resilience to Black Swans. This is a somewhat different message than the one in several studies investigating the role of leverage in economic recessions, which typically find that firms are constrained by leverage in such periods. Our results should not be interpreted to suggest that leverage is never dangerous or never contributes towards corporate misfortunes. They simply say that in a firm-fixed framework, using a broad sample of firms spanning more than five decades and controlling for cash resources and cash margins, the equity ratio is not a dominating factor in mediating the relation between revenue shocks and the size of the workforce. Also in this particular respect, cash is king.

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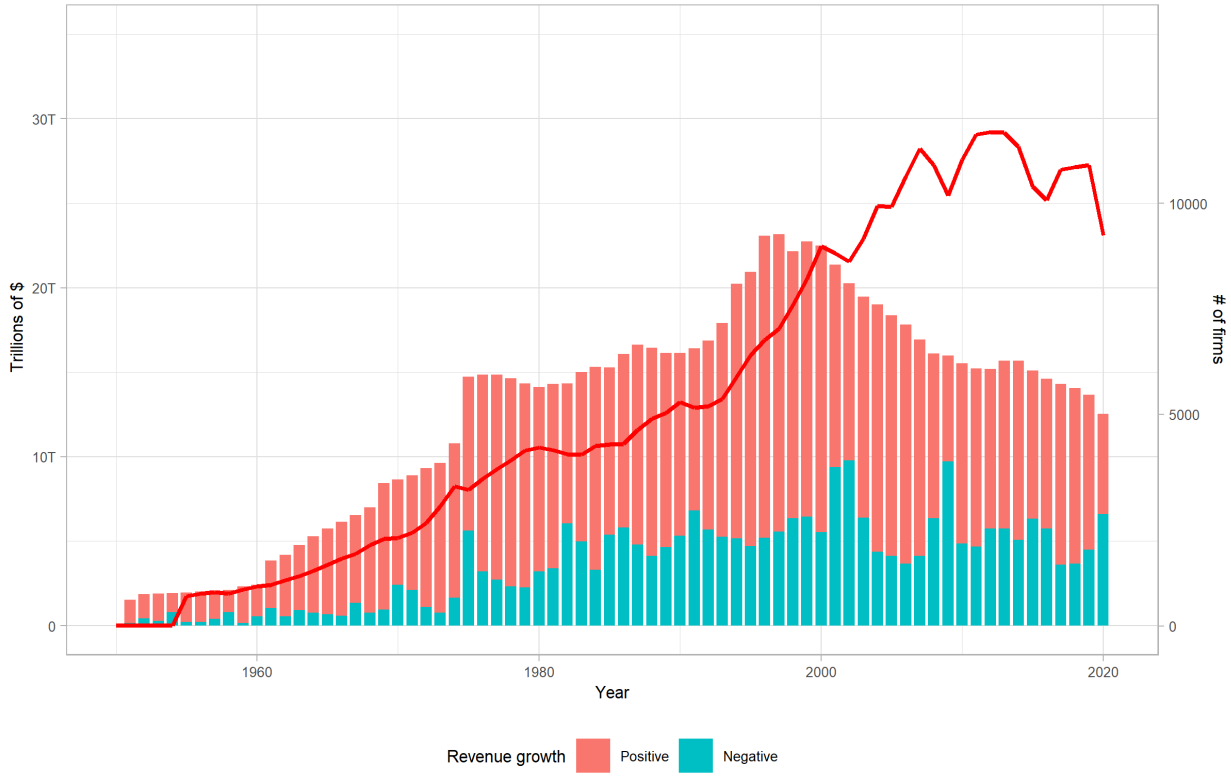
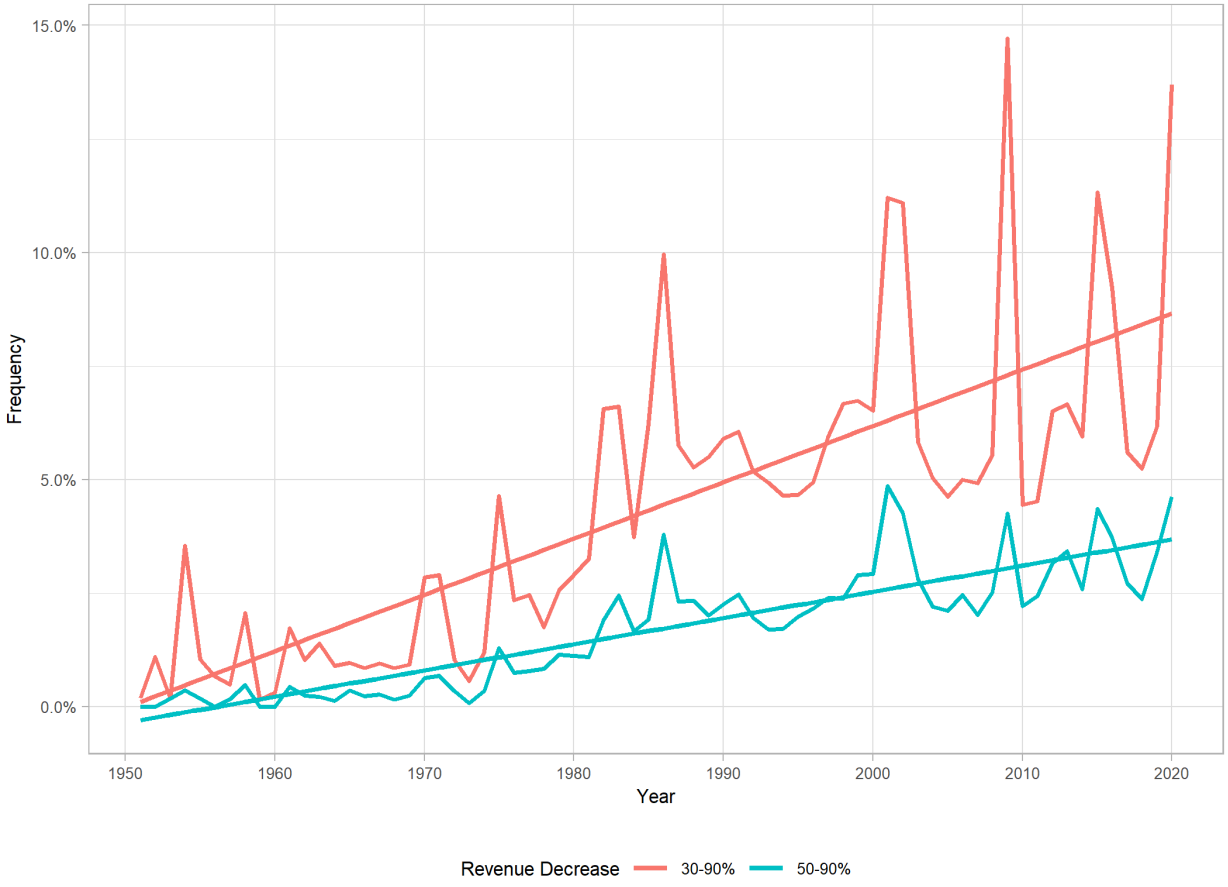
List of Figures

Figure 1: Historical revenue trends



Note: Figure shows historical total yearly revenue (red line) and proportion of firms with positive and negative revenue growth over the years from years 1955-2020. Sample consists of all firms in the Compustat database.

Figure 2: Frequency of revenue drops over time

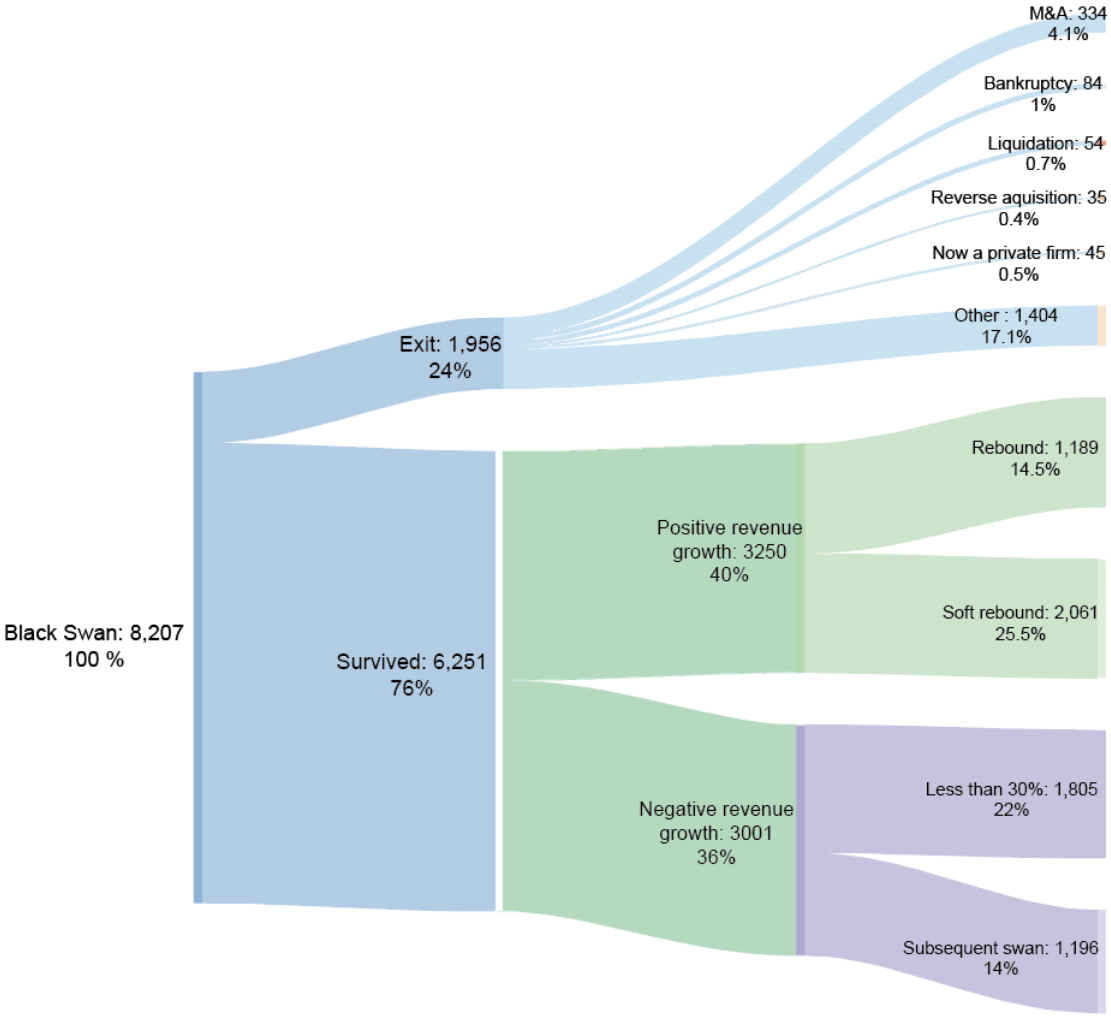


Note: Figure shows frequency of extreme revenue drops over time: firm obseravtions with negative revenue growth between 30 and 90 percent (red line), along with the frequency of firm observations with revenue declines of 50 to 90 percent (blue line). Sample consists of all firms, excluding financial and utilities, in the US Compustat universe from years 1955-2020. Firm year observations with asset divestments greater than 5% are excluded from sample.

Figure 3: Industry trends - frequency of revenue drops over time

Note: Figure shows frequency over time and industry of extreme revenue declines in the 30-90% range (red line) and 50-90% range (blue line). Sample consists of firms in the Compustat database from years 1955-2020. Firm year observations with asset divestments greater than 5% are excluded from sample. Industries classified according to the Fama and French 12 industry scheme (Finance, Utilities, and Non-classifible not reported)

Figure 4: What happens after a swan event?



Note: Figure shows revenue patterns in the year following a Black Swan event. Black Swan is defined as firm years where negative revenue growth is between 30 and 90 percent. Sample consists of entire Compustat US universe from the period 1970-2019, excluding financial and utility firms. Firm-year observations where sale of assets exceeding 5% of total are excluded from sample, as well as observations with invalid values for variables in study. Reasons for exits provided by Compustat data code DLRSN.

List of Tables

Table 1: Summary statistics

Statistic	N	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
$Log(Employees)$	165,353	0.150	2.225	−1.366	0.215	1.690
$Size_{t-2}$	165,353	4.907	2.357	3.198	4.721	6.495
Q_{t-2}	165,353	0.458	0.631	0.019	0.322	0.760
$Tangibility_{t-2}$	165,353	0.284	0.217	0.112	0.233	0.403
$Cash\ margin_{t-2}$	165,353	1.121	0.317	1.038	1.109	1.199
$OP\ flexibility_{t-2}$	165,353	0.680	0.219	0.568	0.738	0.844
$Cash_{t-2}$	165,353	0.156	0.183	0.030	0.082	0.213
$Equity\ ratio_{t-2}$	165,353	0.475	0.337	0.354	0.508	0.676

Note: Table reports the descriptive statistics for variables in the study. Log(Employees) is the natural logarithm of employees (EMP), while Size is the natural logarithm of total assets. Tangibility is asset tangibility defined as the proportion of firm physical assets (ppent) to total assets (AT). Cash margin is defined as total revenue (REVT) to the sum of cost of goods sold (COGS) and selling, general, and administation expense (XSGA). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivelents(CHE) to total assets (AT). Equity ratio is 1 minus the proportion of total liabilities (LT) to total assets. Black swan is a dumy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent with two years prior positive revenue growth, zero otherwise. Continous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Sample includes all firms available in the Compustat files from the 1970-2020 period excluding financal and utility firms.

Table 2: Correlations

	$Log(Employees)$	$Size_{t-2}$	Q_{t-2}	$Tangibility_{t-2}$	$Cashmargin_{t-2}$	$OPflexibility_{t-2}$	$Cash_{t-2}$	$Equityratio_{t-2}$
$Log(Employees)$	1							
$Size_{t-2}$	0.816	1						
Q_{t-2}	-0.178	-0.134	1					
$Tangibility_{t-2}$	0.145	0.156	-0.183	1				
$Cashmargin_{t-2}$	0.26	0.353	-0.115	0.302	1			
$OPflexibility_{t-2}$	0.407	0.264	-0.442	0.305	0.263	1		
$Cash_{t-2}$	-0.27	-0.156	0.354	-0.37	-0.19	-0.471	1	
$Equityratio_{t-2}$	0.019	0.018	-0.158	-0.064	0.146	-0.011	0.267	1

[1] **Note:** Table presents Pearson correlations between variables in the study. Variable definitions are provided in Table 1.

Table 3: Black Swans across size terciles

	No. of Swans	Obs	Freq	% of sample	% of total swans
1st Tercile	5276	55137	9.6%	3.2%	61.6%
2nd Tercile	2018	55098	3.7%	1.2%	23.6%
3rd Tercile	1275	55118	2.3%	0.8%	14.9%

[1] **Note:** Table illustrates frequency and proportions of black swans (revenue decreases between 30-90 percent) across terciles of total assets. Sale of PPE is required to be 5% or less. Sample includes all firms, excluding financial and utilities, in the Compustat database from 1970-2020. Table reports percentage of black swans within each tercile, proportion of tercile swans to enitre sample, and percentage of total swans in each tercile.

Table 4: Industry swans and financial resources

Industry	$Cash_{t-2}$	$Eq\ ratio_{t-2}$	$Cash\ margin_{t-2}$	$OP\ flex_{t-2}$	*Swan Freq*	*%Tot swans*	*Obs*
Oil, Gas, and Coal Extraction and Products	0.056	0.486	1.244	0.812	10.6%	13.6%	9093
Business Equipment	0.201	0.600	1.102	0.593	6.7%	33.3%	35111
Healthcare, Medical Equipment, and Drugs	0.168	0.593	1.096	0.488	5.9%	12.3%	14827
Manufacturing	0.056	0.496	1.120	0.812	4.2%	16.8%	28582
Chemicals and Allied Products	0.064	0.484	1.141	0.732	3.9%	3.3%	6013
Telephone and Television Transmission	0.070	0.393	1.288	0.622	3.9%	2.7%	4895
Consumer Durables	0.064	0.496	1.111	0.799	3.5%	3.3%	6692
Wholesale, Retail, and Some Services	0.057	0.463	1.067	0.775	3%	9.4%	22210
Consumer NonDurables	0.052	0.506	1.112	0.749	2.6%	5.2%	14127

[1] **Note:** Table illustrates median industry finacial resources and black swan frequency across industries classified under the Fama and French scheme (Utilities, Finance, and Non-classifiable not reported). Cash margin is defined as total revenue (revt) to the sum of cost of goods sold (cogs) and selling, general, and administation expense (xsga). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivelents(che) to total assets (at). Equity ratio is 1 minus the proportion of total liabilities (lt) to total assets. Black swan is a dumy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent, zero otherwise. Continous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Sample includes all firms available in the Compustat files from the 1970-2020 period

Table 5: Baseline Regressions

	Dep var = $log(employees)$	
	Model 1	Model 2
Q_{t-2}	0.038***	0.028***
	(3.81)	(2.98)
$Tangibility_{t-2}$	0.245***	0.063
	(3.87)	(0.99)
$Cash\ margin_{t-2}$	0.302***	0.330***
	(11.39)	(12.22)
$OP\ flexibility_{t-2}$	0.997***	1.007***
	(14.75)	(14.80)
$Cash_{t-2}$	-0.553***	-0.567***
	(-13.54)	(-13.76)
$Equity\ ratio_{t-2}$	0.356***	0.305***
	(18.84)	(16.39)
Black swan	-0.171***	-0.170***
	(-11.94)	(-7.85)
Post 2000		0.397***
		(21.30)
Swan x Post 2000		-0.013
		(-0.45)
Constant	-1.500***	-1.164***
	(-24.42)	(-21.84)
Observations	165,353	165,353
Adjusted R-squared	0.130	0.130
Firm FE	Yes	Yes
Year FE	Yes	No

*** p<0.01, ** p<0.05, * p<0.1

Note: Table reports regression results from Equation 1. Log(Employees) is the natural logarithm of employees (EMP). Tobin's Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times price (PRCCF x CSHOC). Tangibility is asset tangibility defined as the ratio of physical assets (PPENT) to total assets (AT). Cash margin is defined as total revenue (REVT) to the sum of cost of goods sold (COGS) and selling, general, and administation expense (XSGA). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivelents(CHE) to total assets (AT). Equity ratio is 1 minus the ratio of total liabilities (LT) to total assets. Black swan is a dummy variable taking the value of 1 if revenue growth has fallen between 30 and 90 percent, following two years of positive revenue growth, zero otherwise. Post 2000 is a dummy variable that takes on the value 1 if a firm-year is greater than the year 1999, and zero otherwise. Continous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Sample includes all firms available in the Compustat files from the 1970-2020 period excluding financal and utility firms. Standard errors are clustered at firm level.

Table 6: Regressions on Size

	Dep var = $log(employees)$			
	Model 1	Model 2	Model 3	Model 4
Q_{t-2}	0.070***	0.146***	-0.011	0.063***
	(5.45)	(11.17)	(0.012)	(6.71)
$Tangibility_{t-2}$	0.264***	0.066	0.052	0.212***
	(3.54)	(0.72)	(0.12)	(3.58)
$Cash\ margin_{t-2}$	0.316***	0.130***	-0.0040	0.249***
	(9.65)	(3.47)	(0.045)	(9.96)
$OP\ flexibility_{t-2}$	0.854***	0.748***	0.41***	0.968***
	(11.69)	(8.38)	(0.14)	(15.44)
$Cash_{t-2}$	-0.249***	-0.564***	-0.929***	-0.503***
	(-5.54)	(-10.56)	(0.085)	(-13.16)
$Equity\ ratio_{t-2}$	0.298***	0.241***	0.458***	0.358***
	(16.38)	(7.14)	(0.050)	(20.08)
Black swan	-0.219***	-0.190***	-0.170***	-0.183***
	(-10.52)	(-9.47)	(0.026)	(-11.26)
Top Tercile				0.755***
				(41.67)
Swan x Top Tercile				-0.042
				(-1.33)
Constant	-2.821***	-0.685***	1.573***	-1.482***
	(-37.13)	(-7.34)	(0.13)	(-26.04)
Observations	55,137	55,118	55,098	165,353
Adjusted R-squared	0.113	0.203	0.146	0.205
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1

Note: Table reports regression results on terciles of total assets (AT) calculated on a yearly basis. Models 1 through 3 report results on 1st through 3rd terciles of size, respectively . Model 4 includes an interaction term with TOP TERCILE, a dummy variable that takes on the value of 1 if a firm belongs to the highest tercile of size and 0 otherwise. Log(Employees) is the natural logarithm of employees (EMP). Tobins Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price (PRCCF x CSHOC). Tangibility is asset tangibility defined as the proportion of firm physical assets (PPENT) to total assets (AT). Cash margin is defined as total revenue (REVT) to the sum of cost of goods sold (COGS) and selling, general, and administation expense (XSGA). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivelents(CHE) to total assets (AT). Equity ratio is 1 minus the proportion of total liabilities (LT) to total assets. Black swan is a dummy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent with two years prior positive revenue growth, zero otherwise. Continous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Sample includes all firms available in the Compustat files from the 1970-2019 period excluding financal and utility firms

Table 7: Regressions - Interaction terms

	Dep var = $log(employees)$					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Q_{t-2}	0.038***	0.038***	0.038***	0.038***	0.038***	0.038***
	(3.81)	(3.81)	(3.81)	(3.74)	(3.80)	(3.74)
$Tangibility_{t-2}$	0.245***	0.244***	0.245***	0.245***	0.245***	0.245***
	(3.87)	(3.87)	(3.87)	(3.88)	(3.87)	(3.87)
$Cash\ margin_{t-2}$	0.302***	0.301***	0.302***	0.302***	0.302***	0.299***
	(11.39)	(11.30)	(11.39)	(11.40)	(11.39)	(11.23)
$OP\ flexibility_{t-2}$	0.997***	0.997***	0.998***	0.996***	0.997***	0.996***
	(14.75)	(14.75)	(14.76)	(14.74)	(14.75)	(14.71)
$Cash_{t-2}$	-0.553***	-0.553***	-0.553***	-0.559***	-0.553***	-0.561***
	(-13.54)	(-13.54)	(-13.54)	(-13.70)	(-13.54)	(-13.73)
$Equity\ ratio_{t-2}$	0.356***	0.356***	0.356***	0.356***	0.355***	0.357***
	(18.84)	(18.85)	(18.83)	(18.82)	(18.80)	(18.86)
Black swan	-0.171***	-0.214***	-0.142***	-0.218***	-0.179***	-0.317***
	(-11.94)	(-5.34)	(-3.67)	(-11.26)	(-8.39)	(-5.35)
$Swan\ x\ Cash\ margin_{t-2}$		0.040				0.077**
		(1.19)				(2.01)
$Swan\ x\ OP\ flexibility_{t-2}$			-0.045			0.026
			(-0.80)			(0.37)
$Swan\ x\ Cash_{t-2}$				0.244***		0.318***
				(3.85)		(4.08)
$Swan\ x\ Equity\ ratio_{t-2}$					0.020	-0.038
					(0.58)	(-1.04)
Constant	-1.500***	-1.499***	-1.501***	-1.498***	-1.500***	-1.495***
	(-24.42)	(-24.37)	(-24.43)	(-24.37)	(-24.41)	(-24.27)
Observations	165,353	165,353	165,353	165,353	165,353	165,353
Adjusted R-squared	0.130	0.130	0.130	0.130	0.130	0.131
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1

Note: Table reports regression results from Equation 1 with variables interacted with the dummy Black swan. Log(Employees) is the natural logarithm of employees (emp). Tobins Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price (PRCCF x CSHOC). Tangibility is asset tangibility defined as the proportion of firm physical assets (ppent) to total assets (at). Cash margin is defined as total revenue (revt) to the sum of cost of goods sold (cogs) and selling, general, and administation expense (xsga). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivelents(che) to total assets (at). Equity ratio is 1 minus the proportion of total liabilities (lt) to total assets. Black swan is a dumy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent with two years prior positive revenue growth, zero otherwise. Continous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Sample includes all firms available in the Compustat files from the 1970-2019 period excluding financal and utility firms. Standard errors are clustered at firm level.

Table 8: Alternate swan definitions

	Dep var = $log(employees)$				
	20 - 90	40 - 90	50 - 90	30 - 60	60 - 90
Q_{t-2}	0.038***	0.038***	0.037***	0.037***	0.037***
	(3.75)	(3.76)	(3.73)	(3.69)	(3.69)
$Tangibility_{t-2}$	0.243***	0.247***	0.248***	0.245***	0.249***
	(3.84)	(3.91)	(3.93)	(3.88)	(3.94)
$Cash\ margin_{t-2}$	0.300***	0.299***	0.298***	0.300***	0.298***
	(11.17)	(11.28)	(11.26)	(11.26)	(11.30)
$OP\ flexibility_{t-2}$	0.993***	0.993***	0.996***	0.991***	0.993***
	(14.68)	(14.70)	(14.75)	(14.66)	(14.72)
$Cash_{t-2}$	-0.562***	-0.557***	-0.553***	-0.556***	-0.553***
	(-13.72)	(-13.67)	(-13.58)	(-13.60)	(-13.57)
$Equity\ ratio_{t-2}$	0.358***	0.357***	0.356***	0.356***	0.356***
	(18.83)	(18.92)	(18.86)	(18.83)	(18.87)
$Black\ swan$	-0.202***	-0.420***	-0.491***	-0.223***	-0.518***
	(-4.42)	(-5.43)	(-5.09)	(-3.48)	(-3.75)
$Swan\ x\ Cash\ margin_{t-2}$	0.034	0.094*	0.133**	0.038	0.134
	(1.19)	(1.85)	(2.01)	(0.93)	(1.34)
$Swan\ x\ OP\ flexibility_{t-2}$	0.057	0.029	-0.068	0.055	-0.218
	(1.10)	(0.30)	(-0.49)	(0.74)	(-1.17)
$Swan\ x\ Cash_{t-2}$	0.204***	0.405***	0.482***	0.222***	0.682***
	(3.45)	(3.68)	(3.49)	(2.70)	(3.34)
$Swan\ x\ Equity\ ratio_{t-2}$	-0.028	-0.062	-0.066	-0.030	-0.110
	(-0.94)	(-1.33)	(-1.07)	(-0.75)	(-1.26)
$Constant$	-1.491***	-1.496***	-1.500***	-1.493***	-1.500***
	(-24.18)	(-24.36)	(-24.44)	(-24.26)	(-24.49)
Observations	165,228	165,459	165,546	165,353	165,622
Adjusted R-squared	0.130	0.131	0.131	0.130	0.131
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1

Note: Table reports regression results from Equation 1 using various definitions of black swan, ranging from a 20-90 percent revenue decrease(Column 1) to 60-90 percent decrease (Column 5). Log(Employees) is the natural logarithm of employees (emp). Tobin's Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price (PRCCF x CSHOC). Tangibility is asset tangibility defined as the proportion of firm physical assets (ppent) to total assets (at). Cash margin is defined as total revenue (revt) to the sum of cost of goods sold (cogs) and selling, general, and administation expense (xsga). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivelents(che) to total assets (at). Equity ratio is 1 minus the proportion of total liabilities (lt) to total assets. Black swan is a dumy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent with two years prior positive revenue growth, zero otherwise. Post 2000 is a dummy variable that takes on the value 1 if a firm-year is greater than the year 1999, and zero otherwise. Continous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Sample includes all firms available in the Compustat files from the 1970-2019 period excluding financal and utility firms. Standard errors are clustered at firm level.

Table 9: Regressions - Rebound and top swan years

	Dep var = $log(employees)$	
	Model 1	Model 2
Q_{t-2}	0.073***	0.032***
	(5.53)	(3.03)
$Tangibility_{t-2}$	0.114	0.259***
	(1.31)	(3.89)
$Cash\ margin_{t-2}$	0.358***	0.293***
	(8.88)	(10.53)
$OP\ flexibility_{t-2}$	0.822***	0.999***
	(8.66)	(13.97)
$Cash_{t-2}$	-0.629***	-0.564***
	(-10.65)	(-13.16)
$Equity\ ratio_{t-2}$	0.394***	0.343***
	(13.19)	(16.75)
$Black\ swan$	-0.314***	
	(-2.74)	
$Swan\ x\ Cash\ margin_{t-2}$	-0.002	
	(-0.03)	
$Swan\ x\ OP\ flexibility_{t-2}$	0.246*	
	(1.85)	
$Swan\ x\ Cash_{t-2}$	0.455***	
	(3.32)	
$Swan\ x\ Equity\ ratio_{t-2}$	-0.097	
	(-1.24)	
$Rebound$		-0.191**
		(-2.39)
$Rebound\ x\ Cash\ margin_{t-2}$		0.048
		(1.07)
$Rebound\ x\ OP\ flexibility_{t-2}$		-0.015
		(-0.16)
$Rebound\ x\ Cash_{t-2}$		0.181*
		(1.69)
$Rebound\ x\ Equity\ ratio_{t-2}$		-0.109**
		(-2.255)
$Constant$	-1.390***	-1.447***
	(-17.27)	(-22.62)
Observations	35,893	151,418
Adjusted R-squared	0.134	0.137
Firm FE	Yes	Yes
Year FE	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1

Note: Model 1 reports results from Equation 1 restricting the sample to years with the highest frequency of swans: 2001, 2009, 2002, 2020, 1998, 2015, 1999, 2000, 1997 and 2012. Model 2 includes the dummy, Rebound, that takes the value of 1 under the condition of positive revenue growth following a black swan and zero otherwise. Log(Employees) is the logarithm of employees (EMP). Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price (PRCCF x CSHOC). Tangibility is asset tangibility defined as the ratio of firm physical assets (PPENT) to total assets (AT). Cash margin is defined as total revenue (REVT) to the sum of cost of goods sold (COGS) and selling, general, and administation expense (XSGA). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivelents(CHE) to total assets (AT). Equity ratio is 1 minus the proportion of total liabilities (LT) to total assets. Black swan is a dumy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent with two years prior positive revenue growth, zero otherwise. Continous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Standard errors are clustered at firm level

Table 10: Regressions - Robustness checks

	Dep var = $log(employees)$			
	Model 1	Model 2	Model 3	Model 4
Q_{t-2}	0.043***	0.041***	0.188***	0.028**
	(4.20)	(4.02)	(50.51)	(2.42)
$Tangibility_{t-2}$	0.223***	0.246***	-0.154***	0.145**
	(3.51)	(4.06)	(-8.55)	(2.07)
$Cash\ margin_{t-2}$	0.295***	0.275***	0.131***	0.257***
	(11.17)	(10.32)	(14.14)	(8.07)
$OP\ flexibility_{t-2}$	1.015***	1.041***	-0.344***	1.039***
	(15.03)	(15.62)	(-17.08)	(13.09)
$Cash_{t-2}$	-0.5666***	-0.5491***	0.3296***	-0.5968***
	(-13.87)	(-13.63)	(22.50)	(-12.22)
$Equity\ ratio_{t-2}$	0.364***	0.360***	0.087***	0.400***
	(18.85)	(19.18)	(11.42)	(17.41)
$Debt\ ratio_{t-2}$				-0.003***
				(-9.41)
Black swan	-0.299***	-0.329***	-0.407***	-0.330***
	(-5.19)	(-5.52)	(-8.04)	(-4.02)
$Swan\ x\ Cash\ margin_{t-2}$	0.069*	0.086**	0.042	0.099**
	(1.85)	(2.27)	(1.38)	(2.15)
$Swan\ x\ OP\ flexibility_{t-2}$	-0.0002	0.027	0.043	0.013
	(-0.003)	(0.38)	(0.76)	(0.15)
$Swan\ x\ Cash_{t-2}$	0.287***	0.319***	0.146**	0.438***
	(3.72)	(4.07)	(2.21)	(4.15)
$Swan\ x\ Equity\ ratio_{t-2}$	-0.025	-0.032	-0.039	-0.072
	(-0.71)	(-0.862)	(-1.04)	(-1.57)
$Swan\ x\ Debt\ ratio_{t-2}$				-0.0003
				(-0.18)
Constant	-1.531***	-1.535***	0.296***	-1.191***
	(-24.75)	(-7.02)	(12.96)	(-16.23)
Observations	170,299	165,353	103,336	136,153
Adjusted R-squared	0.128	0.151	0.008	0.134
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	No	Yes	Yes
Industry-Year FE	No	Yes	No	No
Firm clustering	Yes	Yes	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Note: Model 1 reports results from Equation 1 after adding back all observations exceeding 5 percent of total assets. Model 2 introduces industry-year fixed effects. Model 3 utilizes the log-difference between mean employees three years before and after a black swan event. Model 4 augments the baseline model with the variable Debt ratio, defined as the ratio of short to long term debt (DLC/DLTT). Log(Employees) is the logarithm of employees (EMP). Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price (PRCCF x CSHOC). Tangibility is asset tangibility defined as the ratio of firm physical assets (PPENT) to total assets (AT). Cash margin is defined as total revenue (REVT) to the sum of cost of goods sold (COGS) and selling, general, and administation expense (XSGA). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivelents(CHE) to total assets (AT). Equity ratio is 1 minus the proportion of total liabilities (LT) to total assets. Black swan is a dummy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent with two years prior positive revenue growth, zero otherwise. Continous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Standard errors are clustered at firm level