Financing Lumpy Adjustment*

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Abstract

We study how firms finance lumpy adjustment in capital, employment and inventories. We analyze U.S. firm data from Compustat covering 1971-2013. Lumpy expansion and contraction episodes in firms' productive assets are important in accounting for movements in macroeconomic and financial aggregate variables. Firms use primarily cash balances and debt in order to expand or contract capacity, but these margins are not perfect substitutes. Cash balances play a preparatory role rising (falling) temporarily prior to lumpy positive (negative) adjustment. Debt is also important as firms de-leverage (increase leverage) prior to lumpy positive (negative) adjustment and then slowly increase leverage (deleverage) often several years after the event. Small and large firms differ in their use of external equity to finance lumpy events. During lumpy adjustment profitability and leverage are positively correlated.

Keywords: Lumpy firm adjustment, Event study, Leverage, Debt, Cash, Financing.

JEL Classification: G30, G32, E32.

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1 Introduction

Firms respond to business conditions by adjusting their operations. This adjustment is not continuous and is often lumpy. In adjusting their operations, firms also adjust leverage, cash balances, dividends and several other margins of finance. Are there clear patterns in the policies that firms use to finance lumpy adjustment? The answer to this question is important for research in both corporate finance and macroeconomics. At the center of this research is the effort to understand the nature of financing and operational frictions that firms face and their impact on corporate policies of capital structure, savings, cash balances, investment and employment.

In this paper, we use an event-study approach to address the above question. Looking at publicly traded U.S. firms in Compustat, we examine episodes of lumpy adjustment in their capital stock, employment and inventories.[1] We describe how, on average, firms use different finance margins in preparation for the lumpy adjustment, as well as during and after that. We argue that placing emphasis on lumpy adjustment at the firm level is warranted for two reasons: 1) Recent research has demonstrated that expansion in productive firm assets is intimately associated with variations in corporate leverage.[2] 2) Lumpy firm adjustment is an important determinant of macroeconomic fluctuations.[3]

How do firms finance lumpy adjustment? Our first set of findings is that debt and cash play a dominant role. In particular, we find that firms *expand* real assets by using predominantly a combination of cash and debt. Cash balances play an important preparatory role in the financing of the lumpy episodes. Cash balances are built up a year before the expansion in real assets and are reduced significantly during the year of the expansion. Moreover, firms de-leverage in the year leading to asset expansions, and then leverage up significantly beginning in the year of the expansion event. The increase in leverage persists at least for two years following the adjustment episode. This shows

[1] We use the methodology of Sakellaris (2004) in order to identify lumpy adjustment events.

[2] Denis and McKeon (2012) find that the primary reason for large debt increases in their sample was to fund capital expansion and the secondary reason was increases in working capital (such as inventories). DeAngelo and Roll (2015) find evidence of a strong association between departures from leverage stability and company expansion.

[3] Gourio and Kashyap (2007) establish this as regards aggregate investment behavior.

that firms actively create debt capacity in order to use it later as the expansion of assets unfolds. Furthermore, cash is not equivalent to (and should not be modelled as) negative debt. *Contraction* in productive assets is associated with firms temporarily reducing cash in the year before the lumpy contraction while also having higher than "normal" debt growth. During the event, they rebuild cash and decrease leverage by reducing debt growth significantly. Firms finance lumpy expansions with debt issuance, whereas they use lumpy contractions to reduce debt. These patterns are qualitatively similar for both small and large firms. However, the dynamic patterns described above cannot speak to the relative quantitative prevalence of various finance margins during lumpy events. To examine this from a quantitative perspective, we compute the share of lumpy adjustment events where each of the six margins (increases or decreases in debt, cash and equity) accounts for more than half of the absolute value of all financing margins combined. Changes in cash and debt are the predominant finance margins either during the event or in the preparation phase of the event in a large share of lumpy events for both small and large firms. Moreover, the predominance of changes in cash before and during the event is stronger for small firms compared to large firms.

We establish the importance of lumpy adjustment for macroeconomic fluctuations by decomposing the shares of variability in various aggregate real and financial variables that are due to lumpy adjustment vs. those due to normal activity periods in firm histories. As we demonstrate, a disproportionate share of aggregate variability in real and financial variables is due to firms that are undergoing lumpy adjustment. To give a sense of magnitudes, we find that lumpy adjustment events in employment and inventories explain approximately 77%(84%) and 97%(57%) of the variance in fixed investment (Tobin's Q) respectively. We also find that lumpy adjustment events in employment and inventories explain about two thirds of the variance in aggregate debt issuance.[4]

Recent work documents significant cross sectional differences in the financing patterns of firms. The corporate sector substitutes between debt and equity over the business cycle, and this pattern is driven by large firms (see Jermann and Quadrini (2012) and Covas and Den Haan (2011)). By contrast, small firms have pro-cyclical debt and equity issuance as shown by both Begenau and Salomao

[4]Debt issuance is defined as the change in debt outstanding. This is a disproportionate share when compared to 'normal' periods in firm histories that are not classified as part of a lumpy adjustment episode.

(2015) and Covas and Den Haan (2011), suggesting that the costs of external finance (debt and equity) affect differently small and large firms.[5] We identify size differences in the use of external equity to finance lumpy events, consistent with the existing evidence. We find that small firms (those in the bottom 90% of asset size) rely more on equity issuance to finance expansions compared to large firms (those in the top 10% of asset size). For example, small firms use some combination of increases in equity (and either an increase or decrease in debt) in close to half of all lumpy expansion events. In contrast, large firms use these combinations of external finance in significantly lower frequencies during the same type of events. The issuance of debt and reduction in equity is much more prevalent for large firms, accounting for about half of all lumpy expansion events. Interestingly, during contractions the behavior of small and large firms in terms of the use of equity and debt issuance combinations is much more similar. Reductions in equity, driven by either increases in dividends and/or share repurchases, are the norm during lumpy contraction for both small and large firms although they are more prevalent for large firms. This suggests that large firms tend to make cash payouts during episodes of lumpy contraction.

Our paper is complementary to a series of recent papers on corporate leverage (see Denis and McKeon (2012), DeAngelo and Roll (2015), and DeAngelo et al. (2016)). These papers study events identified by large adjustment in corporate leverage and inform us about the reasons they were undertaken. Denis and McKeon (2012) find that the primary reason for large debt increases in their sample was to fund capital expansion and the secondary reason was increases in working capital (such as inventories). DeAngelo and Roll (2015) find evidence of unstable leverage ratios associated with episodes of company expansion. DeAngelo et al. (2016) provide evidence consistent with firms de-leveraging to replenish financial flexibility, but also a strong empirical connection between de-leveraging and

[5] Recent empirical work attempts to estimate the costs of raising external finance. Hennessy and Whited (2007) estimate the indirect costs of debt and equity financing using a model with endogenous investment and financing decisions. Eisfeldt and Muir (2016), infer the aggregate cost of external finance (both debt and equity) by using firms' cross sectional investment, financing, and saving decisions in a dynamic model. Erel et al. (2012) show that firms' access to external finance markets changes with macroeconomic conditions. McLean and Zhao (2014) emphasize how, independently of business cycle conditions, investor sentiment affects the cost of external finance. Belo et al. (2014) show that equity issuance is costly and varies with macroeconomic conditions (see also Bolton et al. (2013)).

decisions to retain rather than pay out earnings. Our paper differs in focusing on the events that cause movements in corporate leverage. In this manner, we contribute to understanding the drivers of leverage, about which we know little according to DeAngelo and Roll (2015). In particular, our empirical analysis demonstrates that lumpy adjustment in productive assets (capital, inventories, and employment) is a systematic and fundamental driver of corporate leverage. We also study variations in several financing margins, in addition to leverage, during these events as well as during periods leading up to lumpy adjustment.

We revisit the leverage-profitability empirical relationship in the light of firm lumpy adjustment. Strebulaev (2007) showed in model simulations that the purportedly anomalous negative sensitivity of leverage to income when looking at cross-sections is in fact consistent with dynamic trade-off models of capital structure.[6] The key to understanding this result is that the above relationship need be positive only at times of adjustment. Danis et al. (2014) demonstrate that at times of capital structure rebalancing the cross-sectional correlation between profitability and leverage is positive. We provide empirical evidence that during lumpy adjustment there is a positive correlation between profitability and leverage. We show that, conditional on lumpy adjustment events, the correlation between leverage and profitability is significantly positive. This is not the case when not conditioning on lumpy events. Our results on the empirical patterns may provide useful guidance in the construction of firm models that endogenize policies for both dynamic financing and productive assets.

Our paper is also related to the literature on corporate liquidity management in the presence of financing constraints (see the recent survey by Almeida et al. (2014)). Motivated by the large increase in cash balances for U.S. corporations (see Bates et al. (2009)), theory and empirical work studies the economic mechanisms that leads corporations to save or dissave. Almeida et al. (2014) argue that among alternative means of ensuring future liquidity for future investments, such as cash holdings, hedging or lines of credit, cash remains "king". Benhima et al. (2014) emphasize firms' holding liquid assets in order to facilitate their ability to pay the wage bill. Riddick and Whited (2009) emphasize

[6] Fama and French (2002) characterized this as "the important failure of the trade-off model" (p. 29).

the trade-offs between interest income taxation and the cost of external finance that determine optimal savings and show that financial and physical assets are substitutes. Eisfeldt and Muir (2016) argue that firms will raise cash for a rainy day by issuing equity or debt when it is cheap to do so. Bolton et al. (2013) demonstrate theoretically that improved external financing conditions lower precautionary demand for cash buffers, which in turn can incentivize cash rich firms to use cash for share repurchases when share prices are high. Our findings suggest that cash is valuable in that it confers "financial flexibility" to the firm. It is perhaps surprising that small and large firms in our analysis exhibit similar cash management, suggesting that cash remains "king", even in the presence of many financing margins available to large firms.[7] Finally our finding that cash and debt cannot be viewed as perfect substitutes implies that equilibrium models should model them as separate state variables. Gamba and Triantis (2008) present a model where cash and debt are imperfect substitutes and where the key feature that allows the two to coexist are debt issuance costs.

Finally our paper contributes to the understanding of the inventory behavior of corporations. Changes in inventory holdings are volatile, procyclical and a source of economic fluctuations, but this literature typically ignores how firms finance changes in inventories (see Ramey and West (1999)). A typical finding in this literature is that traditional cost of capital measures—such as the real interest rate—have very little explanatory power for the behavior of inventories, but internal finance measures can explain a substantial fraction of their volatility (see for example Gertler and Gilchrist (1994)). Recently Jones and Tuzel (2013) and Belo and Lin (2012) established a link between risk premiums and inventory investment. Our paper contributes to this literature in two ways. First, we demonstrate that lumpy changes in inventories are crucial for the understanding of the aggregate cyclical behavior of financial variables such as cash and debt. Second, we document the patterns of financing used by firms during lumpy inventory adjustment.

The rest of the paper is organized as follows. Section 2 describes the data and methodology, Section 3 establishes the dynamic adjustment patterns during events, and Section 4 documents the importance of lumpy adjustment for aggregate movements in real and financial variables. Section 5

[7]Tsoukalas et al. (2016) provide evidence from eight European economies that small (un-quoted) firms use cash to finance big investment projects.

quantifies the relative predominance of finance margins used during the lumpy events and Section 6 discusses the substitutability of debt and equity during lumpy adjustment. Section 7 concludes.

2 Data and Methodology

2.1 Data

We use firm-level data from the Compustat (North-America) Fundamentals Annual Files. We focus on firms in the manufacturing (SIC code 2000-3999), wholesale trade (SIC code 5000-5199), retail trade (SIC code 5200-5999) and communications (SIC code 4800-4899) sectors with more than five years of data. Our dataset is an unbalanced panel with 9021 firms and 143,543 observations over the time horizon from 1971 to 2013.[8]

The key variables for our analysis are investment and the capital stock, given by the Investment (CAPX), Sales (SPPE) and Stock (PPENT) of Property, Plant and Equipment, the Number of Employees (EMP), and the stock of inventories measured by Total Inventories (INVT).[9] The gross investment rate, CAPX over lagged PPENT, is used to define the positive investment event. The net investment rate, the difference between CAPX and SPPE over lagged PPENT, is used to analyse disinvestment and very low investment rates. The growth rates in INVT and EMP are used to define the positive and negative inventory and employment events, respectively. The precise definitions for the events are discussed in Section 2.2. We focus on three margins of finance for lumpy events, namely, debt, equity and cash. Our definitions for equity and debt follows Salomao and Begenau (2016). Specifically, external equity issuance is defined as equity issuance (SSTK) minus cash dividends (DV) minus equity repurchases (PRSTKC), and total debt is the sum of Long Term Debt Total (DLTT) and Debt in Current Liabilities (DLC). Moreover, Cash holdings are defined as Cash and Short-Term Investments (CHE). Detailed information about variable construction and cleaning procedures

[8] The data from Compustat is supplemented with deflators from the Bureau of Economic Analysis and the Bureau of Labor Statistics and with wage data from the Social Security Administration.

[9] We deflate CAPX and SPPE using the implicit price deflator for private fixed nonresidential investment, INVT is deflated using the price deflator for finished goods (PPI) and PPENT is deflated as in Hall (1990).

is provided in the appendix.

2.2 Methodology

Event identification schemes. We focus on six events of large adjustments in firms' major assets. Specifically, we study large positive and negative adjustments in the capital stock, the inventory stock, and the number of employees. We employ the event-study framework developed by Sakellaris (2004). A year t is considered a positive (negative) adjustment event if (i) in year t the variable concerned with the event exceeds (is below) a certain threshold and (ii) in year $t-1$ the variable is below (above) the threshold. The thresholds for the six events are chosen so that each of the events appears in approximately 20% of the observations in our dataset. In order to qualify for a large positive adjustment in the capital stock the gross investment rate has to exceed 35% (investment spike, which we denote SPIKE). For an event of capital disinvestment/low investment rates the net investment rate has to be smaller than 8% (capital disinvestment, which we denote DISINV). For large positive (negative) inventory adjustment to be observed the threshold is that the inventory investment rate has to exceed 25% (to be smaller than -11%) (large positive/negative inventory adjustment, which we denote LPADJ/LNADJ). For a positive (negative) employment event the growth rate of employees has to exceed 15% (to be smaller than -7%) (large positive/negative employment event, which we denote POSEG/NEGEG).[10] The time variation of the events we study is quite cyclical as evidenced by the statistics we report in the Appendix, that is, lumpy expansion of assets are procyclical and lumpy contraction of assets are countercyclical.

We study the behavior of many balance sheet variables around the six events defined above. In particular, if an event occurs in year t, we examine the behavior of variables of interest over five year windows, in years $t-2$ to $t+2$, using the empirical strategy developed in Sakellaris (2004). To identify the dynamic pattern of variables around events, we use the regression,

$$X_{is} = \mu_i + \nu_s + \sum_{j=-2}^{+2} \beta_j \cdot EVENTD_{is}^{t+j} + \beta \cdot OTHERD_{is} + \varepsilon_{is}, \tag{1}$$

[10] Our results are robust to alternations in the thresholds. These are available upon request.

where X_{is} is the variable of interest – for example investment rate – for firm i in year s and μ_i and ν_s denote firm and year fixed effects. $EVENTD_{is}^{t+j}$ is a dummy variable which equals 1 if firm i experienced an event in year $s-j$.[11] For example, if firm i experienced an investment spike in year 2000, then $EVENTD_{i,2002}^{t+2} = 1$ and $EVENTD_{i,2000}^{t} = 1$. The five $EVENTD$ dummies for each event therefore indicate a window of two years before and after the event.[12] Due to the inclusion of fixed effects absolute magnitudes are not meaningful in the figures, whereas relative magnitudes are. The inclusion of fixed year effects control for aggregate trends as well as other aggregate dynamics in the data that may be unrelated to the particular lumpy adjustment episode being studied. $OTHERD_{is}$ is a dummy variable that equals 1 if and only if firm i has experienced at least one event and $EVENTD_{i,s}^{j} = 0$ for $j = t-2, t-1, t, t+1, t+2$. $OTHER$ therefore captures the average level of X in years outside the five year window around the event for firms that have experienced at least one event. For the variables of interest, it provides an indication of the variable's level during "normal times".

This event-study framework is rich in its ability to identify lumpy adjustment by observation of any margin of firm adjustment. The nature of the adjustment will be determined by the frictions in operations and in finance. Moreover, as we demonstrate below, events typically take longer than one year and events can have effects on the evolution of financing variables both before and after the adjustment in assets. Thus once an event has been identified, we study the interrelated behavior of firm variables in a window of five years centered on the event-year.

[11] We examine the responses to the six adjustment events separately, so $EVENTD$ can be any of SPIKE, DISINV, LPADJ, LNADJ, POSEG and NEGEG.

[12] Note, that we only consider events in the regression if the variable X_{is} has non-missing observations for all five periods of the event window, or non-missing observations for periods $t-1$ to $t+1$.

3 Results

3.1 Dynamic adjustment

We display our results graphically in a series of figures, each corresponding to the dynamic behavior of a specific firm-level variable around a window of lumpy firm adjustment. Specifically, we plot the difference of each estimated value β_j (for $j = -2$ to 2) and β from β_0. Each figure contains six graphs one for each type of lumpy firm adjustment: 1) Investment Spike (SPIKE), 2) Disinvestment (DISINV), 3) Inventory accumulation (LPADJ), 4) Inventory reduction (LNADJ), 5) Employment growth (POSEG), and 6) Employment reduction (NEGEG). In the figures below, the x-axis label 'other' shows the difference between β_0 and the coefficient of $OTHERD$ the latter providing an indication for the level of the variables during 'normal times'. The x-axis label 'std err' shows the standard error associated with β_0 to serve as a metric of whether the differences between the βs are significant. Typically, the standard errors for the other four estimated β_j's coefficients do not differ by more than 15%. We discuss our findings by collecting plots of firm variables that capture the following patterns around event windows: asset adjustment margins, movements in fundamentals, financing margins.

3.1.1 Asset adjustment margins

Figure 3 displays the behavior of investment rates, employment growth, inventory investment rates, in each of the six events—these variables correspond to the LHS variable in equation (1). All three variables rise (fall) sharply on the year of the positive (negative) event, t, and return to "normal" levels (as captured by OTHER) only gradually. This shows that firms adjust along many different operational margins. Figure 4 shows that sales of fixed capital goods in proportion to the capital stock are elevated (lower) during a negative (positive) event. An exception is investment spikes where capital sales are at "normal" rates and drop off after two years. This suggests that fixed capital expansion along with the new technology/organization it embodies during a SPIKE is associated with the firm retiring old technology or old organizational practices. The qualitative patterns of dynamic adjustment are therefore remarkably similar across the three categories of positive (or alternatively of negative) lumpy adjustment. On average, this adjustment takes more than one year to be completed. This indicates the existence of convex adjustment costs and/or auto-correlated shocks to profitability.

3.1.2 Movements in fundamentals

We examine the behavior of several fundamental profitability variables around the six events. Figure 5 displays the behavior of total factor productivity (TFP) levels, EBITDA (operating income before depreciation) over lagged total assets and sales growth rates. These profitability variables display a largely similar pattern over the event windows. Specifically they display an (inverted) hump-shaped behavior for positive (negative) events centered on the year of adjustment. It is worth emphasizing that for positive events, EBITDA is already elevated–compared to OTHER periods–both in year 't-2' and 't-1' before the adjustment year.[13] Figure 6 displays the behavior of Tobin's Q. The shape of these dynamic plots are similar to those discussed in Figure 5 above. Tobin's Q is elevated in years 't-2' and 't-1' for SPIKE and LPADJ, compared to OTHER periods. But Tobin's Q is significantly lower compared to OTHER throughout the negative events. Thus Tobin's Q is an important leading indicator for lumpy adjustment in fixed capital and inventory adjustment.

3.1.3 Financing margins and relation to asset adjustment

The richness of our window approach framework will become apparent when we examine the adjustment patterns of financing margins below. As we illustrate, finance margins adjust in the year preceding events but also in the years following events. Figure 7 displays corporate savings behavior. During positive events firms accumulate cash in year 't-1', taking advantage of the increased profitability and earnings and in preparation for the lumpy adjustment they will undertake the following year. During years 't' to 't+2', they spend it and gradually return to normal ratios of cash to total assets. For negative events, the pattern is symmetric. So, cash buildup (rundown) is a leading indicator of lumpy positive (negative) adjustment in firm assets. The fact that this is reversed

[13] Measured TFP displays a (inverted) hump-shaped pattern during negative (positive) events probably due to the firm adjusting its capacity utilization using margins that are not captured in the production function estimation.

gradually in years 't' to 't+2' indicates that firms maintain a target cash-to-asset ratio throughout their histories. Figures 3 and 7 confirm the prediction by Riddick and Whited (2009) that financial (cash balances) and physical assets are substitutes. While the Riddick and Whited (2009) prediction relates to fixed investment, our analysis suggests that the substitutability is present for other firm assets (and production inputs), such as employment and inventories. For example, in both cases, the cash build up during year 't-1' is associated with subdued inventory investment and employment growth. Cash therefore plays an important preparatory role for these lumpy events.

Figure 8 displays the behavior of market leverage. Market leverage is defined as the ratio of total debt and the sum of total debt and market value, consistent with the definition of Denis and McKeon (2012). We observe that leverage is significantly lower than "normal" before positive events and drops even further the year before ('t-1'). Leverage is still subdued during the event year at 't', but starting at 't+1' leverage rises back to normal rates. For negative events, leverage rises to levels higher than normal during and after the lumpy negative adjustment. Thus, comparing leverage to its level during OTHER, it is clear that in expansions the firms start with a lot of debt capacity, which they use freely to expand physical assets. In contractions, firms have leverage way above OTHER so they make efforts to rebuild debt capacity. Therefore firms during expansion events have unused debt capacity before and even during the event. This result combined with the behavior of cash from Figure 7 above suggests that firms value "financial flexibility" perhaps as a means to reduce reliance on costly external finance. Our findings on leverage are consistent with the prediction from the model of DeAngelo et al. (2011) and evidence given in DeAngelo and Roll (2015) that departures from leverage stability are associated with company expansions. Our findings also complement the evidence reported by Denis and McKeon (2012) that proactive leverage increases are primarily associated with funding fixed and working capital (including inventories). Figure 9 displays the behavior of the growth rate of debt. For positive events, firms accumulate debt during years 't' and 't+1', compared to OTHER, and return to "normal" levels at the end of the episode. This is consistent with the behavior of leverage examined above. The pattern is symmetric for negative events, that is, in the years leading to negative adjustment firms exhibit higher growth rates compared to OTHER and trigger a massive downward adjustment in the year centered around the event. Figure 10 examines the maturity structure of debt around lumpy episodes. The general pattern suggests that lumpy expansion tend to happen by firms when they are tilted to long term debt compared to OTHER times. In lumpy contractions, there is a steady increase in the proportion of short-term debt converging to the proportions prevailing at OTHER periods.

The leverage–profitability relationship. Fama and French (2002) (FF) compare the predictions of the trade-off and pecking order theories of optimal capital structure and come to the conclusion that the effect of profitability on leverage is the most outstanding difference between the two theories. In a series of regressions they establish a negative correlation between leverage and profitability suggesting a failure of the trade-off model. However, Figures 5 and 8 suggest that this conclusion may be subject to a qualification. In fact, the dynamic pattern observed for profits and leverage is consistent with a positive correlation between leverage and profitability during lumpy expansions or contractions. To formally examine this relation we report results from a OLS regression in the spirit of FF that further conditions on lumpy expansion or contraction of assets. We have included several controls in those regressions, namely, size, dividend rate, and a dummy that captures whether firms report R&D expenditures, argued to be important determinants of leverage by FF.[14] The estimates reported in Table 1 confirm the intuition on the behavior of leverage and profitability displayed in Figures 5 and 8. First, as implied by the coefficient of the "Lumpy event" dummy, market leverage falls the year that the firm undertakes lumpy expansion of assets. By contrast, market leverage rises the year that the firm undertakes lumpy contraction of assets. Outside of lumpy expansion or contraction event windows, the correlation between leverage and profitability is significantly negative as found in FF and several other empirical studies. However, as implied by the coefficients on the "Lumpy event x Profitability" interaction term, when we condition on the year of the lumpy event (expansionary or contractionary), the correlation between leverage and profitability becomes

[14] Size controls for the volatility of earnings and both theories of capital structure predict a positive relationship between size with leverage. The R&D dummy controls for future investment opportunities and the dividend rate is included as a control since both the pecking order and trade-off theory predict a negative relationship between payouts and leverage.

significantly **higher**. In fact, the importance of conditioning on lumpy events can be seen when taking the sum of the coefficients on profitability and the interaction between profitability and the lumpy dummy. These sums, with the exception of the inventory events, are significantly greater than zero. The remaining controls have the expected signs and are broadly consistent with the regression results reported in FF. R&D expenditures tend to be negatively associated with leverage, and size is positively correlated with leverage. Finally dividend payouts exhibits a negative correlation with leverage.

We now examine external equity formation around events. Figure 11 shows that for positive adjustment events, external equity issuance is subdued below normal levels reaching a trough in year 't+2'. Indeed this pattern suggests that equity issuance is far from a major source of finance when firms expand. For negative adjustment events, external equity issuance drops precipitously from normal levels and reaches a trough at the time of negative adjustment. Thus during positive events, firms reduce the share of external equity in total assets starting from normal levels. Combined with the findings for leverage and debt discussed above this leads to a hypothesis that firms avoid raising costly external equity but prefer to issue debt for lumpy physical expansions (opposite for contractions). We further discuss the pattern of use of external equity issuance in section 6 where we examine and compare the behavior of firms of different sizes.

4 The significance of lumpy adjustment for aggregate variables

In this section we proceed to examine the extent to which episodes of lumpy firm adjustment drive the variability in aggregate variables. One key fact we uncovered by examining firm-level behavior above is that there are meaningful patterns of adjustment that in many cases take place before the onset of the adjustment and continue thereafter. Specifically we focus on 3-year event windows with periods $t-1$ to $t+1$ around a pair of positive and negative events of adjustment in the same real asset, i.e. either SPIKE and DISINV, or LPADJ and LNADJ, or POSEG and NEGEG. We then decompose the variability in aggregated variables to determine the contributions of the covariances of that variable with all its subcomponents. For example, if we separated the aggregate change in variable X (scaled

Table 1: Leverage and profitability

	(1) SPIKE	(2) LPADJ	(3) POSEG
Profitability	-0.048***	-0.114***	-0.0233***
	(-9.53)	(-17.16)	(-5.36)
Lumpy event	-0.106***	-0.062***	-0.058***
	(-30.75)	(-20.87)	(-19.54)
Lumpy event x profitability	0.064***	0.082***	0.039***
	(5.48)	(7.34)	(4.16)
Dividend rate	-2.169***	-2.177***	-2.217***
	(-55.45)	(-47.96)	(-50.79)
Size	0.013***	0.015***	0.016***
	(29.77)	(30.17)	(33.75)
R&D dummy	-0.0862***	-0.0834***	-0.087***
	(-36.71)	(-30.60)	(-33.54)
Observations	61,596	49,107	50,997
	(1) DISINV	(2) LNADJ	(3) NEGEG
Profitability	-0.008***	-0.124***	-0.019***
	(-2.57)	(-21.55)	(-5.49)
Lumpy event	0.127***	0.038***	0.104***
	(38.67)	(14.51)	(41.39)
Lumpy event x profitability	0.134***	0.100***	0.110***
	(9.67)	(7.76)	(9.37)
Dividend rate	-1.253***	-1.848***	-1.612***
	(-33.20)	(-41.94)	(-39.49)
Size	0.016***	0.016***	0.017***
	(35.68)	(33.42)	(38.51)
R&D dummy	-0.091***	-0.086***	-0.095***
	(-34.59)	(-32.70)	(-38.16)
Observations	46,487	47,956	49,237

Notes. The dependent variable is market leverage defined as ratio of total debt and the sum of total debt and market value. Profitability is defined as $\frac{EBITDA}{\text{lagged total assets}}$. The lumpy event dummy takes the value of one if it coincides with year 't' of the event (SPIKE, LPADJ, POSEG). It takes the value of zero in all other observations that do not belong to a five year event window and observations that cannot by construction be classified as events (the first two and the last two years for each firm). Dividend rate is the ratio of dividends to total assets. Size is log of total assets. The R&D dummy takes the value of one for firms that report R&D expenditures greater or equal to zero and zero otherwise. All columns were estimated with a OLS regression and include a constant. The figures in parentheses are robust t-statistics. *indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

by aggregate assets in the sample that year), X_{TOT}/A_{TOT} into its seven subcomponents, we get

$$\frac{X_{TOT}}{AT} = \sum_{j=t-1}^{t+1} \frac{X_{POS,j}}{AT} + \sum_{j=t-1}^{t+1} \frac{X_{NEG,j}}{AT} + \frac{X_{OTHER}}{AT},$$

where X_{TOT} and AT denotes time series for aggregate variable X and total assets, respectively. $X_{POS,j}$ ($X_{NEG,j}$), for $j = \{t-1, t, t+1\}$ denotes the time series of X when aggregating conditional on one particular period in windows of positive (negative) events, e.g. the SPIKE (DISINV) event.[15] X_{OTHER} is the aggregated X of all periods that have not been classified as part of event windows. Then the variance may be decomposed as

$$VAR\left(\frac{X_{TOT}}{AT}\right) = \sum_{j=t-1}^{t+1} COV\left(\frac{X_{TOT}}{AT}, \frac{X_{POS,j}}{AT}\right) + \sum_{j=t-1}^{t+1} COV\left(\frac{X_{TOT}}{AT}, \frac{X_{NEG,j}}{AT}\right) + COV\left(\frac{X_{TOT}}{AT}, \frac{X_{OTHER}}{AT}\right). \tag{2}$$

This formulation allows us to show for many variables of interest the share of variance explained by six episodes in the event windows (e.g. SPIKE(-1), SPIKE(0), SPIKE(+1) and DISINV(-1), DISINV(0), DISINV(+1)) and the times outside event windows (OTHER). Table 2 displays the decompositions for investment events. Similar decompositions for the inventory events and the employment events are shown in Tables 3 and 4. Entries in all the tables show the share of variance explained by each of the seven RHS components of equation (2) in the LHS term of this equation. Note, that all variables in the table are divided by total assets as shown in the example above, with the exception of Tobin's Q.

Investment events. Table 2 shows that capital adjustment events explain quite well the variability in capital asset purchases and sales. The last two columns, namely SUM(SPIKE) and

[15] Overlaps between event windows are possible only for the positive events' $t-1$ period and negative events' $t+1$ period and for the positive $t+1$ and negative $t-1$ periods. Since each observation can only belong to one particular time in an event window, we classify the observations to belong to the positive categories in case of overlaps. Our results are robust to only considering windows that do not overlaps. Note further that results are also robust across different firm sizes which are available upon request.

SUM(DISINV) display the total share of variance accounted for by the positive event and negative event respectively throughout the 3-year event window. The column denoted OTHER shows the share of variability accounted for by observations which do not belong to an event. For example, 67.8% of the variability in the aggregate investment rate is related to the investment rate of just 15.9% (in asset-weighted terms) of observations that are undergoing lumpy capital enlargements. In general, firm behavior during these investment events (SPIKE and DISINV) explains more than 50% of the variance in the real adjustment variables. Investment events also account for approximately 50% of the variance in Tobin's Q. The overwhelming share of the latter is accounted for by the SPIKE events. When it comes to financing variables these events combined account for less than 50% of the variance in any financing variable. For most of these variables the positive and negative events combined account for approximately 40% of their variance. The majority of the variance for all the financial variables we consider is accounted for by firm behavior outside of these events, i.s. during "normal" activity (column OTHER in Table 3). It is interesting to note that the investment rate due to firms undergoing large capital decreases is positively correlated with the aggregate investment rate the year before the lumpy negative adjustment (1st row of Table 3, DISINV(-1) column). However, it is *negatively* correlated with the aggregate investment rate during the year of the adjustment (1st row of Table 3, DISINV(0) column). This indicates that large capital decreases are undertaken with a lag of about one year after a general macroeconomic slump. It is also interesting to note the strong positive covariance with the aggregate rate of asset sales both for observations undergoing large capital increases as well as those undergoing large capital reductions. This indicates that the cyclical behavior of assets sales is driven as much by firms expanding dramatically as by those contracting substantially.

Table 2: Decomposition for investment event windows

	SPIKE(-1)	SPIKE(0)	SPIKE(+1)	DISINV(-1)	DISINV(0)	DISINV(+1)	OTHER	SUM(SPIKE)	SUM(DISINV)
Real adjustment/reallocation variables:									
Fixed investment	1.4	72.6	-6.2	11.4	-11.5	3.6	28.7	**67.8**	3.5
Change in employment	2.6	12.0	2.3	8.5	22.6	6.3	45.7	16.9	37.4
R&D expenditures	0.4	42.9	-4.4	4.4	9.5	13.6	33.6	38.9	27.5
Capital reallocation	1.6	24.7	1.9	20.2	8.9	2.8	39.9	28.2	31.9
Fixed asset sales	3.1	43.1	8.8	8.1	29.1	1.5	6.2	55.0	38.8
Inventory investment	1.5	6.8	2.6	7.0	11.1	6.7	64.4	10.8	24.8
Fundamentals/profitability variables:									
Change in Sales	1.4	5.8	2.2	6.5	14.9	6.1	63.0	9.5	27.5
Tobin's Q	9.8	38.0	-0.5	-1.7	5.2	-0.9	**50.1**	47.3	2.6
Cash Flow generated	4.5	19.7	-2.3	-1.1	3.4	4.7	71.2	21.9	7.0
Financing variables:									
Change in Cash	3.5	9.8	9.1	4.1	12.6	4.9	56.0	22.4	21.7
Change in debt outstanding	1.1	13.8	2.8	7.7	12.0	0.8	61.7	17.7	20.6
Equity issuance	2.2	21.0	2.7	4.5	7.0	5.2	57.2	26.0	16.8
Change in Total Liabilities	2.2	18.5	3.7	3.9	9.3	1.3	61.1	24.5	14.5
Dividends paid	4.8	10.3	5.6	0.7	2.3	7.5	68.7	20.7	10.6
Frequency	5.0	21.2	7.7	5.0	22.7	6.8	31.5	33.9	34.6
Asset weighted frequency	2.4	9.3	4.2	3.7	9.3	3.6	67.6	**15.9**	16.5

SPIKE(0) refers to the centre of windows for the SPIKE event, SPIKE(-1) and SPIKE(+1) denote the periods in the window before and after the event. Similarly for the DISINV event. OTHER refers to all periods outside event windows. SUM(SPIKE) is the sum of entries in columns 1-3 and SUM(DISINV) the sum of columns 4-6. All variables are divided by total assets with the exception of Tobin's Q.

Table 3: Decomposition for inventory event windows

	LPADJ(-1)	LPADJ(0)	LPADJ(+1)	LNADJ(-1)	LNADJ(0)	LNADJ(+1)	OTHER	SUM(LPADJ)	SUM(LNADJ)
Real adjustment/reallocation variables:									
Fixed investment	-6.9	44.2	12.7	34.4	36.6	-23.9	2.9	49.9	47.1
Change in employment	8.0	25.8	5.2	5.5	25.5	1.4	28.6	38.9	32.5
R&D expenditures	29.8	-3.1	-21.0	15.9	21.5	41.6	15.4	5.7	79.0
Capital reallocation	17.3	43.7	3.2	9.1	7.7	7.1	11.9	64.2	23.9
Fixed asset sales	15.2	8.4	4.7	-5.1	19.7	7.4	49.8	28.3	21.9
Inventory investment	3.0	49.3	2.7	2.8	24.4	0.9	16.8	55.0	28.1
Fundamentals/profitability variables:									
Change in Sales	5.6	32.1	8.5	4.2	21.8	3.9	23.8	46.2	30.0
Tobin's Q	23.1	30.7	7.2	-1.2	-5.9	2.5	43.5	61.0	-4.5
Cash Flow generated	21.3	43.9	6.5	7.3	-15.1	-0.5	36.6	71.7	-8.3
Financing variables:									
Change in Cash	6.9	14.5	8.3	5.4	28.8	8.7	27.3	29.7	43.0
Change in debt outstanding	2.7	30.0	3.1	6.3	19.9	2.3	35.7	35.8	28.5
Equity issuance	10.0	16.6	6.8	7.6	11.5	5.4	42.1	33.4	24.5
Change in Total Liabilities	2.8	39.4	4.8	7.1	17.6	0.3	28.0	47.0	25.0
Dividends paid	6.5	-3.6	-3.1	18.7	25.6	6.6	49.4	-0.2	50.9
Frequency	6.9	22.5	9.9	5.6	21.2	7.6	26.4	39.3	34.4
Asset weighted frequency	5.2	13.9	8.4	7.1	15.8	7.9	41.5	27.6	30.9

LPADJ(0) refers to the centre of windows for the LPADJ event, LPADJ(-1) and LPADJ(+1) denote the periods in the window before and after the event. Similarly for the LNADJ event. OTHER refers to all periods outside event windows. SUM(LPADJ) is the sum of entries in columns 1-3 and SUM(LNADJ) the sum of columns 4-6. All variables are divided by total assets with the exception of Tobin's Q.

Table 4: Decomposition for employment event windows

	POSEG(-1)	POSEG(0)	POSEG(+1)	NEGEG(-1)	NEGEG(0)	NEGEG(+1)	OTHER	SUM(POSEG)	SUM(NEGEG)
Real adjustment/reallocation variables:									
Fixed investment	-3.5	36.2	24.5	35.5	-3.7	-12.1	23.2	57.2	19.6
Change in employment	2.1	27.9	4.0	2.6	39.1	0.5	23.8	34.0	42.2
R&D expenditures	10.4	32.9	7.7	12.0	35.4	21.2	-19.6	51.0	68.6
Capital reallocation	12.4	45.7	4.5	17.7	10.4	1.9	7.5	62.6	30.0
Fixed asset sales	2.1	9.7	2.9	14.3	33.7	5.8	31.5	14.7	53.8
Inventory investment	1.6	10.2	8.4	9.1	16.8	3.7	50.2	20.2	29.6
Fundamentals/profitability variables:									
Change in Sales	2.9	9.4	5.1	5.4	22.7	5.4	49.1	17.3	33.5
Tobin's Q	13.5	55.4	8.9	-0.2	6.1	-0.1	16.4	77.9	5.7
Cash Flow generated	4.1	25.6	1.9	3.9	-4.1	2.4	66.2	31.6	2.2
Financing variables:									
Change in Cash	8.1	12.4	3.9	4.8	18.7	5.2	46.9	24.4	28.7
Change in debt outstanding	2.1	28.6	4.7	6.7	17.9	4.5	35.4	35.4	29.2
Equity issuance	1.5	16.5	5.8	5.6	10.2	7.3	53.2	23.8	23.1
Change in Total Liabilities	1.5	29.1	8.0	5.5	11.9	2.4	41.6	38.6	19.8
Dividends paid	1.7	5.5	5.5	-5.9	-1.8	4.1	90.9	12.7	-3.5
Frequency	6.1	22.1	9.2	5.8	21.9	8.2	26.8	37.4	35.8
Asset weighted frequency	3.8	10.4	6.6	6.4	13.1	7.2	52.5	20.9	26.7

LPADJ(0) refers to the centre of windows for the POSEG event, POSEG(-1) and POSEG(+1) denote the periods in the window before and after the event. Similarly for the NEGEG event. OTHER refers to all periods outside event windows. SUM(POSEG) is the sum of entries in columns 1-3 and SUM(NEGEG) the sum of columns 4-6. All variables are divided by total assets with the exception of Tobin's Q.

Inventory investment events. From the three adjustment events the one that is most successful in accounting for the variability of different firm variables is lumpy adjustment of inventories. Table 3 displays the relevant decompositions. Positive and negative lumpy events explain the majority of the variance in inventory investment, suggesting that lumpiness is very important for the understanding of aggregate behavior of inventory investment. It is also obvious that the majority variance of the real adjustment variables is also accounted for by movements that occur during those lumpy episodes. It is quite striking to see that the share of variance accounted for by "normal-activity" observations (OTHER) is lower than the asset-weighted proportion of these observations for the majority of variables considered (with the exception of Fixed asset sales, Tobin's Q, Equity issuance and dividends paid). The most interesting observation here is that the variability in aggregate financing variables are explained disproportionately by the behavior of firms undergoing lumpy inventory adjustment, whether positive or negative. For example, lumpy expansion of inventories plays a significant part in driving the variability in "Change in Debt Outstanding" and "Change in Total Liabilities", accounting for 35.8% and 47% respectively. Lumpy contraction of inventories is also overwhelmingly able to explain the variability in "Change in Cash," and "Dividends paid", accounting for 43% and 50.9% respectively. Moreover, if firms have committed projects that need financing during recessions, inventories may help in generating internal finance to substitute for more expensive external equity finance. The row in Table 4 that corresponds to fixed investment provides some evidence for this hypothesis. It reports a negative covariation between fixed investment and contraction of inventories occurring a year later.

Employment events. Table 4 reports the decomposition for employment events. Positive and negative events are quite important for the variability of real adjustment variables. The share of variance in many variables accounted by these lumpy events exceed by a large margin their proportions of asset weighted observations. Lumpy contractions in employment account for over 50% of the variability in fixed asset sales and R&D expenditures. Lumpy expansions in employment account for over 50% of the variability of fixed investment, R&D expenditures and capital reallocation. For financing variables positive events are quite important for "Change in debt outstanding", and

"Change in total liabilities", accounting for 35.4% and 38.6% of the variance respectively. Lumpy contractions play a significant role in explaining the variability of "Change in Cash" and "Change in Debt outstanding", accounting for 28.7% and 29.2% respectively. A noteworthy exception is "Dividends Paid", where "normal activity" accounts for over 90% of its variability.

5 Quantifying finance margins during events

Although the dynamic analysis in section 3 can reveal interesting adjustment patterns in various finance margins it cannot establish the relative predominance of those finance margins used in different events. Therefore in this section we quantify the importance of finance margins during events. This analysis also serves as a robustness check to the dynamic patterns we have identified in section 3. We consider three margins: cash, debt, equity issuance. For the cash and debt margins we compute the ratio of the change in that margin to lagged total assets, that is, for finance margin $x =$ cash, debt, we compute, $\frac{\Delta x_t}{AT_{t-1}}$. Equity issuance is a flow variable so we simply take $\frac{\text{equity issuance}_t}{AT_{t-1}}$. We then compute the fraction of firm-year observations during any event where this ratio is the dominant finance margin. To define dominance, we require the said margin to constitute the majority (more than 50%) of the movement in that margin for a particular episode compared to the absolute movement of all margins combined, where in each event we can observe increases or decreases in any of cash, debt, and equity issuance, thus in total six margins. We consider movements in the finance margins described above in years 't-1' and 't' inside the event window. Tables 5 and 6 below report the top three most observed financing margins. These margins account for the majority of events during the 't-1' and 't' event phase in firms histories. We report results for the bottom 90% and the top 10% of firms (in terms of total assets).

For the bottom 90% of firms, the most observed financing margin during SPIKE and LPADJ events in the preparatory phase at year 't-1', is cash accumulation which is the dominant margin in 25% of all events that have a dominant margin.[16] The second most observed in the preparatory

[16] There is a share of events that do not have a dominant finance margin. For the top 10% of firms the percent of SPIKE, LPADJ, POSEG, LNADJ, NEGEG events that do not have a single dominant margin is equal to, 23%, 17%,

phases of these events is debt reduction, where it accounts for the majority of movements across all margins in 23% and 25% percent of all events. The first (second) most observed margin in the POSEG event is debt reduction (cash accumulation) accounting for 24%, 22% of events respectively. The first most observed margin during the year 't' across all three events is debt accumulation accounting for 37%, 41% and 39% of events in SPIKE, LPADJ, and POSEG respectively. Cash reduction is the second most observed margin where it accounts for the majority of movements in 21%, 23%, and 19% of all positive events. It is interesting to note that the movements in the margins considered, in either year 't-1' or 't', account for the majority of the events, namely two-thirds or above of the share of events. Moreover the pattern of changes in financing margins are consistent with the analysis from the dynamic plots examined in section 4, where we have established that cash is build-up and leverage declines in preparation of the event and where cash reductions and debt build up is observed during the event. It is interesting that external equity issuance (positive or negative) does not feature among the top three most observed financing margins for the bottom 90% of firms.[17] Covas and Den Haan (2011) report different cyclical behaviour of equity between large and small firms; we therefore explore whether these patterns of financing margins differ for the top 10% of firms. There are some notable differences in comparison to the top panel which considers the bottom 90% of firms. For all positive events the main difference is on the importance of debt accumulation which accounts as the most observed margin in over 50% of these events at year 't'. Reductions of equity is the second most observed margin. Interestingly in contrast to the top panel of Table 5 cash reduction is not in the top three finance margins for these events. For LPADJ and POSEG events, negative equity issuance is the most observed margin in year 't-1' and second most observed margin in year 't', whereas debt accumulation is the first most observed margin in year 't'. Cash reductions is the third most observed margin during year 't' for both of these events, but clearly not as important compared to the bottom 90% of firms .

19%, 19%, 21% respectively. For the bottom 90% firms the percent of SPIKE, LPADJ, POSEG, LNADJ, NEGEG events that do not have a single dominant margin is equal to, 10%, 11%, 10%, 10%, 11% respectively.

[17]For the bottom 90% of firms, positive (negative) external equity issuance is the dominant margin is a relatively small share of events, always smaller than 10%. For example, positive/negative equity issuance is the dominant margin accounting for 8% (in year 't')/9% (in year 't-1') of SPIKE events.

Table 6 report results from negative events. For LNADJ and NEGEG the results are qualitatively a mirror image of the movements in the margins during the equivalent positive events. That is, debt is accumulated in the year 't-1' and then is retired during year 't', confirming the analysis from the dynamic plots, which suggests that leverage initially increases and then decreases when firms are in the event year. For the largest 10% of firms the negative equity issuance is the most observed margin during both LNADJ and NEGEG events. But in terms of debt increases and reductions the shares of events where these margins are dominant are very similar to the shares of events for the bottom 90% of firms.

Table 5: Finance margins positive adjustment events

Bottom 90% firms

SPIKE				LPADJ				POSEG			
	year t-1		year t		year t-1		year t		year t-1		year t
$\Delta Cash(>0)$	0.25	$\Delta Debt(>0)$	0.37	$\Delta Cash(>0)$	0.25	$\Delta Debt(>0)$	0.41	$\Delta Debt(<0)$	0.24	$\Delta Debt(>0)$	0.39
$\Delta Debt(<0)$	0.23	$\Delta Cash(<0)$	0.21	$\Delta Debt(<0)$	0.25	$\Delta Cash(<0)$	0.23	$\Delta Cash(>0)$	0.22	$\Delta Cash(<0)$	0.19
$\Delta Debt(>0)$	0.18	$\Delta Cash(>0)$	0.16	$\Delta Debt(>0)$	0.17	$\Delta Cash(>0)$	0.12	$\Delta Debt(>0)$	0.20	$\Delta Cash(>0)$	0.15
Sum of rows	0.66		0.73	Sum of rows	0.67		0.76	Sum of rows	0.66		0.73

Top 10% firms

SPIKE				LPADJ				POSEG			
	year t-1		year t		year t-1		year t		year t-1		year t
$\Delta Cash(>0)$	0.25	$\Delta Debt(>0)$	0.53	Equity issuance(<0)	0.32	$\Delta Debt(>0)$	0.50	Equity issuance(<0)	0.32	$\Delta Debt(>0)$	0.58
$\Delta Debt(>0)$	0.20	Equity issuance(<0)	0.16	$\Delta Debt(>0)$	0.21	Equity issuance(<0)	0.23	$\Delta Debt(<0)$	0.20	Equity issuance(<0)	0.14
$\Delta Debt(<0)$	0.20	$\Delta Cash(>0)$	0.13	$\Delta Debt(<0)$	0.20	$\Delta Cash(<0)$	0.10	$\Delta Debt(>0)$	0.19	$\Delta Cash(<0)$	0.08
Sum of rows	0.65		0.82	Sum of rows	0.73		0.83	Sum of rows	0.71		0.80

Each number records the percent share of all events that have a single dominant margin, where the margin $x = Cash, Debt,$ Equity issuance, is the dominant margin among all other margins.

Table 6: Finance margins: negative adjustment events

Bottom 90% firms							
LNADJ				**NEGEG**			
	year t-1		year t		year t-1		year t
$\Delta Debt(>0)$	0.33	$\Delta Debt(<0)$	0.40	$\Delta Debt(>0)$	0.32	$\Delta Debt(<0)$	0.34
$\Delta Cash(<0)$	0.21	$\Delta Cash(>0)$	0.24	$\Delta Debt(<0)$	0.20	$\Delta Debt(>0)$	0.18
$\Delta Debt(<0)$	0.19	$\Delta Cash(<0)$	0.13	$\Delta Cash(<0)$	0.19	$\Delta Cash(<0)$	0.18
Sum of rows	0.71		0.77	Sum of rows	0.71		0.70

Top 10\% firms							
LNADJ				**NEGEG**			
	year t-1		year t		year t-1		year t
Equity issuance(<0)	0.32	$\Delta Debt(<0)$	0.41	Equity issuance(<0)	0.32	$\Delta Debt(<0)$	0.38
$\Delta Debt(>0)$	0.31	Equity issuance(<0)	0.30	$\Delta Debt(>0)$	0.29	Equity issuance(<0)	0.32
$\Delta Debt(<0)$	0.17	$\Delta Cash(>0)$	0.12	$\Delta Debt(<0)$	0.22	$\Delta Debt(>0)$	0.13
Sum of rows	0.80		0.83	Sum of rows	0.83		0.83

Each number records the percent share of all events that have a single dominant margin, where the margin Δx, $x = Cash, Debt,$ Equity issuance, is the dominant margin among all other margins.

6 Debt and equity substitutability

Financing frictions might well affect differently the ability of firms to finance lumpy adjustment. A large literature views size as an indicator of financing constraints and estimates direct and indirect costs of external finance (see Altinlikic and Hansen (2000) Hennessy and Whited (2007) among others). For example Hennessy and Whited (2007) find small firms face costlier debt and equity finance compared to large firms. Covas and Den Haan (2011) argue that large firms (in the top 10 percentile) exhibit very different cyclical financing behaviour in comparison to smaller firms below the 90th percentile. Salomao and Begenau (2016) confirm these empirical facts using COMPUSTAT quarterly data and offer a theoretical explanation based on differences in the costs of debt and equity across different firm sizes. These differences show up in the cyclicality of debt and equity financing conditional on firm size. In this section we examine the patterns of adjustment in debt and equity for the six events under consideration after splitting into sub-samples comprising of the 0-90% firms and the top 10% of firms in terms of size (total assets).

To examine whether the use of debt and equity differs across firms we tabulate the share of events which are characterized by (i) increases in debt and equity, (ii) increases in debt and decreases in equity, (iii) decreases in debt and increases in equity, (iv) decreases in debt and equity. Table 7 reports the share of events for each event separately. There are several noteworthy findings. First, for the bottom 90% of firms reductions in debt and increases in equity are observed in 28%, 23%, 22% percent of SPIKE, LPADJ, POSEG events respectively in year 't-1'. This combination is observed in the largest share of events SPIKE and LPADJ at year 't-1'. By contrast, for the top 10% of firms, reductions in both debt and equity are observed in the largest share of SPIKE and LPADJ events. Therefore, during positive events reductions in debt are commonplace for both small and large firms in the preparatory year 't-1', consistent with the dynamic analysis in section 4. However, small firms seem to be using equity in a greater proportion of positive events compared to large firms and the latter to be reducing the use of equity. Increases in debt and equity are observed in 33%, 31%, 32% percent of SPIKE, LPADJ, POSEG events respectively in year 't' and this combination is observed in the largest share of events for the bottom 90% of firms. The combination of an increase in debt and reduction in equity becomes observed in 48%, 52%, 52% of SPIKE, LPADJ, POSEG events respectively in year 't' for the top 10% of firms. Thus while both small and large firms use debt to finance expansion in assets, the latter substitute debt for equity during those events. This is consistent with the evidence reported by Covas and Den Haan (2011), namely large firms substituting debt for equity. Turning to negative events the behavior of small and large firms appears more similar. For both the bottom 90% and 10% large firms, increases in debt and decreases in equity account for the largest share of events in year 't-1'. And decreases in both debt and equity account for the largest share of events in year 't'.

7 Conclusion

Firms respond to business conditions by adjusting their operations. This adjustment is often lumpy and an important determinant of macroeconomic fluctuations—a disproportionate share of aggregate variability in real and financial variables is due to firms that are undergoing lumpy adjustment. Rel-

Table 7: Debt and equity use during lumpy events

All firms	year t-1				year t			
	+ debt +equity	+ debt - equity	- debt + equity	- debt - equity	+ debt +equity	+ debt - equity	- debt + equity	- debt - equity
SPIKE	0.23	0.19	0.27	0.19	0.33	0.28	0.19	0.10
DISINV	0.20	0.29	0.14	0.20	0.14	0.15	0.18	0.32
LPADJ	0.20	0.21	0.21	0.24	0.30	0.32	0.14	0.12
LNADJ	0.23	0.27	0.15	0.20	0.15	0.15	0.21	0.31
POSEG	0.22	0.21	0.21	0.22	0.32	0.29	0.16	0.11
NEGEG	0.22	0.26	0.16	0.21	0.16	0.19	0.18	0.30

Bottom 90% firms	year t-1				year t			
	+ debt +equity	+ debt - equity	- debt + equity	- debt - equity	+ debt +equity	+ debt - equity	- debt + equity	- debt - equity
SPIKE	0.23	***0.18***	0.28	0.18	0.33	***0.27***	0.19	0.10
DISINV	0.20	0.28	0.14	0.19	0.14	0.14	0.19	0.31
LPADJ	0.20	***0.19***	0.23	0.23	0.31	***0.30***	0.15	0.11
LNADJ	0.24	0.25	0.16	0.19	0.16	0.15	0.22	0.29
POSEG	0.23	***0.19***	0.22	0.21	0.32	***0.27***	0.17	0.11
NEGEG	0.23	0.25	0.16	0.20	0.17	0.18	0.19	0.28

Top 10% firms	year t-1				year t			
	+ debt +equity	+ debt - equity	- debt + equity	- debt - equity	+ debt +equity	+ debt - equity	- debt + equity	- debt - equity
SPIKE	0.20	**0.32**	0.15	0.32	0.28	**0.48**	0.10	0.14
DISINV	0.11	0.46	0.08	0.33	0.07	0.22	0.13	0.54
LPADJ	0.13	**0.36**	0.12	0.38	0.21	**0.52**	0.06	0.19
LNADJ	0.12	0.41	0.09	0.35	0.08	0.24	0.14	0.51
POSEG	0.12	**0.36**	0.14	0.35	0.26	**0.52**	0.05	0.14
NEGEG	0.12	0.41	0.10	0.35	0.07	0.26	0.12	0.52

Notes. Each number records the percent share of all events that show an increase in the growth rate of debt and an increase in equity issuance(+debt/+equity), an increase in the growth rate of debt and a decrease in equity issuance (+debt/-equity), a decrease in the growth rate of debt and increase in equity (-debt/-equity), and a decrease in the growth rate of b debt and decrease in equity issuance (-debt/-equity). Numbers do not add up to 1 because we have excluded observations that entail zero changes in either debt or equity or both.

atively little is known about the specific margins of finance that firms use during lumpy adjustment. This paper uses an event-study approach to study how publicly traded U.S. firms in Compustat firms finance lumpy adjustment in capital, employment and inventories in the period 1971-2013.

We find that debt and cash play a dominant role. Firms *expand* real assets by using predominantly a combination of cash and debt. Cash balances play an important preparatory role in the financing of the lumpy episodes building up a year before the expansion in real assets and reduced significantly during the year of the expansion. Thus cash becomes a leading indicator for expansion events. There is, therefore, evidence that cash is valuable in that it confers "financial flexibility" to the firm. Moreover, firms actively create debt capacity by de-leveraging in the year prior to the event in order to use it later as the expansion of assets unfolds. Notably our findings imply that cash is not equivalent to (and should not be modelled as) negative debt. *Contraction* in productive assets is associated with firms temporarily reducing cash in the year before the lumpy contraction while also having higher than "normal" debt growth. During the event, they rebuild cash and decrease leverage by reducing debt growth significantly. Firms finance lumpy expansions with debt issuance, whereas they use lumpy contractions to reduce debt. These patterns are qualitatively similar for both small and large firms. Moreover, from a quantitative perspective changes in debt and cash are the predominant finance margins in a large share of lumpy events.

Our paper is complementary to a series of recent papers on corporate leverage (see Denis and McKeon (2012), DeAngelo and Roll (2015), and DeAngelo et al. (2016)). These papers study events identified by large adjustment in corporate leverage and inform us about the reasons they were undertaken. Our paper makes headway in that we identify underlying causes of leverage movements, in particular lumpy adjustment in productive assets. We then study variations in several financing margins in addition to leverage during these events. Our results provide insights about the fundamental drivers of the time series variation of leverage, about which we know little according to DeAngelo and Roll (2015). We revisit the leverage-profitability empirical relationship in the light of firm lumpy adjustment. This relationship is important in as much as it can shed light on the relative merits of the trade-off and pecking order theories of capital structure. We formally show that, conditional on lumpy adjustment events, the correlation between leverage and profitability is significantly positive, consistent with a dynamic trade-off theory. Our results on the empirical patterns of lumpy asset adjustment and finance margins may provide useful guidance in the construction of firm models that endogenize policies for both dynamic financing and productive assets.

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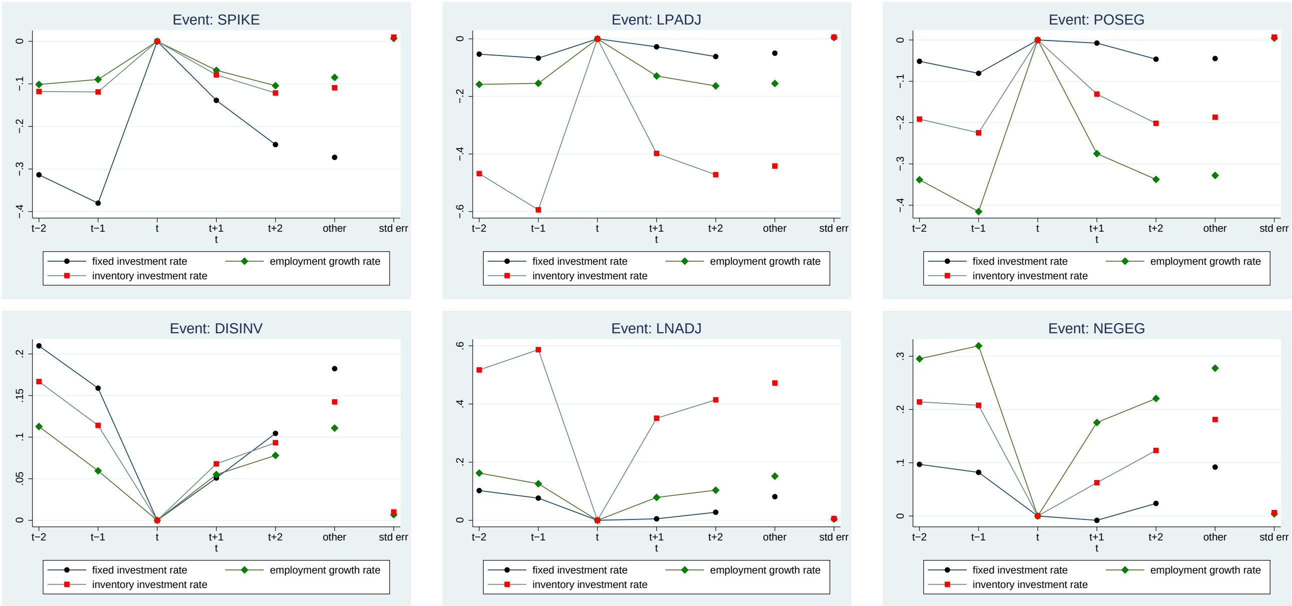

Figure 1: Behavior of asset adjustment around lumpy events: (1) investment spike (top-left), (2) large positive inventory adjustment (top-center), (3) positive employment burst (top-right) (4) disinvestment (bottom-left), (5) large negative inventory adjustment (bottom-center), (6) negative employment burst (bottom-right).

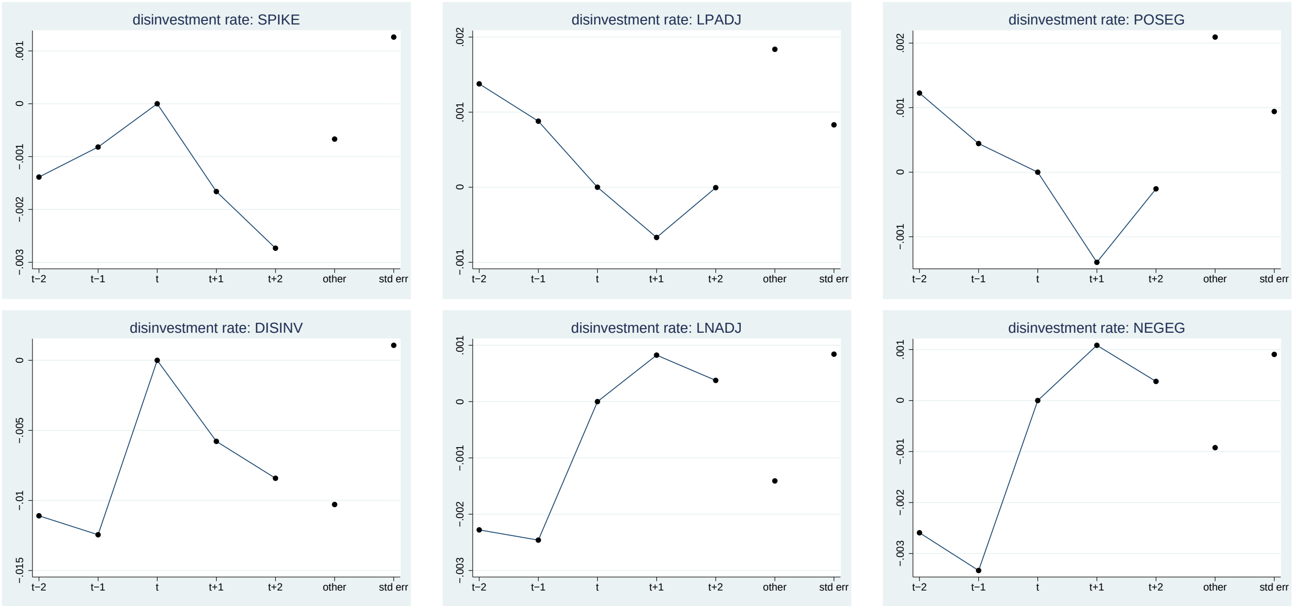

Figure 2: Behavior of fixed disinvestment rate (SPPE/PPENT) around events: (1) investment spike (top-left), (2) large positive inventory adjustment (top-center), (3) positive employment burst (top-right) (4) disinvestment (bottom-left), (5) large negative inventory adjustment (bottom-center), (6) negative employment burst (bottom-right).

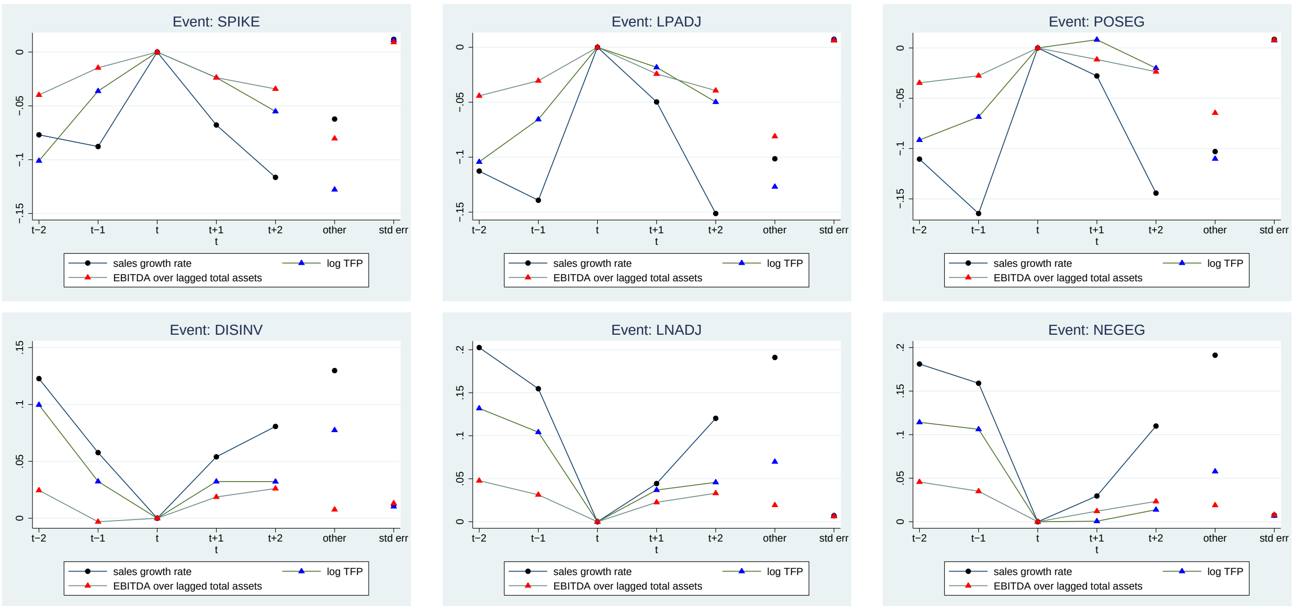

Figure 3: Behavior of profitability variables around lumpy events: (1) investment spike (top-left), (2) large positive inventory adjustment (top-center), (3) positive employment burst (top-right) (4) disinvestment (bottom-left), (5) large negative inventory adjustment (bottom-center), (6) negative employment burst (bottom-right).

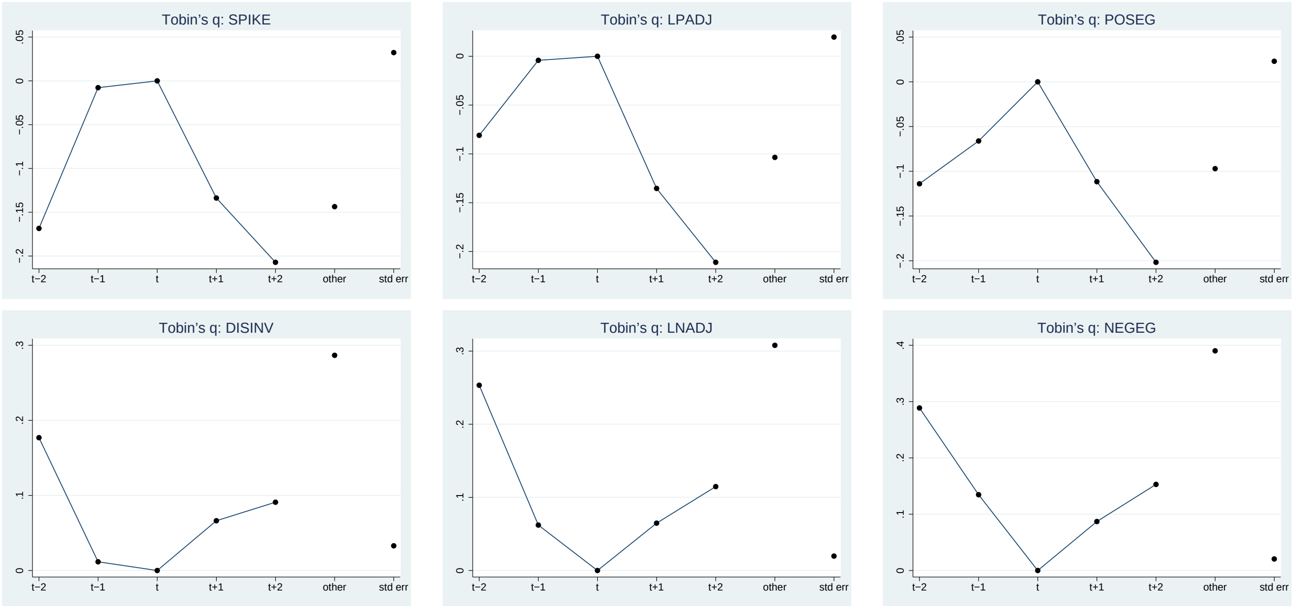

Figure 4: Behavior of Tobin's Q around lumpy events: (1) investment spike (top-left), (2) large positive inventory adjustment (top-center), (3) positive employment burst (top-right) (4) disinvestment (bottom-left), (5) large negative inventory adjustment (bottom-center), (6) negative employment burst (bottom-right).

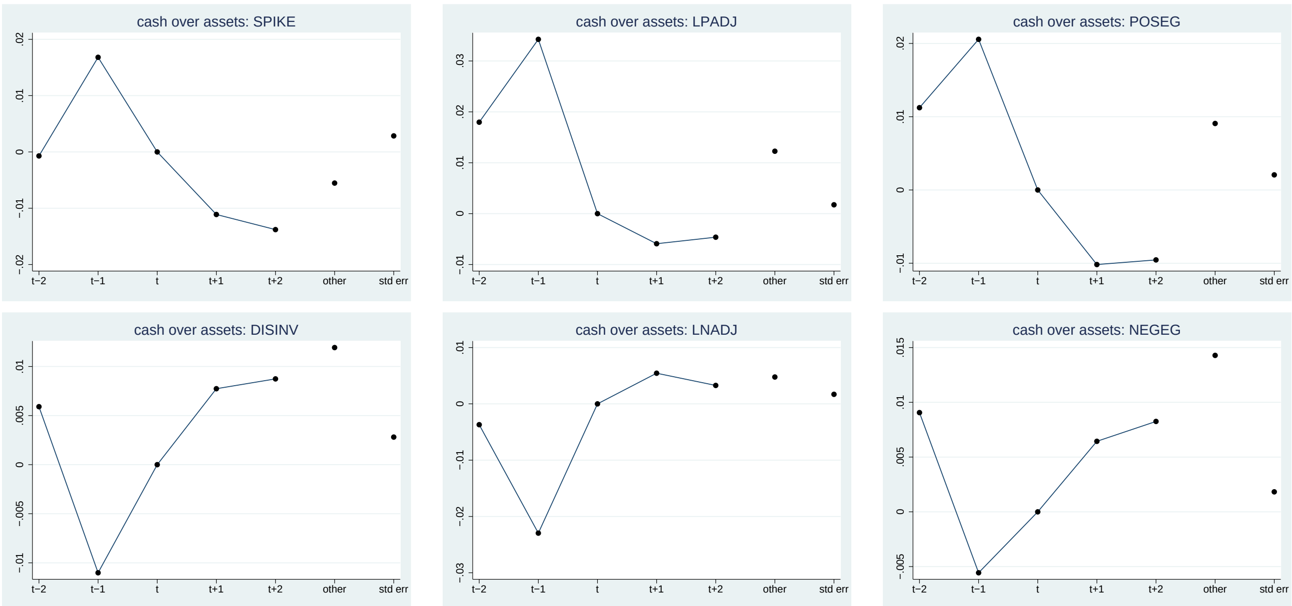

Figure 5: Behavior of cash over contemporaneous assets around events: (1) investment spike (top-left), (2) large positive inventory adjustment (top-center), (3) positive employment burst (top-right) (4) disinvestment (bottom-left), (5) large negative inventory adjustment (bottom-center), (6) negative employment burst (bottom-right).

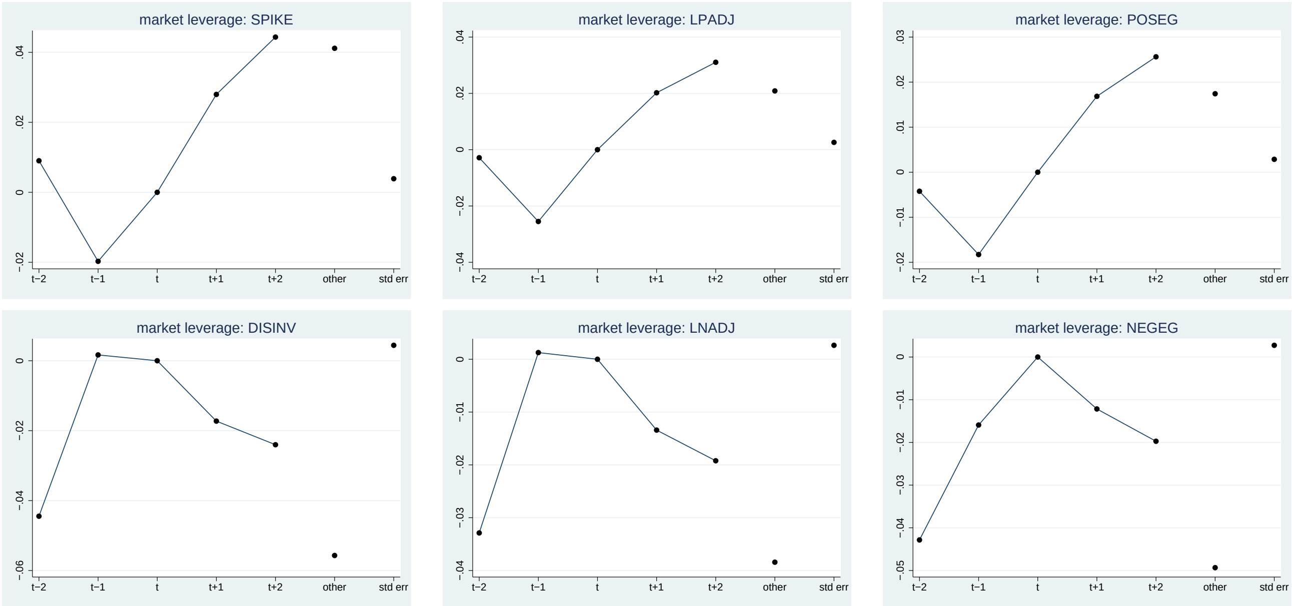

Figure 6: Behavior of market leverage around events: (1) investment spike (top-left), (2) large positive inventory adjustment (top-center), (3) positive employment burst (top-right) (4) disinvestment (bottom-left), (5) large negative inventory adjustment (bottom-center), (6) negative employment burst (bottom-right).

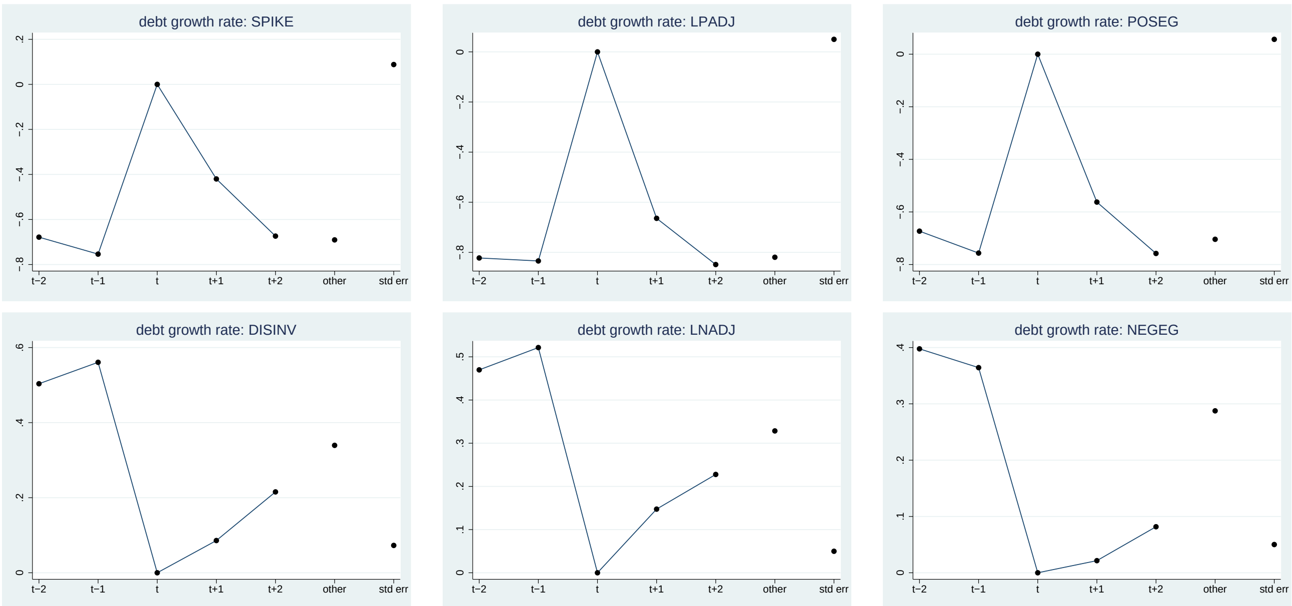

Figure 7: Behavior of growth rate of debt around events: (1) investment spike (top-left), (2) large positive inventory adjustment (top-center), (3) positive employment burst (top-right) (4) disinvestment (bottom-left), (5) large negative inventory adjustment (bottom-center), (6) negative employment burst (bottom-right).

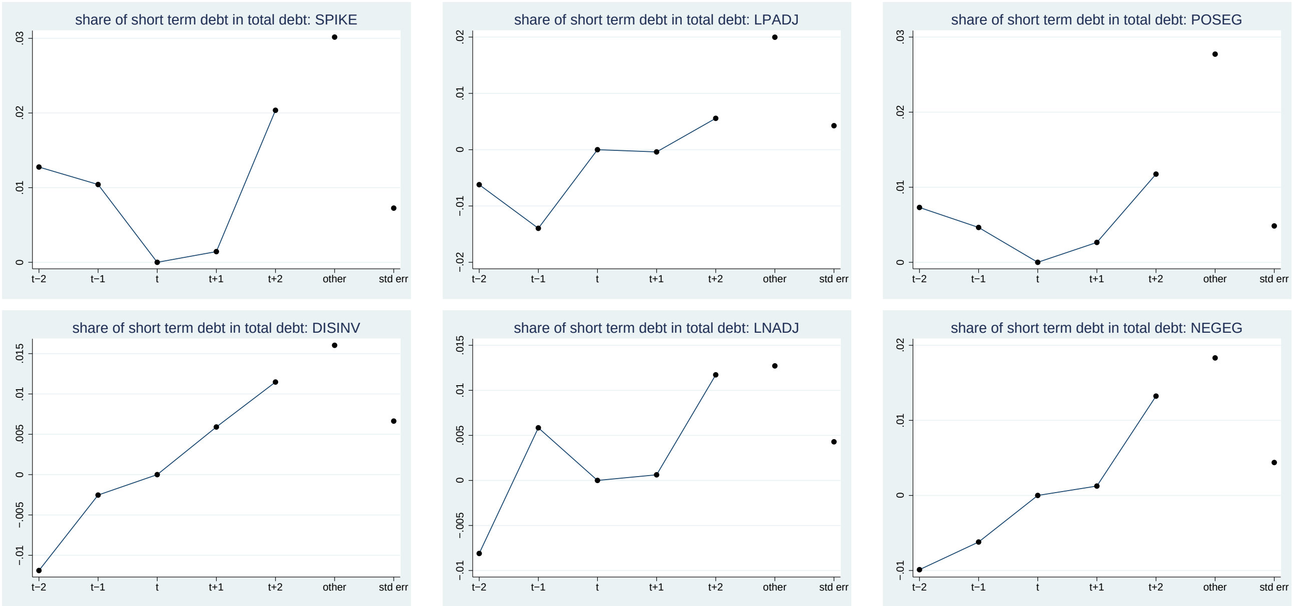

Figure 8: Behavior of the share of short term debt in total debt around events: (1) investment spike (top-left), (2) large positive inventory adjustment (top-center), (3) positive employment burst (top-right) (4) disinvestment (bottom-left), (5) large negative inventory adjustment (bottom-center), (6) negative employment burst (bottom-right).

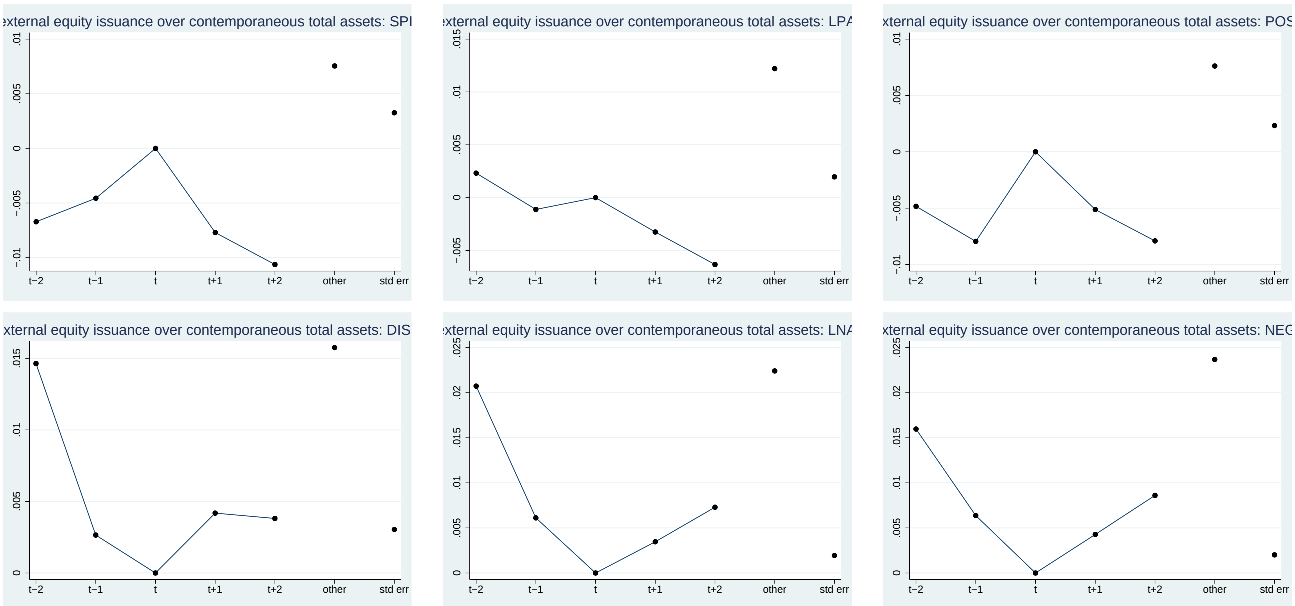

Figure 9: Behavior of (external) equity issuance scaled by contemporaneous total assets around events: (1) investment spike (top-left), (2) large positive inventory adjustment (top-center), (3) positive employment burst (top-right) (4) disinvestment (bottom-left), (5) large negative inventory adjustment (bottom-center), (6) negative employment burst (bottom-right).

8 Appendix with supplementary material (Not for publication)

.1 Basic event statistics

Table 8 reports the joint occurrence of events in our sample. Different events are not necessarily synchronized although for some lumpy events the joint probability of occurrence is higher that others. For example, investment spikes are accompanied by lumpy expansion in inventories (or employment) in just over 20% of the times.

Table 8: Joint occurrence of events (in percent)

	SPIKE	DISINV	LPADJ	LNADJ	POSEG	NEGEG
SPIKE	100.0	0.0	24.5	7.3	21.8	6.7
DISINV	0.0	100.0	6.6	23.9	5.3	22.1
LPADJ	14.2	3.3	100.0	0.0	28.4	4.8
LNADJ	4.0	11.4	0.0	100.0	4.0	29.5
POSEG	15.9	3.3	35.9	5.3	100.0	0.0
NEGEG	4.2	11.9	5.1	33.2	0.0	100.0

The table shows the probability of an event in a column conditional on an event in a row. SPIKE/DISINV is the positive/negative investment event, LPADJ/LNADJ is the positive/negative inventory event and POSEG/NEGEG is the positive/negative employment adjustment event.

.2 Cyclicality of Events

Figures 10 and 11 display the evolution of events over time in our sample. Figure 10 displays the proportion of observations that are classified as having a lumpy event in each year in the sample, termed the *event rate*. The left panel displays the positive events and the right panel the negative events. Figure 10 suggests that, typically, positive event rates decline before and during official NBER recessions (except the 1981-1982 recession, where the event rate has risen) and rise during the recovery phase of the cycle. By contrast, negative event rates rise shortly before and during recessions and typically fall in the early stages of the recovery phases. Figure 11 displays the fraction of observations that either experience a lumpy event or belong to the event window for each year in the sample, termed the *event window* rate. Figure 11 suggests that our event window rate captures a significant fraction of the history of firm adjustment.

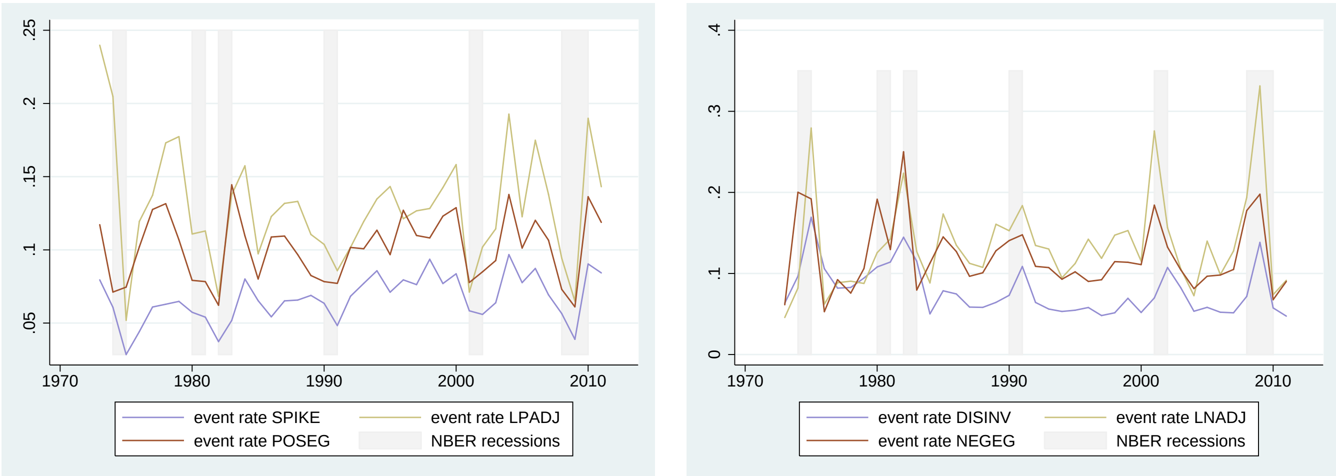

Figure 10: Event rates. Proportion of firm observations per year that are classified as having a lumpy event. Grey bars denote NBER recessions dates.

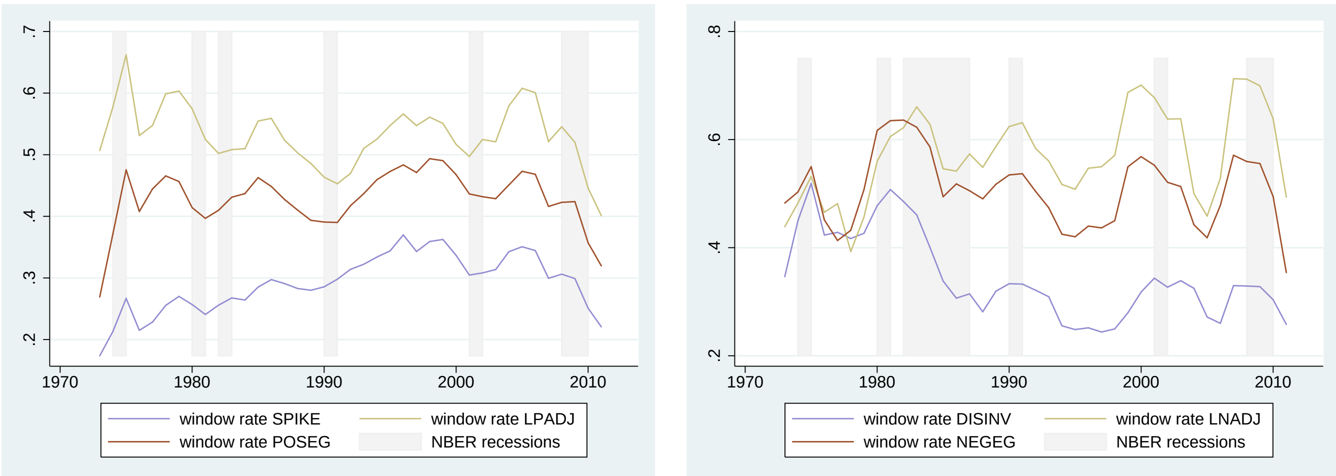

Figure 11: Event window rates. Proportion of firm observations per year that either experience a lumpy event or belong to the event window. Grey bars denote NBER recessions dates.

Table 9 provides evidence on the cyclicality of events and confirms the "eye-balling" visual provided by Figures 1 and 2 above regarding the evolution of events in different phases of the business cycle. It reports contemporaneous as well as lagging and leading correlations of event rates with the conventional measure of the cycle, namely, Gross Domestic Product (GDP). Table 9 reports that the event rate is positively correlated with GDP when considering any one of the three positive adjustment events. The corresponding correlation is negative for negative events. The same pattern of correlations holds for the aggregate value of the variable used in defining the events conditioned on observations that are classified as events.

Table 9: Correlations with GDP

	GDP(-1)	GDP	GDP(+1)	GDP(-1)	GDP	GDP(+1)
	SPIKE			**DISINV**		
Event rate	-0.37	0.47*	0.49*	0.07	-0.62*	-0.46*
	LPADJ			**LNADJ**		
Event rate	-0.15	0.55*	0.40*	0.37*	-0.40*	-0.39*
	POSEG			**NEGEG**		
Event rate	-0.43*	0.36*	0.61*	0.53*	-0.32*	-0.57*

Notes. * indicates significance at the 10% level. GDP indicates the log of real gross value added of non-financial corporate business. All series in this table are HP(100)-filtered. GDP(+1) indicates the correlation with GDP one period ahead. For the six events x denotes investment (SPIKE), net investment (DISINV), inventory investment (LPADJ, LNADJ), employment growth (POSEG, NEGEG).

.3 Data Appendix

Our dataset comprises information provided by COMPUSTAT (North-America) Fundamentals Annual Files (Monthly updates). In the sections below, we describe the relevant variables and their construction, followed by sample selection and cleaning criteria.

Data Sources and Variable Construction

- Fixed investment is Capital Expenditures (CAPX). Net investment is CAPX minus Sale of Property, Plant and Equipment (SPPE).
- The capital stock is the net value of Total Property, Plant and Equipment(PPENT).

- Total Inventories (INVT) is end of period total inventories, which are measured in LIFO terms. Inventory investment is defined as difference between beginning and end of period inventories.
- Net total sales is Total Sales (SALE).
- For cash holdings we use the COMPUSTAT variable Cash and Short-Term Investments (CHE).
- Total debt (DEBT) is constructed as the sum of Long Term Debt Total (DLTT) and Debt in Current Liabilities (DLC). Thereby we only consider observations for which book equity is larger than zero so that DEBT over contemporaneous assets is bounded between zero and one. Book equity (BE) is defined as Stockholder's Equity (SEQ) as in Covas and Den Haan (2011).
- Ebitda is Operating Income before Depreciation (OIBDP).
- Tobin's q (Q) is defined as (AT+(PRCC·CSHO)-CEQ)/AT, where PRCC is the Annual Price Close (fiscal year end), CSHO is Common Shares Outstanding, AT is Total Assets and CEQ is Common Equity.
- Market leverage (MLEV) is constructed in line with Denis and McKeon (2012) as total debt over the sum of total debt and market value (DEBT/(DEBT+MVAL), where market value MVAL is given by the product of the Annual Price Close (fiscal year end), PRCC, and Common Shares Outstanding, CSHO.
- (External) equity issuance is defined according to Salomao and Begenau (2016) as equity issuance (SSTK) minus cash dividends (DV) minus equity repurchases (PRSTKC)
- We estimate firm level productivity (TFP) based on the methodology outlined in Olley and Pakes (1996). This methodology is widely used in the literature (see e.g. Imrohoroglu and Tuzel (2011)) which is why we outline here only the variables we used in the estimation. The key variables for this estimation are he beginning of period capital stock (PPENT), the stock of labor (EMP) and value added. We further require the average age of the capital stock which is calculated by the quotient of Accumulated Depreciation, Depletion and Amortization (DPACT)

and current Depreciation and Amortization (DP). The final variable for age is smoothed by taking a 3-year moving average. For a firm with a history shorter than three years we take the average over the available years. Value added is constructed as the difference of sales and materials. While sales (SALE) is directly available in COMPUSTAT, we construct materials as total expenses minus labour expenses. Total expenses is sales (SALE) minus the sum of Operating Income after Depreciation (OIADP) and Depreciation (DP). Data on labor expenses is very sparse in COMPUSTAT, we therefore construct it as the product of employees (EMP) and aggregate yearly average wage index from the US Social Security Administration.[18]

- Cash flow is defined as the sum of Income Before Extraordinary Items (IB) and Depreciation and Amortization (DP).
- We define capital reallocation as the sum of acquisitions (ACQ) and Sales in Property, Plant and Equipments (SPPE). To maximise coverage, we treat missing observations for ACQ as zeros.
- R&D expenditures are given by Compustat variable Research and Development Expense, XRD.
- Total Liabilities are Compustat variable LT.
- Dividend payments are given by Dividends Total, DVT.

Deflators We apply the P_K, the implicit price deflator for private fixed nonresidential investment (available from the Bureau of Economics Analysis) to deflate fixed investment (CAPX) and sales of property plant and equipment (SPPE). Since investment is made at various times, capital stock variables, PPENT and PPEGT, are deflated using P_K following the methodology as in Hall (1990). For this purpose we calculate the average age of the capital stock in every year (by firm) and apply the appropriate deflator with timing 'current period' minus 'average capital stock age'.

[18] This limitation of Compustat data is widely documented, see e.g. Imrohoroglu and Tuzel (2011), and a comparison of the Compustat variable for Staff Expenses (XLR) with our series on labor expenses suggests that our approximation is reasonable, delivering an unbiased estimate for labor expenses.

Following Imrohoroglu and Tuzel (2011) we calculate the average age of the capital stock as the quotient of accumulated depreciation (DPACT) by current depreciation (DP).[19] Inventory variables are deflated using, P_{invt}, the price deflator for finished goods (PPI). It is the finished goods PPI obtained from the Bureau of Labor Statistics, Producer Price Index: Finished Goods (PPIFGS). All other relevant variables are deflated using, the GDP deflator, P_{GDP}, available from the Bureau of Economics Analysis.

Sample Selection

We select the sample by making the following adjustments to the data retrieved from COMPUSTAT:

- We delete all regulated, quasi-public or financial firms (primary SIC classification is between 4900-4999 and 6000-6999). We only retain firms in manufacturing (SIC code 2000-3999), wholesale trade (SIC code 5000-5199), retail trade (SIC code 5200-5999) and communications (SIC code 4800-4899).
- If a firm's report date is before June, we allocate the respective observations to the previous year.
- We delete firms reported earnings in a currency other than USD.
- As conventional in the literature, we account for the effects of mergers and acquisitions by deleting all firm-year observations including and after (i) an acquisition (ACQ) exceeding 15% of total assets (AT), (ii) sales growth exceeding 50% in any year due to a merger as indicated by SALE footnote AB, or (iii) the absolute difference between CAPX and CAPXV over PPENT exceeds 0.5 and is accompanied by a substantial increase ($> 20\%$) of the absolute growth rate of PPENT. While CAPX includes all investment in property, plant and equipment including increases in the capital stock due to acquisitions of other companies, this is excluded in CAPXV. CAPXV is Capital Expenditures on Property, Plant and Equipment (Schedule V).

[19] We smooth the age variable by taking a 3-year moving average. If there are less than three years available, we take the average over these years.

- We drop observations prior to 1989 for Ford, GM, Chrysler and GE as these are most affected by the accounting change in 1988 (for details see Bernanke et al. (1990)). We also drop observations for AT&T as the changes to the company structure in 1981 strongly affect aggregates.
- We drop observations if values are missing at the beginning or end of firm time series for all variables CAPX, SALE, PPENT, CHE, INVT and AT.
- We drop firms that never invest or hold inventories.
- We drop firms with less than six years of data.
- We drop all observations prior to 1971 and after 2013.

Cleaning Procedures

We apply the following filters to the variables used:

- We set negative values of the following variables to missing: CAPX, INVT, DVT, CHE, PRSTKC, DP, SPPE, DLTT, DLC, XRD, ACQ, SSTK, PRSTKC, DV.
- We set values smaller and equal to zero of the following variables to missing: PPENT, PPEGT, SALE, EMP, AT, MVAL, Q.
- For extremely high investment rates we check for potential miscoding in CAPX by evaluating whether the growth rate of PPENT actually changes substantially. In the top percentile of CAPX/PPENT we set values for PPEGT, PPENT and CAPX to missing unless the absolute difference between (CAPX-SPPE-ACQ)/PPEGT and the growth rate of PPENT does not exceed 0.1. We further set observations for CAPX to missing if for any particular observation CAPX/PPENT exceeds 5 and CAPX/PPEGT exceeds 2 to exclude effects of mergers and acquisitions. We further set values for CAPX, PPENT and PPEGT to missing if CAPX/PPENT exceeds 5 or CAPX/PPEGT exceeds 2.

- In the top percentile of SPPE/PPEGT we set values for SPPE to missing unless the absolute difference between (CAPX-SPPE-ACQ)/PPEGT and the growth rate of PPENT does not exceed 0.1. We further set values for SPPE to missing if SPPE/PPEGT > 0.9.

- We set values for AT, INVT, SALE, EMP, PPENT and CAPX to missing for extreme changes in these variables. In particular, values for EMP, SALE, PPENT (AT, INVT, CAPX) are replaced with missing in the bottom 0.5 (1) percentile of their respective growth rates. Values for EMP, INVT, SALE, AT (PPENT) [CAPX] are replaced with missing in the top 0.5 (0.01) [1] percentile of their respective growth rates. These percentiles are chosen so that values are set to missing if a variable's growth rate is approximately above 9 or below -0.9.

- We replace negative values for BE by missing. We further set values for BE to missing if (i) the ratio of BE to AT exceeds one, and (ii) all observations for BE that are within the 0.5th percentile.

- We winsorise the inventory to sales ratio and the disinvestment rate (SPPE/PPENT) at the bottom and top 1 percentile. We also winsorise Q at the bottom and top 0.5 percentile.

- We set values to missing in the top and bottom 0.1 (1) percentiles of EBITDA over AT (leverage, external equity issuance over lagged assets, external equity issuance, average age of capital which is DPACT over DP).

- We replace values in the top 0.1 (0.5) [1] percentile with missing of the depreciation rate (CHE over lagged assets and debt over lagged assets) [the growth rate of cash].

- We replace values in the top 0.5 (1) percentile of the growth rate of DEBT (XRD) with missing. These observations are also set to missing for total DEBT (XRD).

- We set values for cash flow to missing for the top and bottom one percentile of cash flow over contemporaneous (and lagged) total assets. We also set it to missing if the raw variables for CEQ or SEQ were reported to be negative.

- We set values to missing in the top 0.25 percentile of DVT over AT (and over lagged assets) and the top 0.5 percentile of DVT over SEQ. The time-year observations that have been set to missing for these two variables are also replaced by missing values in DVT.
- For the growth rate of TFP we set the top and bottom 0.1 percentile to missing. For these observations we also set TFP to missing.