How do Firms Finance Lumpy Adjustment?*

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Abstract

We study how firms finance lumpy adjustment in capital and employment using U.S. firm-level data from Compustat. Lumpy adjustment is preceded by a finance preparatory phase. During this phase firms use primarily two margins in order to expand or contract capacity, namely, cash balances and debt, but these margins are not perfect substitutes. Cash balances rise (fall) temporarily in preparation to lumpy expansion (contraction). Firms de-leverage (increase leverage) in preparation to lumpy expansion (contraction). Leverage increases slowly often several years after the lumpy adjustment. Understanding the financing of lumpy adjustment is highly relevant from a macroeconomic perspective as lumpy expansions and contractions drive a disproportionate share in the aggregate volatility of fixed investment, Tobin's Q, aggregate debt issuance and corporate cash use.

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

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1 Introduction

Firms respond to business conditions by adjusting their operations in a manner that is often lumpy. In so doing, firms also adjust leverage, cash balances, dividends and several other margins of finance. Are there clear and systematic patterns in the policies that firms use to finance lumpy adjustment in capital and employment? Indeed, there are. We show firms anticipate the incipient lumpy adjustment and prepare to finance it already a year before. For lumpy expansions in capital or employment, firms increase cash balances and reduce leverage the year before. Then, during the expansion, the associated expenses are covered by drawing down cash holdings and increasing debt, thus driving up leverage. Interestingly, leverage continues to rise significantly for two years after the lumpy adjustment was initiated. The joint movements of cash and leverage suggest that firms actively create debt capacity in order to use it later as the expansion of assets unfolds, and also that cash balances play a complementary role to the creation of debt capacity.

The movements of cash and debt described above for asset expansions are mirrored for lumpy contractions. Contraction in capital or employment is associated with firms temporarily reducing cash the year before the lumpy contraction, while also having higher than average debt growth. During and after the contraction, firms rebuild cash and reduce debt growth significantly. Interestingly, the movements we have uncovered are qualitatively similar for firms that differ across several dimensions: size, cash balances, and leverage. Our results also indicate that equity issuance is not a major source of finance when firms undergo lumpy adjustment. The adjustment patterns in finance variables we have uncovered are qualitatively similar for both capital and employment lumpy adjustment.

To the best of our knowledge, ours is the first paper to provide a systematic study of financing patterns in preparation, during and after lumpy adjustment in capital and employment. Understanding these patterns is important as, based on new evidence for U.S. public firms contained in our paper, movements in aggregate real and financial variables are, to a large extent, accounted for by firms that are undergoing lumpy adjustment in capital and employment.

Our analysis focuses on annual U.S. firm data from Compustat. An important feature of our approach is to go beyond analysis of contemporaneous relationships. Our methodology, adopted from

Sakellaris (2004), allows us to examine how different financing margins are employed in preparation, during and after the year of the lumpy adjustment. The richness of our approach means we are able to identify important and novel lead-lag relationships among different financing margins and productive assets' movements.

The need to capture firms' dynamic financing patters with such a rich methodology is shown by means of an example: a lumpy capital expansion undertaken by Schlitz Brewing company in year 1974. Figure 1 displays the investment rate (investment over capital), and two other variables that aim to capture patterns in the financing behavior around this lumpy adjustment. The figure tracks this adjustment over a period of five years, starting two years prior to the lumpy increase in capital (years, '-2', and '-1'), followed by the year of the expansion (year '0' in the figure) and two years after (years, '1, and '2'). Tracing out the adjustment over time is important because it ensures that we can capture all the interesting patterns in financing the adjustment in assets. Moreover, we can trace out the average behavior of any of the three variables displayed in the figure outside of a particular lumpy adjustment episode, i.e. in periods that do not belong to this five year window. In the figure, this is captured by 'other', indicating normal operational times without a lumpy capital adjustment. It is what we expect the level of the variable to return to once the adjustment is complete. We can thus detect differences, if any, in the behavior of variables during a particular lumpy episode compared to their average behavior during any other time in the history of a firm.

Figure 1 displays several patterns that are of interest. First, the investment rate is already elevated in years '-2', and '-1', relative to 'other'. It exhibits the largest increase in the year of the adjustment and stays significantly elevated relative to 'other' in year '1', indicating that the adjustment takes time to complete. The level of cash begins from a high level compared to 'other' and then drops significantly as the adjustment unfolds. The level of debt falls temporarily in the year preceding the adjustment, it then rises significantly above 'other' during adjustment, and interestingly, continues to rise in the two years following the adjustment.

In relation to the literature, our contribution relates to four lines of work: recent papers on corporate leverage, studies on the substitutability of firm debt and equity issuance over the business

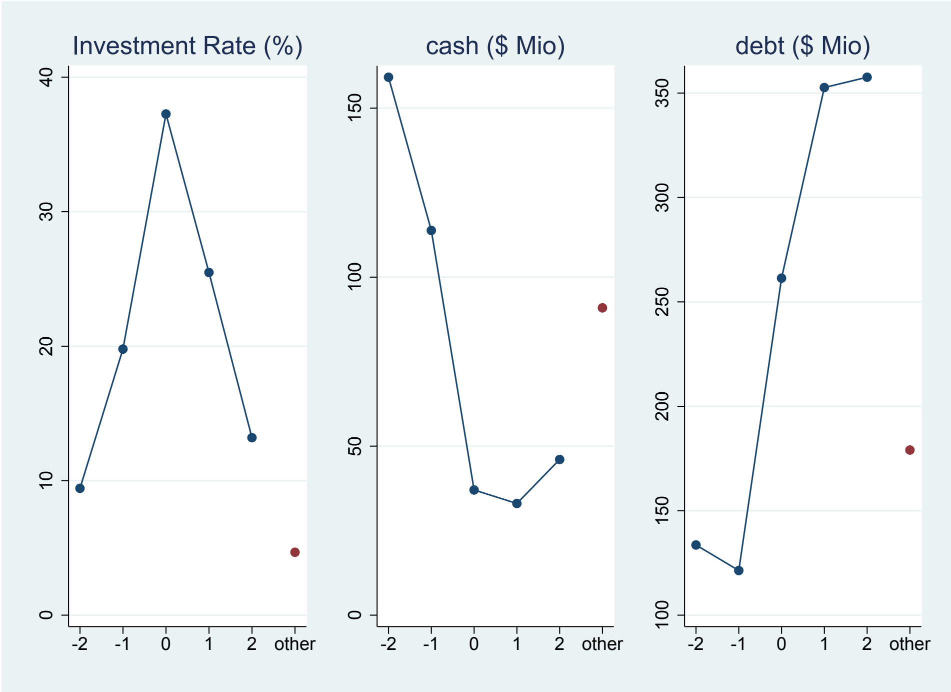

Figure 1: Behavior of investment rate, cash and debt around a lumpy capital adjustment episode for Schlitz Brewing. Lumpy capital expansion occurs in year 1974, 1974='0' in the Figure. *other* is the average value of the respective variable outside the +-2 period adjustment window.

cycle at the aggregate level, studies on cash management policies and finally studies that explore the importance of lumpiness at the macroeconomic level.

Our study contributes to understanding the drivers of leverage, about which we know little according to DeAngelo and Roll (2015). Specifically, our empirical analysis demonstrates that a systematic and fundamental driver of corporate leverage is lumpy adjustment in capital, and employment. Denis and McKeon (2012), DeAngelo and Roll (2015) and DeAngelo et al. (2016) study episodes of 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. Our distinct approach is to examine this association from the opposite end. First, we identify episodes of large operational adjustments by the firm and then we study what happens to leverage as well as other financing margins. Moreover, by analysing both asset expansions and contractions we study both leverage increases and decreases. 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 decisions to retain rather than pay out earnings. Our paper differs in focusing on the adjustments that cause movements in corporate leverage but also movements in several financing margins, in addition to leverage, during these adjustments as well as during periods leading up to lumpy adjustment.

Jermann and Quadrini (2012), Covas and Den Haan (2011) and Begenau and Salomao (2015) document the aggregate substitutability between debt and equity over the business cycle for small and large firms and suggest that external finance costs (for debt and equity) affect small and large firms quite differently.[1] Our contribution relative to the studies above is to look beyond the aggregate pattern. We establish, at the firm level, the nature of adjustment that is driving the preparatory role of debt and cash and the predominant role of the latter, especially for small firms, for the financing of lumpy adjustment. Our work connects directly with the studies mentioned above when we explore the use of equity as a financing margin and we uncover an interesting asymmetry. Small firms exhibit a significantly higher proportion of lumpy expansions that involve equity issuance, compared to large firms. Large firms exhibit a significantly higher proportion of lumpy expansions that involve reductions in equity. Related to this, we also observe large firms to finance a far higher proportion of expansions with debt issuance, compared to small firms.[2]

Our paper is also related to the literature on corporate liquidity management in the presence of

[1]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)).

[2]In terms of debt and equity substitutability we confirm the findings of studies mentioned above, where large firms use increases in debt and reductions in equity in far greater proportions of lumpy adjustment episodes compared to small firms.

financing constraints (see the recent survey by Almeida et al. (2014)).[3] Our findings on the dynamics of cash balances and leverage during lumpy adjustment suggests that cash and leverage interact in a meaningful way. Cash build-up and leverage decreases go hand in hand during the preparation phase of the adjustment. This pattern indicates that firms cannot simply use rapid build-up in debt alone to finance an expansion. Cash seems to be valuable in conferring ”financial flexibility” to the firm. Cash balances are drawn down to finance the lumpy expansion of capital and employment, a finding especially evident for small firms.[4] Finally, our findings imply that cash and debt cannot be viewed as perfect substitutes. The most obvious pattern that speaks against this view is the concurrent rapid cash buildup and decrease in leverage in the year preceding the adjustment. Our findings, therefore, suggest that equilibrium models should specify cash and debt as separate state variables consistent with the approach of Gamba and Triantis (2008).

Our work also connects to the lumpy adjustment literature in macroeconomics. A large body of work in Cooper and Haltiwanger (1993),Cooper et al. (1999), Caballero and Engel (1999), Khan and Thomas (2003), Khan and Thomas (2008) and more recently in Gourio and Kashyap (2007), Bachmann and Bayer (2014), Bachmann et al. (2013), Cooper et al. (2015) argues that lumpiness is a pervasive phenomenon at the plant level and matters for industry and aggregate investment dynamics and potentially for the business cycle. Our findings connect with the main thread in this body of work, namely, the importance of lumpy adjustment for real aggregate investment and employment in U.S. firms. We contribute to this literature by highlighting the importance of lumpy adjustment for aggregate financing variables.

The rest of the paper is organized as follows. Section 2 describes the data and methodology

[3]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. 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 the trade-offs between interest income taxation and the cost of external finance that determine optimal savings. 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.

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

and quantifies the importance of lumpy adjustment, Section 3 establishes the dynamic adjustment patterns during lumpy adjustment, and quantifies the relative predominance of finance margins used during the lumpy adjustments. Section 4 discusses the evidence on the importance of lumpy adjustment for volatility in aggregate real and financial variables. Section 5 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.[5]

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, and the Number of Employees (EMP).[6] The gross investment rate, CAPX over lagged PPENT, is used to define the positive investment adjustment. 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 rate in EMP is used to define the positive and negative employment adjustment. The precise definitions for the lumpy adjustment episodes are discussed in Section 2.2. We study three margins of finance for lumpy adjustments, namely, debt, equity and cash. Our definitions for equity and debt follows Salomao and Begenau (2016). Specifically, 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

[5]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.

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

as Cash and Short-Term Investments (CHE). Detailed information about variable construction and cleaning procedures is provided in the appendix.

2.2 Methodology

Identification schemes for lumpy expansions and contractions. We focus on four types of lumpy adjustments in firms' productive assets. Specifically, we study large positive and negative adjustments in the capital stock, and large positive and negative adjustments in the number of employees. A firm-year observation at time k is considered a lumpy positive (negative) adjustment if (i) in year k the variable under scrutiny exceeds (is below) a certain threshold and (ii) in year $k-1$ the variable is below (above) the threshold. The thresholds for the four types of adjustment are chosen so that each of the adjustment episode appears in approximately 20% of the observations in our dataset.[7] This implies that 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 episode of capital disinvestment/low investment rate the net investment rate has to be smaller than 8% (capital disinvestment, which we denote DISINV). For large positive employment adjustment the growth rate of employees has to exceed 15% (which we denote POSEG). For large negative employment adjustment the growth rate of employees has to be smaller than -7% (which we denote NEGEG). The time variation of the large adjustments we study is quite cyclical as evidenced by the statistics we report in the Appendix, that is, lumpy expansion of productive assets is procyclical and lumpy contraction of productive assets is countercyclical.

Our methodology is non-parametric. This is warranted since we wish to study patterns in many firm level variables and to be able to capture parsimoniously lead-lag relationships during lumpy adjustment. We study the dynamic behavior of many balance sheet variables around the four types of lumpy adjustment defined above. In particular, if a lumpy adjustment occurs in year k, we examine the behavior of variables of interest over five year windows, in years $k-2$ to $k+2$, using the empirical

[7] This threshold is consistent with those applied in similar studies, e.g. Cooper and Haltiwanger (2006). Our results are robust to alternations in the thresholds. These results are available upon request.

strategy developed in Sakellaris (2004). To identify the dynamic pattern of variables around lumpy adjustments, we use the regression,

$$X_{i,s} = \mu_i + \nu_s + \sum_{j=-2}^{+2} \beta_j \cdot ADJUSTD_{i,s}^{k+j} + \beta_{other} \cdot OTHERD_{i,s} + \varepsilon_{i,s}, \quad (1)$$

where $X_{i,s}$ 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. $ADJUSTD_{i,s}^{k+j}$ is a dummy variable which equals 1 if firm i experienced a lumpy adjustment in year $s+j$.[8] For example, if firm i experienced an investment spike in year 2000, then $ADJUSTD_{i,2002}^{k+2} = 1$ and $ADJUSTD_{i,2000}^{k} = 1$. The five $ADJUSTD$ dummies for each adjustment therefore indicate a window of two years before and after the adjustment.[9] Due to the inclusion of fixed effects absolute coefficient magnitudes are not meaningful, 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. $OTHERD_{i,s}$ is a dummy variable that equals 1 if and only if firm i has experienced at least one adjustment and $ADJUSTD_{i,s}^{j} = 0$ for $j = k-2, k-1, k, k+1, k+2$. $OTHERD$ therefore captures the average level of X in years outside the five year window around the adjustment for firms that have experienced at least one adjustment. For the variables of interest, it provides an indication of the variable's level during "normal times", i.e. it is the average for years when the firm does not undertake lumpy adjustment. We would therefore expect a firm variable to revert to 'other' when the adjustment is complete and is not followed by another adjustment episode.

This framework is rich in its ability to identify lumpy adjustment by observation of any margin of firm adjustment. The assumption behind this framework is that a change in the firm's fundamentals prompts it to make an adjustment in a lumpy way. The nature of the adjustment will be determined by the frictions in operations and in finance. Importantly, as we demonstrate below, lumpy adjustment episodes typically take longer than one year and they can have effects on the evolution

[8]We examine the responses to the four adjustments separately, so $ADJUSTD$ can be any of SPIKE, DISINV, POSEG and NEGEG.

[9]Note, that we only consider adjustments in the regression if the variable $X_{i,s}$ has non-missing observations for all five periods of the adjustment window, or non-missing observations for periods $k-1$ to $k+1$.

of financing variables both before and after the adjustment in productive assets. Thus once an adjustment has been identified, we study the interrelated behavior of firm variables in a window of five years centered on the lumpy adjustment-year.

3 Results

3.1 Dynamic adjustment

We display the results from the regression specified in equation (1) graphically in a series of figures, each corresponding to the dynamic behavior of a specific firm-level variable around a five year window of lumpy firm adjustment. Specifically, we plot the difference of each estimated value β_j (for $j = -2$ to 2) as well as β_{other} from β_0. Each figure contains four graphs–one for each type of lumpy firm adjustment: 1) Investment spike (SPIKE), 2) Disinvestment (DISINV), 3) Positive employment burst (POSEG), and 4) Negative employment burst (NEGEG). In the figures below, the x-axis label 'other' shows the difference between β_0 and the coefficient of $OTHERD$, β_{other}, the latter providing an estimate for the average level of the variables during normal periods. A positive value of 'other' therefore indicates that the level of the variable under scrutiny, in year 'k', is below its average level, and a negative value indicates that the level of the variable under scrutiny, in year 'k', is above its average level. The x-axis label 'std err' shows the standard error associated with β_0 and serves as a metric of whether the differences between the βs are significant. Throughout the study we define significance whenever coefficients differ by at least one standard error. Typically, in the results discussed below the standard errors for the other four estimated β_j's coefficients do not differ by more than 15% compared to β_0. We discuss our findings by collecting plots of firm variables that capture the following patterns around adjustment windows: asset adjustment margins, movements in fundamentals, and financing margins.

3.1.1 Asset adjustment margins

Figure 2 displays the behavior of investment rates, and employment growth, in each of the four adjustment episodes. Both variables rise (fall) sharply on the year of the positive (negative) adjustment, 'k', and return to the 'other' only gradually. The size of the standard error for the estimate of β_0 indicates that the behavior of investment rate and employment growth is statistically different during the year of the adjustment compared to the average behavior outside this window, i.e. one standard error variation in β_0 falls short of 'other' which captures the difference between β_0 and β_{other}. Figure 2 suggests that lumpy adjustments, especially in capital, take time to complete.[10] Figure 3 shows that sales of fixed capital goods in proportion to the capital stock are elevated (lower) during a negative (positive) adjustment. An exception is investment spikes where capital sales are at the 'other' 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 two categories of positive (or alternatively of negative) lumpy adjustment. On average, this adjustment takes more than one year to be completed, suggesting time-to-build effects and/or the existence of convex adjustment costs as well as auto-correlated shocks to profitability.

3.1.2 Financing margins and relation to asset adjustment

The preparatory role of cash and leverage for lumpy adjustment. The evidence below indicates firms enter a preparation phase of financing the lumpy adjustment. The financing patterns suggest that finance margins adjust in the year preceding lumpy adjustments but also in the years following them. We study the dynamic behavior of cash, leverage, debt, and equity. Figure 4 displays corporate savings behavior, where firms rapidly accumulate cash in year 'k-1' during positive adjustments, and in preparation for the lumpy adjustment they will undertake the following

[10]It is important to state that due to fixed effects, comparisons between the same variables across different lumpy adjustments are not meaningful quantitatively.

year. Following the adjustment in years 'k' to 'k+2', cash-to-assets declines gradually and returns to normal ratios of cash to total assets. For negative adjustments, the pattern is largely symmetric, although the return to average cash-to-asset ratios is slower compared to positive adjustments. So, cash buildup (rundown), relative to assets, is a key characteristic of lumpy positive (negative) adjustment in firm productive assets. The fact that this is reversed gradually in years 'k' to 'k+2' indicates that firms maintain a target cash-to-asset ratio throughout their histories. Figures 2 and 6 confirm the prediction by Riddick and Whited (2009) that financial (cash balances) and physical assets are substitutes, i.e. investment rates are below 'other' and cash-to-assets are above 'other' in the year preceding the adjustment. 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. For example, it is immediately apparent from Figures 2 and 6, that during employment episodes, the cash build up during year 'k-1' is associated with subdued employment growth, which is below the 'other' employment growth. Cash therefore plays an important preparatory role for these lumpy adjustments. Figure 5 corroborates the pattern of cash adjustment displayed in Figure 4. The growth rate of cash is in general higher for capital adjustment events in year 'k-1' compared to the 'other' and then drops significantly below the 'other' in years 'k' and 'k+1'. For positive employment events, the years leading to the event do not seem to be significantly different compared to the 'other', however, there is a significant drop off in the growth rate of cash during the event and subsequent event years. For both negative adjustment events, the growth rate of cash drops off substantially in the year leading to the event year and then slowly recovers although it falls short compared to the 'other' periods for the subsequent event years.

Figure 6 displays the behavior of market leverage. Market leverage is defined as the ratio of total debt over the sum of total debt and market value, consistent with the definition of Denis and McKeon (2012) who study proactive leverage increases. We observe that leverage is significantly lower than 'other' before positive adjustments and drops even further the year before ('k-1'). Leverage is still subdued during the adjustment year at 'k', but starting at 'k+1' leverage rises back to normal rates. For negative adjustments, the relative behavior of leverage is the same as for positive adjustments, but it rises to levels higher than 'other' during and after the lumpy negative adjustment. Thus, comparing leverage to its level during 'other', it is clear that in expansions 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. Interestingly during negative adjustments the reversion to the leverage 'other' is quite slow, as firms are still way above 'other' even two years following the adjustment. Therefore firms during expansion episodes have unused debt capacity before and even during the episode. This result combined with the behavior of cash from Figure 4 above suggests that firms value "financial flexibility" perhaps as a means to reduce reliance on costly external finance. Our findings on the behavior of leverage are in line with the prediction from DeAngelo et al. (2011) and evidence given in DeAngelo and Roll (2015) that departures from leverage stability are associated with company expansions. However, we also stress that departures from leverage stability can be due to asset contractions. Relative to these studies, our findings provide a new insight, namely, the fact that firms create debt capacity in anticipation of a lumpy expansion.[11]

Figure 7 complements Figure 6 and displays the behavior of the growth rate of debt. For positive adjustments, firms accumulate debt during years 'k' and 'k+1', compared to the 'other', and return to the latter at the end of the episode. This is consistent with the behavior of market leverage examined above. The pattern is largely symmetric for negative adjustments, that is, in the years leading to negative adjustment firms exhibit higher growth rates compared to the 'other' and trigger a massive downward adjustment in the year centered around the adjustment. Debt growth stays subdued for the years following the adjustment year in 'k'.[12]

Equity movements during lumpy adjustment. We now examine external equity issuance around lumpy adjustments. Figure 8 shows that for positive adjustments, equity issuance relative

[11]We also complementDenis and McKeon (2012) that proactive leverage increases are primarily associated with funding fixed capital. Moreover, we provide evidence for leverage decreases and the latter are typically associated with negative adjustments.

[12]We also examine the maturity structure of debt around lumpy episodes. The general pattern suggests that lumpy expansions tend to happen by firms when they are tilted to long term debt compared to the 'other'. In lumpy contractions, there is a steady increase in the proportion of short-term debt converging to the proportions prevailing during 'other' periods.

to assets is subdued below normal levels reaching a trough in year 'k+2', although in both lumpy expansions, equity issuance rises significantly relative to the periods before the adjustment. This pattern could indicate that equity issuance is not a major source of finance when firms expand in a lumpy episode. For negative adjustments, equity issuance relative to assets drops precipitously from normal levels and reaches a trough at the time of negative adjustment. Our previous findings suggest an important role for leverage, debt, and cash which leads to the conclusion that firms avoid raising costly equity. We confirm this statements based on the dynamic plots in quantitative exercises undertaken in sections 3.3. and 4. However, they come with a qualification: firm size matters for the importance of equity issuance.

Profitability and Tobin's Q. Its interesting to examine the dynamic behavior of fundamental variables around the four adjustment episodes. We focus on profitability, total factor productivity (TFP), sales growth and Tobin's Q. Figure 9 displays the behavior of TFP levels, EBITDA (operating income before depreciation) over lagged total assets and the growth rate of sales. These variables display a largely similar pattern over the adjustment windows. Specifically they display an hump-shaped (inverted hump-shaped) behavior for positive (negative) adjustments centered on the year of adjustment. It is worth emphasizing that for asset expansions, EBITDA and log TFP are already significantly elevated both in year 'k-2' and 'k-1' before the adjustment year and remain elevated for the years following the adjustment year. This is interesting insofar it provides evidence that profitability and productivity are leading the incoming adjustment, rather than just tracking or following it. However, in asset contractions, EBITDA is not statistically different from the average level as the standard error indicates. This suggests that contractions may occur with average levels of profitability. What is different in contractions relative to expansions is the fact that sales growth is persistently below the average level during almost the entire negative episode (from 'k-1' to 'k+2'), whereas sales growth in expansions becomes significantly elevated primarily during the adjustment year.[13] Figure 10 displays the behavior of Tobin's Q. The shape of these dynamic plots are similar to those discussed in Figure 9 above. Tobin's Q is high relative to the average level

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

during expansions and low relative to the average level in negative episodes. Moreover, Tobin's Q is elevated in year 'k-1' for capital adjustments (and employment burst to a milder extent), compared to normal periods. But Tobin's Q is significantly lower compared to normal periods throughout the negative adjustments. The evidence from both Figures suggest that profitability, productivity and Tobin's Q are important leading indicators for lumpy adjustment in fixed capital and employment. This suggests that innovations to fundamental variables are very informative for future fundamentals (even two to three years ahead in expansions) in a way that makes the lumpy adjustment and its financing largely anticipated.

3.1.3 Deviations from normal behavior in finance margins during lumpy episodes.

While the dynamic plots provide rich qualitative information, we will quantify the importance of financing margins for lumpy adjustments in capital and employment in this and the following sections. In this section we use information from the regression in equation (1) to show that the level of financing variables is significantly different from the periods classified as 'other' which provide an indication of average levels during normal times. We focus on cash-to-assets, debt-to-assets, growth rate of debt, and equity issuance-to-assets. To get a sense of how large and significant are the movements in finance margins during a lumpy episode we compute $\frac{\beta_j - \beta_{other}}{stderr(\beta_{other})}$ for each coefficient β_j in an adjustment window. This ratio indicates how far away each β_j coefficient are from 'other', in terms of standard errors of 'other'. Table 1 reports this ratio for each year of the adjustment window, namely, 'k-2',...'k+2'. In the results below we take one standard error variation as our level of statistical significance. A ratio of less or equal to one (in absolute value) therefore means that the difference of the finance variable during a lumpy episode is not statistical significance compared to the 'other', whereas a ratio above one (in absolute value) implies that the difference is statistically significant. The following are worth to report.

For SPIKE episodes, twenty one out of possible twenty five coefficient differences as a ratio to the standard error are significant (i.e. above one). The largest absolute differences can be observed for cash-to-assets in year 'k-1' exceeding the standard error estimated for 'other' by 7.93 times and

Debt-to-assets in year 'k-1' exceeding the standard error estimated for 'other' by 13.71 times. For DISINV, nineteen out of possible twenty five coefficient differences as a ratio to the standard error are significant. The largest absolute differences can be observed for cash-to-assets in year 'k+1' exceeding the standard error estimated for 'other' by 2.76 times.

For POSEG, twenty out of possible twenty five coefficient differences as a ratio to the standard error are significant. The largest absolute differences can be observed for cash-to-assets in year 'k+1' exceeding the standard error estimated for 'other' by 9.44 times and Debt-to-assets in year 'k-1' exceeding the standard error estimated for 'other' by 10.91 times. For NEGEG, twenty four out of possible twenty five coefficient differences as a ratio to the standard error are significant. The largest absolute differences can be observed for cash-to-assets in year 'k-1' exceeding the standard error estimated for 'other' by 10.71 times and Debt-to-assets in year 'k' exceeding the standard error estimated for 'other' by 4.94 times.

Overall, the dynamic plots discussed in section 3.1.2 and Table 1 suggest two main ways that firms finance lumpy adjustment: first, adjusting cash-to-asset ratios, by fast build-up of cash (relative to assets) during expansions and decumulation of the extra cash as the expansion unfolds in years 'k' and beyond. Second, by making room for debt capacity in year 'k-1' and increasing debt significantly in the years of the adjustment. Interestingly, equity issuance relative to assets is subdued below the levels observed during 'other' whether firms are expanding or contracting. We now turn to examine the relative quantitative importance of the different finance margins in lumpy episodes.

3.2 Quantifying finance margins during lumpy adjustments

Although the dynamic analysis of section 3.1 can reveal interesting adjustment patterns in various finance margins it cannot establish the relative importance of those margins. In this section we quantify the importance of finance margins. There are six potential adjustment margins when financing lumpy adjustments: positive and negative changes in cash, debt and equity, respectively. For each firm-year observation we can evaluate whether one of the six margins is dominating the others. This is the case if the absolute adjustment in one of the margins constitutes at least 50%

Table 1: Movements of financing margins around lumpy adjustment in relation to normal times

	k-2	k-1	k	k+1	k+2
SPIKE					
$\frac{Cash}{Assets}$	1.72	7.93	1.96	-1.98	-2.93
Growth rate of cash	-2.03	1.05	-1.25	-3.45	-3.55
$\frac{Debt}{Assets}$	-7.01	-13.71	-8.24	-3.09	-0.21
Growth rate of debt	0.13	-0.73	8.00	0.91	0.20
$\frac{Equityissuance}{assets}$	-4.39	-3.73	-2.32	-4.70	-3.96
DISINV					
$\frac{Cash}{Assets}$	-1.49	-2.46	-2.49	-2.76	-2.72
Growth rate of cash	0.05	-2.56	-0.93	-2.34	-1.84
$\frac{Debt}{Assets}$	-0.99	0.03	0.30	0.88	1.01
Growth rate of debt	1.15	1.41	1.06	-1.15	-1.25
$\frac{Equityissuance}{assets}$	-0.72	-1.28	-4.25	-4.82	-4.20
POSEG					
$\frac{Cash}{Assets}$	1.03	5.62	-4.44	-9.44	-9.13
Growth rate of cash	-2.29	-0.86	-0.94	-4.03 -3.60	
$\frac{Debt}{Assets}$	-7.24	-10.91	-2.73	0.42	1.68
Growth rate of debt	0.54	-0.93	12.52	2.51	-0.96
$\frac{Equityissuance}{assets}$	-5.26	-6.57	-3.21	-5.36	-6.52
NEGEG					
$\frac{Cash}{Assets}$	-2.80	-10.71	-7.71	-4.23	-3.23
Growth rate of cash	-2.09	-6.81	-4.98	-3.33	-4.30
$\frac{Debt}{Assets}$	-0.73	4.07	4.94	2.15	1.75
Growth rate of debt	2.17	1.51	-5.67	-5.24	-4.06
$\frac{Equityissuance}{assets}$	-3.84	-8.64	-11.80	-9.72	-7.52

Notes. The entries shown are computed as, $\frac{\beta_j - \beta_{other}}{stderr(\beta_{other})}$, where j=k-2, k-1,k,k+1,k+2. β_j and β_{other} refer to the estimated coefficients from regression (1). A ratio above one in absolute value indicates statistical significance.

of the sum of the absolute adjustment in the remaining five margins. For example, it is said the positive change in cash is dominating the other margins if it is larger than the sum of the absolute change in equity issuance and change in debt (the negative adjustment in cash is zero in this example by definition). We consider movements in the finance margins described above in years 'k-1' and 'k' inside the adjustment window, motivated by the preparatory role of cash and debt documented above. Tables 2 and 3 below report the three largest proportions of episodes where one of the six financing margins during the 'k-1' and 'k' adjustment phase in firms histories have played a predominant role (as defined above). The sum of the rows reported in the Tables indicate that the three largest proportions also account for over two thirds of all lumpy episodes. Motivated by the evidence in Covas and Den Haan (2011) who document different equity issuance behavior between small firms and large firms we report results separately for the bottom 90% and the top 10% of firms (in terms of total assets).[14]

Preparatory financing phase ('k-1') and expansions. In 25% of all SPIKE adjustments that are financed by a dominant margin, cash accumulation is recorded to be the dominant means of financing. This holds for both the bottom 90% and top 10% of firms.[15] Debt reduction which makes rooms for debt capacity is the dominant margin in 23% of all SPIKE adjustments for small firms and 20% of all SPIKE adjustments for large firms. The proportion of POSEG adjustments where cash accumulation and debt reduction is dominant is quite similar to the proportions of SPIKE adjustment as discussed above for both small and large firms. There is however, a difference between small and large firms in that for employment bursts, negative equity issuance becomes a dominant margin for large firms in a very high proportion equal to 32%. Importantly, this Table demonstrates that cash reductions (not just slower cash accumulation relative to assets)—are a vital finance margin in a large number of expansionary episodes. And similarly, debt reductions in the preparatory year make

[14]For each year we categorize all firm observations by percentile of total assets into different size classes. A firm is classified to belong to a certain size category according to the median size classification of its observations.

[15]There is a relatively small share of adjustments that do not have a dominant finance margin. For the top 10% of firms the percent of SPIKE, DISINV, POSEG, NEGEG that do not have a single dominant margin is approximately equal to 20%. For the bottom 90% firms the percent of SPIKE, DISINV, POSEG, NEGEG that do not have a single dominant margin is equal to approximately 10%.

room for additional debt capacity which is then used during the adjustment year. These numbers highlight the fact that the qualitative patterns documented above are of quantitative significance. It is also interesting, yet corroborative with the evidence from the dynamic patterns above, that equity issuance (positive or negative) does not feature among the top three most observed financing margins for the bottom 90% of firms.[16]

Adjustment year ('k') and expansions. For small firms, the first most observed margin during year 'k' across positive capital, and employment adjustment is debt accumulation accounting for 37%, and 39% of adjustments in SPIKE, and POSEG respectively. Cash reduction in year 'k', is the second most observed margin where it accounts for 21%, and 19% of capital and employment episodes respectively. There is some heterogeneity evident from the fact that there are adjustments in either capital or employment where firms accumulate instead of running down cash balances. For large firms, the dominant margin in over 50% of positive adjustments is debt accumulation. Cash reduction is not as dominant as it is for small firms, being dominant in a significantly lower proportion of positive employment episodes compared to small firms. For large firms reductions in equity continues to feature as a dominant margin and together with debt issuance are much more prevalent margins for large firms as compared to small firms. As in Covas and Den Haan (2011), these numbers suggest that large firms may be substituting equity for debt during those the adjustment year of lumpy expansions. Notably however, relative to Covas and Den Haan (2011), beyond this contemporaneous substitutability our analysis is unearthing a new fact, namely the preparation of debt capacity for lumpy adjustment.

Contractions. Table 3 reports that for the bottom 90% of firms and for both capital and employment contractions, debt accumulation is the most observed margin in year 'k-1', comprising for 33% and 32% of episodes respectively. In year 'k', debt reduction is the most observed margin, accounting for 40% and 34% in capital and employment contractions respectively. Cash reductions are also prevalent in either episode. There is also heterogeneity present in that we also have episodes

[16]For the bottom 90% of firms, positive (negative) equity issuance is the dominant margin in a relatively small share of adjustments, always smaller than 10%. For example, positive/negative equity issuance is the dominant margin in 8% (in year 'k')/9% (in year 'k-1') of SPIKE episodes.

where firms reduce debt both in years 'k-1' and 'k'. For the largest 10% of firms the negative equity issuance is the most observed margin during both episodes accounting for 32% of all episodes. But in year 'k' the largest firms behave more in line to the bottom 90% of firms in that they reduce debt across both episodes, these shares are indeed very similar at 41% and 38% in capital and employment contractions respectively.

In sum, the main differences in the financing patterns across the size categories are: 1) that relatively more small firms use the cash margin in the preparation year 'k-1' of the adjustment, 2) relatively more large firms use the equity issuance margin before and during the lumpy contraction episode. We have decomposed the movements in equity issuance within all episodes described in Tables 5 and 6 and found, using the same definition of dominance as above, that dividend payments, not share repurchases, are the dominant component driving movements in equity issuance for large firms in both expansions and contractions.

Debt and equity mix: small and large firms. Having established the dominant finance margins we briefly discuss several interesting differences in the mix of debt and equity between small and large firms. We tabulate the share of adjustments 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 4 reports the share of adjustments for each adjustment episode separately.

First, small firms in lumpy expansions have a greater proportion of adjustments with increases in equity compared to large firms. For small firms, in year 'k-1' the proportion of adjustments which involve an increase in equity is 51%, and 55% for SPIKE and POSEG respectively. By contrast, for large firms the corresponding proportions are 35% and 26%. For small firms, in year 'k' the proportion of adjustments with an increase in equity is 52%, and 49% for SPIKE and POSEG respectively. By contrast, for large firms the corresponding proportions are 38% and 31%. By contrast, for large firms in lumpy expansions reductions—as compared to increases—in equity is observed in far greater proportions of adjustments. Specifically, for large firms in year 'k-1', the proportion of adjustments that involve a reduction in equity is equal to 64% and 71% for SPIKE and POSEG respectively, and these proportions are roughly similar in year 'k'. This is the key qualitative difference in the use of equity in lumpy expansions between small firms and large firms.

Second, while both small and large firms reduce equity issuance during contractions, this occurs in far greater proportions for large compared to small firms. For example, the proportion of episodes in year 'k', where large firms reduce equity issuance is 76% and 78% for DISINV and NEGEG respectively. The corresponding proportions for small firms are 45% and 46% for DISINV and NEGEG respectively.

Third, in the year of the adjustment, 'k', the proportion of lumpy expansions (contractions) that involve increases (decreases) in debt are significantly higher for large as compared to small firms. The difference in the proportion of lumpy adjustments of the increase in debt, reduction in equity combination during time 'k' for large firms, compared to small firms speaks to the issue of substitutability of debt and equity. That is, we observe a far higher proportion of this specific finance mix undertaken by large firms (48% and 52%) compared to the corresponding proportion in the adjustments undertaken by small firms (27% for either adjustment). This finding is consistent with the differences in the substitutability of debt and equity for small and large firms documented in Covas and Den Haan (2011) and Begenau and Salomao (2015).

3.3 The preparation of finance around lumpy adjustment and firm heterogeneity.

The preparatory role of several finance margins documented in the previous sections suggests that significant movements in finance margins precede lumpy adjustment episodes—firms anticipate they will undergo such adjustment and they make finance choices to facilitate it. The goal in this section is to examine whether these patterns are broadly robust across several dimensions by looking at the behavior of these margins across different sortings of firms. We sort firms according to: i) market leverage, (ii) cash over assets, and (iii) size (measured as above based on total assets). The reference period is the year before the adjustment (t-1). We distinguish four parts of the respective

Table 2: Dominant finance margins: positive adjustments

Bottom 90% firms

SPIKE				**POSEG**			
year k-1		year k		year k-1		year k	
Dominant margin	Share	Dominant margin	Share	Dominant margin	Share	Dominant margin	Share
$\Delta Cash(>0)$	0.25	$\Delta Debt(>0)$	0.37	$\Delta Debt(<0)$	0.24	$\Delta Debt(>0)$	0.39
$\Delta Debt(<0)$	0.23	$\Delta Cash(<0)$	0.21	$\Delta Cash(>0)$	0.22	$\Delta Cash(<0)$	0.19
$\Delta Debt(>0)$	0.18	$\Delta Cash(>0)$	0.16	$\Delta Debt(>0)$	0.20	$\Delta Cash(>0)$	0.15
Sum of rows	0.66		0.73	Sum of rows	0.66		0.73

Top 10% firms

SPIKE				**POSEG**			
year k-1		year k		year k-1		year k	
Dominant margin	Share	Dominant margin	Share	Dominant margin	Share	Dominant margin	Share
$\Delta Cash(>0)$	0.25	$\Delta Debt(>0)$	0.53	$\Delta Equity(<0)$	0.32	$\Delta Debt(>0)$	0.58
$\Delta Debt(>0)$	0.20	$\Delta Equity(<0)$	0.16	$\Delta Debt(<0)$	0.20	$\Delta Equity(<0)$	0.14
$\Delta Debt(<0)$	0.20	$\Delta Cash(>0)$	0.13	$\Delta Cash(>0)$	0.19	$\Delta Cash(<0)$	0.08
Sum of rows	0.65		0.82	Sum of rows	0.71		0.80

For each lumpy adjustment type (SPIKE, POSEG) and time (k-1, k), we report in the table the share of firm-year observations in which one of the six financing margins – positive and negative changes in cash, debt and equity, respectively – is dominating all the others combined. This is the case if the absolute adjustment in one of the financing margins constitutes at least 50% of the sum of the absolute adjustment in the remaining five margins. For each year we categorise firms by percentile of total assets into different size classes. A firm is classified as belonging to the bottom 90%, top 10% by the median size classification of its history.

Table 3: Dominant finance margins: negative adjustments

Bottom 90% firms

DISINV				**NEGEG**			
year k-1		year k		year k-1		year k	
Dominant margin	Share	Dominant margin	Share	Dominant margin	Share	Dominant margin	Share
$\Delta Debt(>0)$	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

DISINV				**NEGEG**			
year k-1		year k		year k-1		year k	
Dominant margin	Share	Dominant margin	Share	Dominant margin	Share	Dominant margin	Share
$\Delta Equity(<0)$	0.32	$\Delta Debt(<0)$	0.41	$\Delta Equity(<0)$	0.32	$\Delta Debt(<0)$	0.38
$\Delta Debt(>0)$	0.31	$\Delta Equity(<0)$	0.30	$\Delta Debt(>0)$	0.29	$\Delta Equity(<0)$	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

For each lumpy adjustment type (DISINV, NEGEG) and time (k-1, k), we report in the table the share of firm-year observations in which one of the six financing margins – positive and negative changes in cash, debt and equity, respectively – is dominating all the others combined. This is the case if the absolute adjustment in one of the financing margins constitutes at least 50% of the sum of the absolute adjustment in the remaining five margins. For each year we categorise firms by percentile of total assets into different size classes. A firm is classified as belonging to the bottom 90%, top 10% by the median size classification of its history.

Table 4: Debt and equity use during lumpy adjustments

All firms	year k-1				year k			
	+ 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
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 k-1				year k			
	+ 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
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 k-1				year k			
	+ 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
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 adjustments 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. For each year we categorise firms by percentile of total assets into different size classes. A firm is classified as belonging to the bottom 90%, top 10% by the median size classification of its history.

distributions: 0-33%, 34-66%, 67-90%, and top 10%.[17] Our motivation is to examine whether the patterns of adjustment in finance we have documented above are (or are not) conditional on the same firm finance variables we seek to understand and hence the patterns we document can be viewed as representative. In other words, is the preparation phase in finance we document above conditional on firms having high or low cash-to-assets and or high or low leverage at time 'k-1'? To compute the dynamics plots we have re-estimated the regression in equation (1) conditioning on the criteria described in (i), (ii), and (iii), for a total of twelve different regressions.

We focus on cash-to-assets, growth rate of debt, and market leverage as a means to test the robustness in the financing patterns identified in Figures 4, 5, and 6. Our key finding established in Figures 4 to 6 is robust across any of the three firm sortings. Specifically, we observe, for any of these sortings, the preparation role of cash balances and leverage in the year preceding the adjustment, 'k-1' and the high growth rate of debt in the year of the adjustment, as well as the run down of the cash-to-assets ratio and the rise in leverage as the adjustment unfolds. We provide a detailed discussion in Appendix 6.

4 Lumpy adjustment and aggregate movements of real and financial variables.

As we have briefly discussed in the introduction lumpy adjustment accounts for a large share of variability in several aggregate Compustat variables. We seek to formally decompose the share of variance in various variables of interest accounted for by periods during which firms undertake lumpy adjustment as compared to the share of variance in those variables that can be accounted for by movements during 'other' periods. To examine this, we focus on 3-year adjustment windows with periods $k-1$ to $k+1$ around a pair of positive and negative adjustment in the same real asset, i.e. either SPIKE and DISINV, or POSEG and NEGEG. We then decompose the variability

[17]To ensure all periods of a window are part of the same size category, we assign all periods of a window to be in the size category of period 't-1'. Transition between size categories happens very rarely.

in aggregated variables to determine the contributions of the covariances of that variable with all of its subcomponents. Denote the total change in a variable under scrutiny by $X_{TOT,t}$. We can, by construction, decompose this aggregate change (scaled by aggregate assets, AT_t), $X_{TOT,t}/AT_t$, in year $t = \{1971, ..., 2013\}$, into seven components,

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

$X_{POS,j,t}$, is the value of X when aggregating in year t conditional on firm observations being classified as episode of a positive lumpy adjustment ($j = k$) or episode before/after a positive lumpy adjustment ($j = k-1$ / $j = k+1$), and similarly for $X_{NEG,j,t}$. That is, in any year t, we can record three different components of $X_{POS,j,t}$, and three different components of $X_{NEG,j,t}$, each belonging to the $k-1$, k, $k+1$ phase of the adjustment episode centered on k.[18] $X_{OTHER,t}$ aggregates observations of variable X in year t not classified as positive/negative lumpy adjustments or the episodes (±1) around these. To illustrate, consider the change in employment as $X_{TOT,1980}$ in year 1980. This can be decomposed exactly into: (a) the positive adjustments, namely, $X_{POS,k-1,1980}$ observed in year 1980, capturing the change in employment for all firms whereby year 1980 was classified as belonging to the $k-1$ period of the adjustment window, $X_{POS,k,1980}$, observed in year 1980, capturing the change in employment for all firms whereby year 1980 was classified as belonging to the k period of the adjustment window, $X_{POS,k+1,1980}$, observed in year 1980, capturing the change in employment for all firms whereby year 1980 was classified as belonging to the $k+1$ period of the adjustment window. (b) the corresponding negative adjustments, and (c) $X_{OTHER,1980}$, which captures the value of X in year 1980 for firms that did not fall into any of the categories in (a) or (b) in year 1980. Then the variance may be

[18] Overlaps between adjustment windows are possible only for the positive adjustments' $k-1$ period and negative adjustments' $k+1$ period and for the positive $k+1$ and negative $k-1$ periods. Since each observation can only belong to one particular time in an adjustment 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 overlap. Note further that results are also robust across different firm sizes which are available upon request.

decomposed as,

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

Table 5 displays the decomposition of the variance for each variable belonging to any of the three broad sets of aggregate variables: real adjustment, profitability, and financing. Entries in all the tables show the share of variance in the variables accounted for by each of the three RHS components of equation (2).[19] For ease of exposition the tables aggregate the covariances for all positive ('expansions') and negative ('contractions') adjustments into one number, corresponding to each summation in the equation above and the entries report the share of variance in the variables listed on the first column accounted for by the covariances for 'expansions' and 'contraction' and the covariance during periods outside of adjustment episodes in the column 'other'. Of particular interest to this accounting exercise is the comparison of each number in the Table with the asset weighted frequency of the episodes under study. The larger the positive difference between the share of variance in any variable of interest accounted for by, e.g. 'capital contractions' in relation to the asset weighted frequency of 'capital contractions', the greater the importance of 'capital contractions' in accounting for the variance in that specific variable. Several notable observations emerge. First, expansions and contractions (in either capital or employment), account for a disproportionate share of variance (in comparison to the asset weighted frequency) in the real adjustment variables, suggesting that these episodes are important for aggregate movements in fixed investment and employment. For financing variables, the shares accounted for by lumpy episodes exceed (with the exception of 'Change in Total Liabilities' for contractions) the corresponding asset weighted frequencies. For example, the employment (capital) expansions account for 77.9% (47.3%) of the variance in Tobin's Q, both significantly above the asset weighted frequency of these two episodes. Employment (capital) episodes account

[19] This formulation allows us to show for many variables of interest the share of variance explained by six episodes in the adjustment windows (e.g. SPIKE(-1), SPIKE(0), SPIKE(+1) and DISINV(-1), DISINV(0), DISINV(+1)) and the times outside adjustment windows (OTHER). The expanded Tables are reported in the Appendix.

for 53.1% (44%) of changes in cash and these shares are both higher compared to the asset weighted frequency. Employment (capital) episodes account for 64.6% (38.3%) of changes in debt—similarly these shares are both higher compared to the asset weighted frequency. The shares of variance accounted for by lumpy adjustment reported above differ quite substantially when we split by firm size (Tables 10 and 11 in the Appendix). In both expansions and contractions, small firms exhibit significantly higher variance shares accounted for by these episodes compared to large firms in the majority of variables studied. For example, the share of the variance in fixed investment accounted for by employment expansions is 84.5% (51.3%), for small (large) firms. For small firms, the share of the variance for all financing variables accounted for by capital adjustment episodes is always above 50% and the share of the variance in the same financing variables accounted for by employment adjustment episodes is always above approximately 65%. By contrast, the share of the variance for all financing variables in capital adjustment is substantially lower than 50% for large firms. However, it is above 50% (with the exception of equity issuance) in employment adjustment episodes for large firms.

Table 5: Volatility of aggregate Compustat variables accounted for by lumpy adjustment in percent

All firms	Capital expansions	Capital contractions	'Other'	Employment expansions	Employment contractions	'Other'
Real adjustment variables:						
Fixed investment	67.8	3.5	28.7	57.2	19.6	23.2
Change in employment	16.9	37.4	45.7	34.0	42.2	23.8
Fundamentals/profitability variables:						
Change in Sales	9.5	27.5	63.0	17.3	33.5	49.1
Tobin's Q	47.3	2.6	50.1	77.9	5.7	16.4
Financing variables:						
Change in Cash	22.4	21.7	56.0	24.4	28.7	46.9
Change in debt outstanding	17.7	20.6	61.7	35.4	29.2	35.4
Equity issuance	26.0	16.8	57.2	23.8	23.1	53.2
Change in Total Liabilities	24.5	14.5	61.1	38.6	19.8	41.6
Asset weighted frequency	15.9	16.5	67.6	20.9	26.7	52.5

'Other refers to all periods outside adjustment windows (expansions or contractions). All variables are divided by total assets with the exception of Tobin's Q.

5 Conclusion

This paper studies the decisions that public U.S. firms take in order to finance lumpy adjustment in capital, and employment. We uncover systematic patterns in the movements of different finance variables. These patterns can guide theoretical work on firm financial decisions and capital structure. They also point to the importance of financial frictions in determining movements of real variables at the firm and the aggregate level. It would be natural to wonder how different would be macroeconomic responses to underlying shocks when firms face different financial constraints.

References

Almeida, H., Campello, M., Cunha, I., and Weisbach, M. S. (2014). Corporate Liquidity Management: A Conceptual Framework and Survey. *Annual Review of Financial Economics*, 6(1):135–162.

Bachmann, R. and Bayer, C. (2014). Investment Dispersion and the Business Cycle. *American Economic Review*, 104(4):1392–1416.

Bachmann, R., Caballero, R. J., and Engel, E. M. R. A. (2013). Aggregate Implications of Lumpy Investment: New Evidence and a DSGE Model. *American Economic Journal: Macroeconomics*, 5(4):29–67.

Bates, T., Kahle, K., and Stulz, R. (2009). Why do U.S. firms hold so much more cash than they used to? *Journal of Finance*, 64:1985–2021.

Begenau, J. and Salomao, J. (2015). Firm financing over the business cycle. *mimeo.*

Belo, F., Lin, X., and Yang, F. (2014). External Equity Financing Shocks, Financial Flows, and Asset Prices. NBER Working Papers 20210, National Bureau of Economic Research, Inc.

Benhima, K., Poilly, C., and Bacchetta, P. (2014). Corporate Cash and Employment. Technical report.

Bernanke, B. S., Campbell, J. Y., and Whited, T. M. (1990). U.S. Corporate Leverage: Developments in 1987 and 1988. *Brookings Papers on Economic Activity*, 21(1):255–286.

Bolton, P., Chen, H., and Wang, N. (2013). Market timing, investment, and risk management. *Journal of Financial Economics*, 109(1):40–62.

Caballero, R. J. and Engel, E. M. R. A. (1999). Explaining investment dynamics in U.S. manufacturing: A generalized (S, s) approach. *Econometrica*, 67(4):783–826.

Cooper, R. and Haltiwanger, J. (1993). The aggregate implications of machine replacement: Theory and evidence. *American Economic Review*, 83(3):360–82.

Cooper, R., Haltiwanger, J., and Power, L. (1999). Machine replacement and the business cycle: Lumps and bumps. *American Economic Review*, 89(4):921–946.

Cooper, R. W. and Haltiwanger, J. (2006). On the nature of capital adjustment costs. *Review of Economic Studies*, 73(3):611–633.

Cooper, R. W., Haltiwanger, J., and Willis, J. (2015). Dynamics of labor demand: Evidence from plant-level observations and aggregate implications. *Research in Economics*, 69(1):37–50.

Covas, F. and Den Haan, W. J. (2011). The cyclical behavior of debt and equity finance. *American Economic Review*, 101(2):877–99.

DeAngelo, H., DeAngelo, L., and Whited, T. (2011). Capital structure dynamics and transitory debt. *Journal of Financial Economics*, 99:235–61.

DeAngelo, H., Goncalves, A., and Stulz, R. (2016). Corporate Deleveraging. NBER Working Papers 22828, National Bureau of Economic Research, Inc.

DeAngelo, H. and Roll, R. (2015). How stable are corporate capital structures? *Journal of Finance*, 70:373–418.

Denis, D. J. and McKeon, S. B. (2012). Debt financing and financial flexibility evidence from proactive leverage increases. *Review of Financial Studies.*

Eisfeldt, A. and Muir, T. (2016). Aggregate external financing and savings waves. *Journal of Monetary Economics*, 84:116–133.

Erel, I., Julio, B., Kim, W., and Weisbach, M. S. (2012). Macroeconomic conditions and capital raising. *The Review of Financial Studies*, 25(2):341.

Fama, E. F. and French, K. R. (2002). Testing trade-off and pecking order predictions about dividends and debt. *Review of Financial Studies*, 15(1):1–33.

Gamba, A. and Triantis, A. (2008). The value of financial flexibility. *Journal of Finance*, 63:2263–2296.

Gourio, F. and Kashyap, A. K. (2007). Investment spikes: New facts and a general equilibrium exploration. *Journal of Monetary Economics*, 54(Supplemen):1–22.

Hall, B. H. (1990). The manufacturing sector master file: 1959-1987. *NBER Working paper*, 3366.

Hennessy, C. A. and Whited, T. M. (2007). How Costly Is External Financing? Evidence from a Structural Estimation. *Journal of Finance*, 62(4):1705–1745.

Imrohoroglu, A. and Tuzel, S. (2011). Firm Level Productivity, Risk, and Return. Technical report.

Jermann, U. and Quadrini, V. (2012). Macroeconomic Effects of Financial Shocks. *American Economic Review*, 102(1):238–271.

Khan, A. and Thomas, J. K. (2003). Nonconvex factor adjustments in equilibrium business cycle models: do nonlinearities matter? *Journal of Monetary Economics*, 50(2):331 – 360.

Khan, A. and Thomas, J. K. (2008). Idiosyncratic shocks and the role of nonconvexities in plant and aggregate investment dynamics. *Econometrica*, 76(2):395–436.

McLean, R. D. and Zhao, M. (2014). The business cycle, investor sentiment, and costly external finance. *The Journal of Finance*, 69(3):1377–1409.

Olley, G. S. and Pakes, A. (1996). The Dynamics of Productivity in the Telecommunications Equipment Industry. *Econometrica*, 64(6):1263–97.

Riddick, L. A. and Whited, T. M. (2009). The corporate propensity to save. *The Journal of Finance*, 64(4):1729–1766.

Sakellaris, P. (2004). Patterns of plant adjustment. *Journal of Monetary Economics*, 51(2):425 – 450.

Salomao, J. and Begenau, J. (2016). Firm Financing over the Business Cycle. Technical report.

Tsoukalas, J., Tsoukas, S., and Guariglia, A. (2016). To what extent are savings cash flow sensitivities informative to test for capital market imperfections? *Review of Finance*, forthcoming.

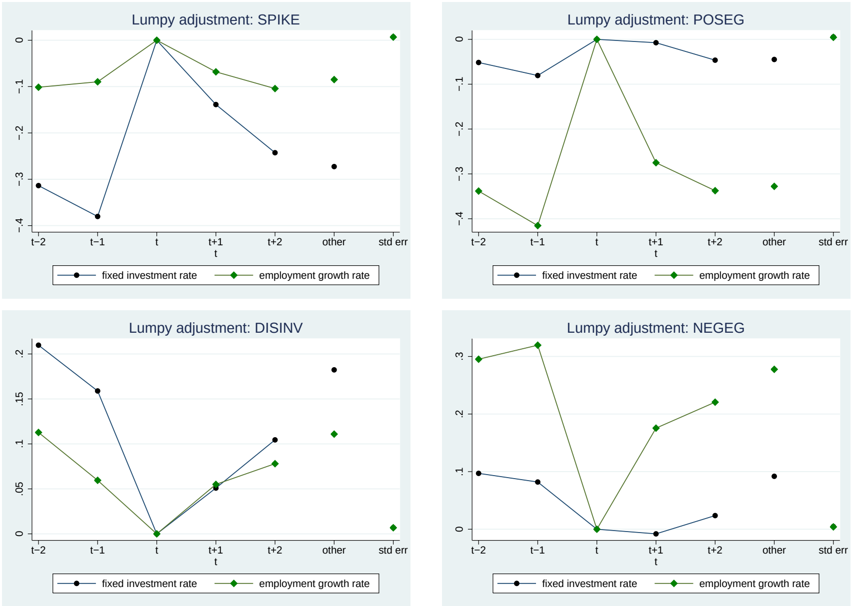

Figure 2: Behavior of productive assets around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right).

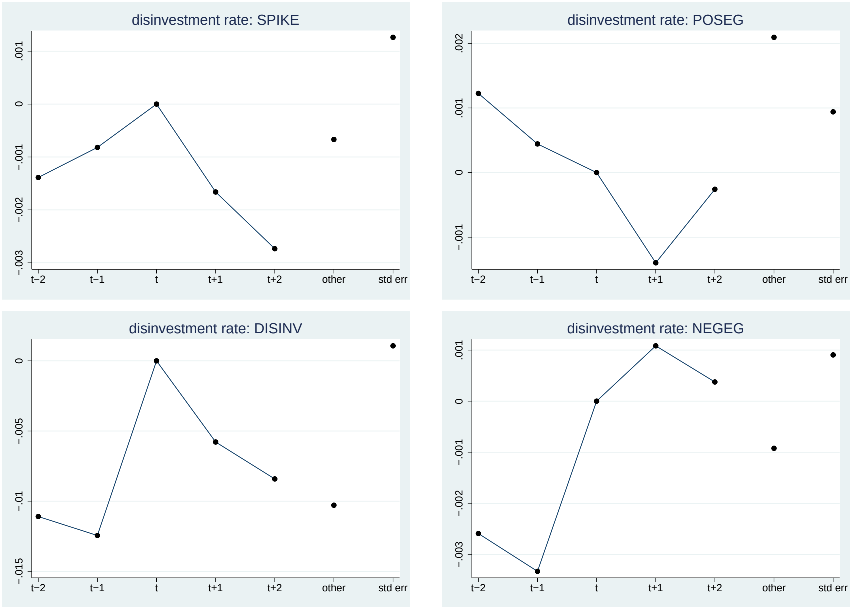

Figure 3: Behavior of fixed disinvestment rate (SPPE/PPENT) around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right).

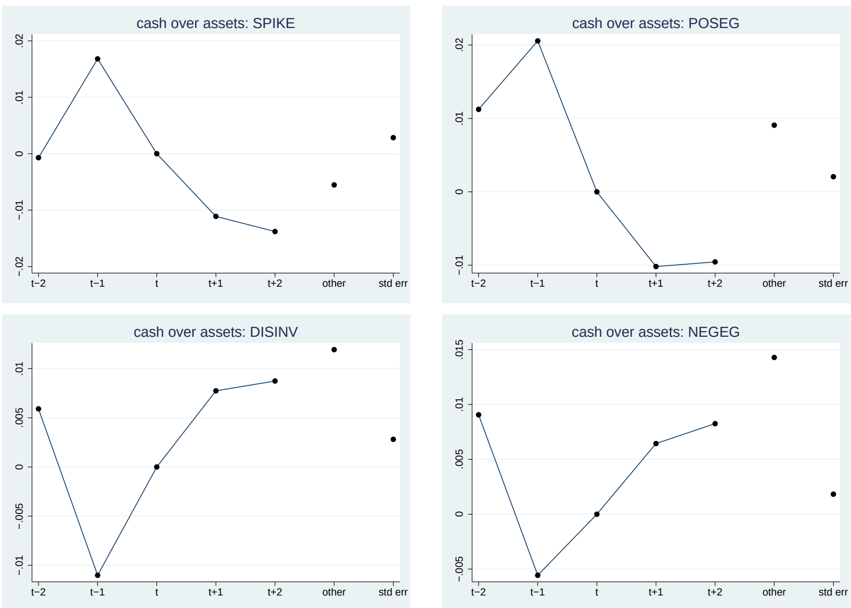

Figure 4: Behavior of cash over contemporaneous assets around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right).

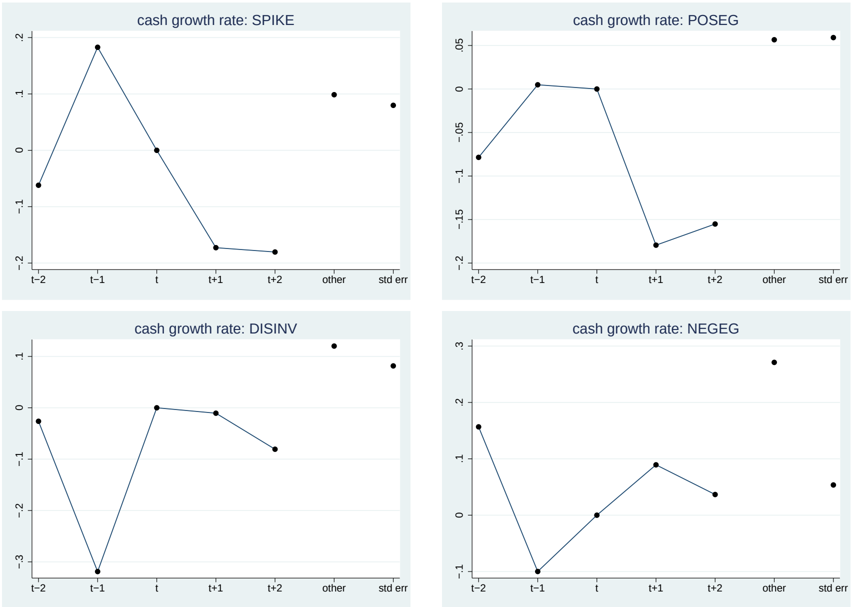

Figure 5: Behavior of growth rate of cash around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right).

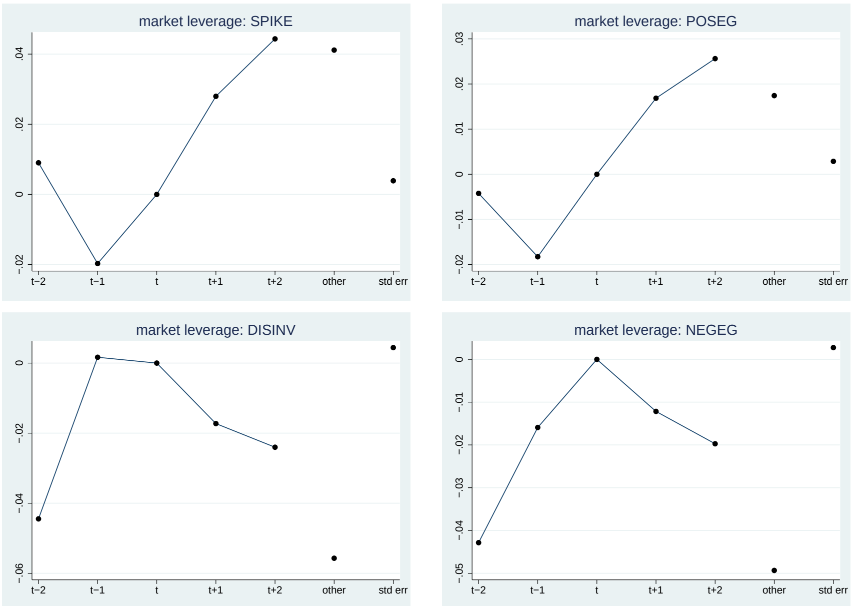

Figure 6: Behavior of market leverage around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right).

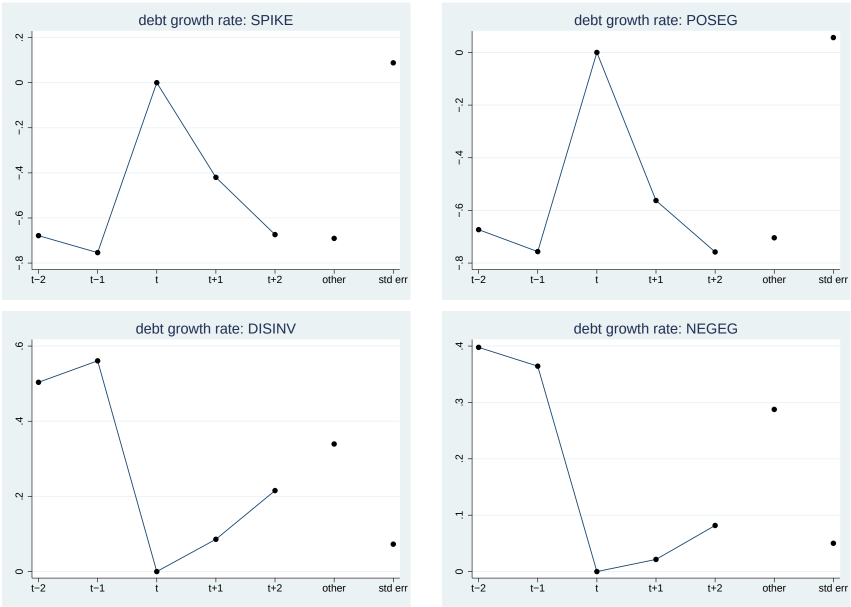

Figure 7: Behavior of growth rate of debt around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right).

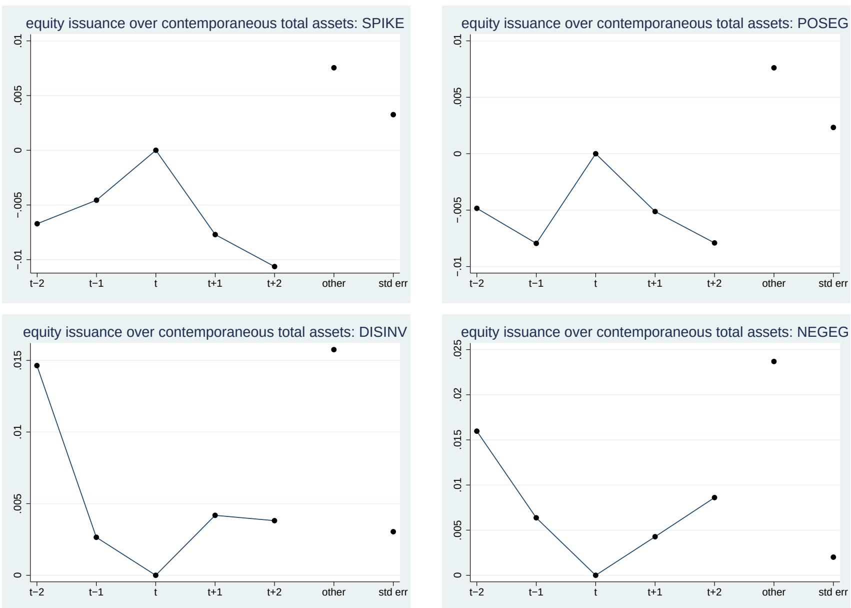

Figure 8: Behavior of equity issuance scaled by contemporaneous total assets around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right).

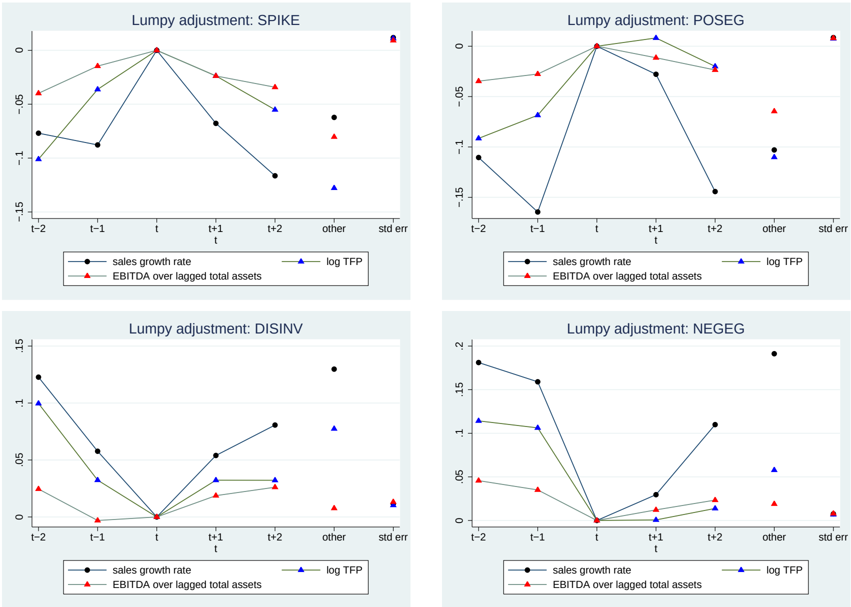

Figure 9: Behavior of profitability variables around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right).

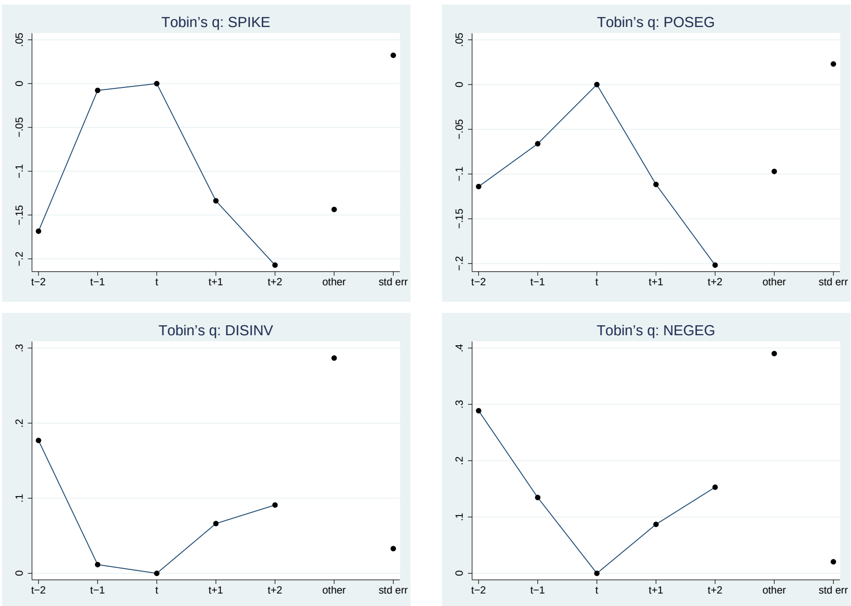

Figure 10: Behavior of Tobin's Q around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right).

6 Appendix with supplementary material (Not for publication)

.1 Basic statistics

Table 1 shows the occurrence of lumpy episodes as share of observations that can potentially be classified as lumpy episode. Table 2 reports the joint occurrence of lumpy adjustment episodes in our sample. Different types of lumpy episodes are not necessarily synchronized although for some types of assets the joint probability of occurrence is higher that others. For example, investment spikes are accompanied by lumpy expansion in employment in just over 20% of the times.

Table 6: Occurrence of lumpy adjustment (in percent)

SPIKE	DISINV	POSEG	NEGEG	All lumpy adjustments
7.8	9.5	11.9	13.9	32.9

The table shows the share of observations classified as lumpy adjustment. SPIKE/DISINV is the positive/negative lumpy investment adjustment, and POSEG/NEGEG is the positive/negative lumpy employment adjustment.

Table 7: Joint occurrence of lumpy adjustment (in percent)

	SPIKE	DISINV	POSEG	NEGEG
SPIKE	100.0	0.0	21.8	6.7
DISINV	0.0	100.0	5.3	22.1
POSEG	15.9	3.3	100.0	0.0
NEGEG	4.2	11.9	0.0	100.0

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

.2 Cyclicality of lumpy adjustment

Figures 11 and 12 display the evolution of lumpy adjustment over time in our sample. Figure 11 displays the proportion of observations that are classified as having a lumpy adjustment in each year in the sample, termed the *lumpy adjustment rate*. The left panel displays the positive adjustment and the right panel the negative adjustment. Figure 11 suggests that, typically, positive lumpy adjustment rates decline before and during official NBER recessions (except the 1981-1982 recession, where this rate has risen) and rise during the recovery phase of the cycle. By contrast, negative lumpy adjustment rates rise shortly before and during recessions and typically fall in the early stages of the recovery phases. Figure 12 displays the fraction of observations that either experience a lumpy adjustment or belong to the adjustment window for each year in the sample, termed the *lumpy adjustment window* rate. Figure 12 suggests that our window rate captures a significant fraction of the history of firm adjustment.

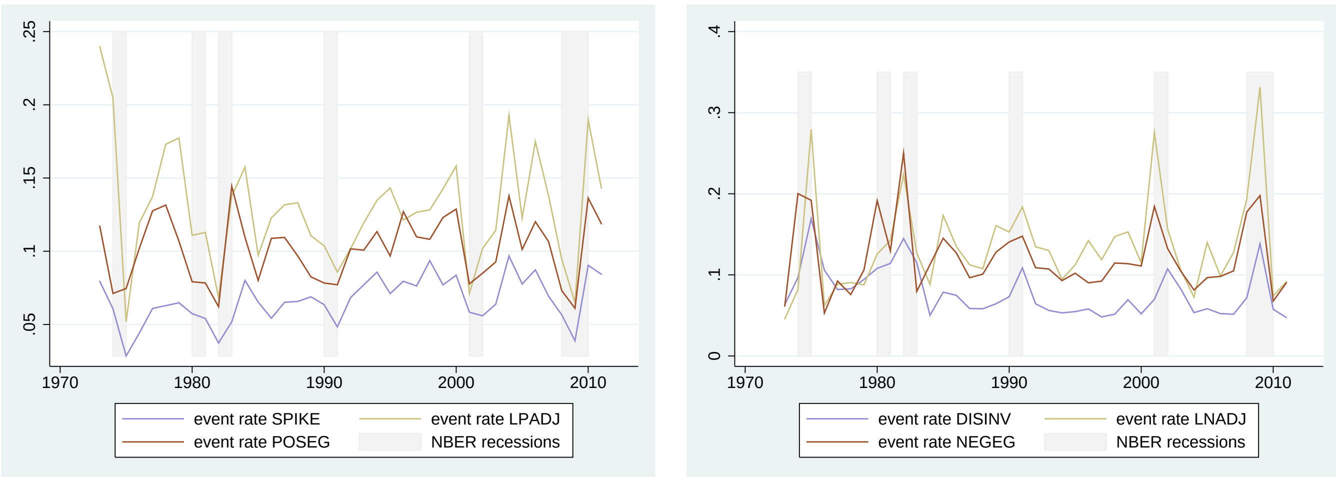

Figure 11: Lumpy adjustment rates. Proportion of firm observations per year that are classified as having a lumpy adjustment. Grey bars denote NBER recessions dates.

Table 8 provides evidence on the cyclicality of lumpy adjustment and confirms the ”eye-balling” visual provided by Figures 11 and 12 above regarding the evolution of lumpy adjustment in different phases of the business cycle. It reports contemporaneous as well as lagging and leading correlations of adjustment rates with the conventional measure of the cycle, namely, Gross Domestic Product (GDP). Table 8 reports that the lumpy adjustment rate is positively correlated with GDP when

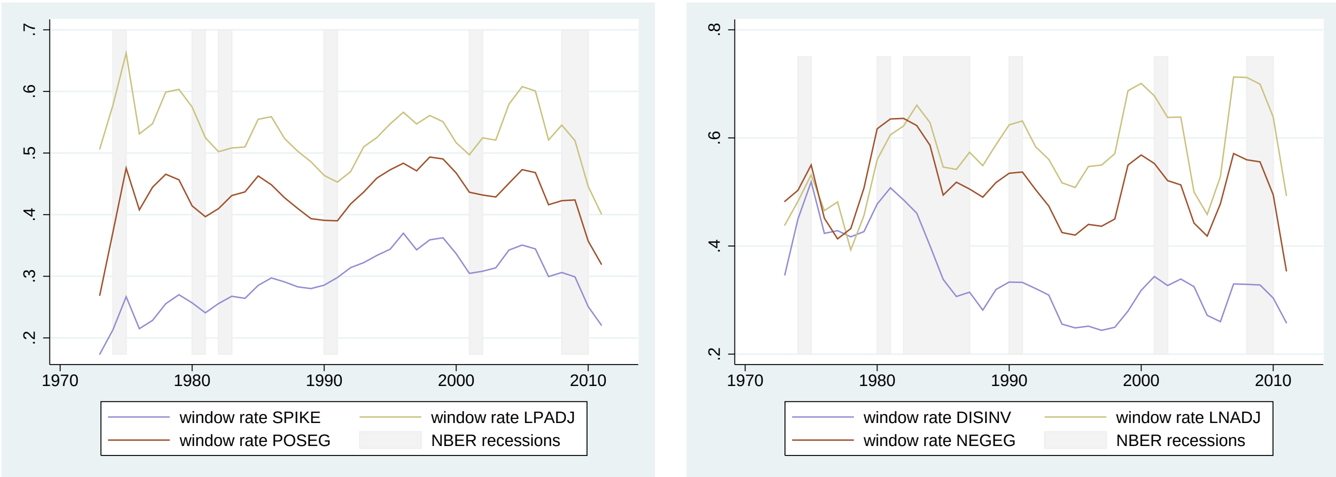

Figure 12: Lumpy adjustment window rates. Proportion of firm observations per year that either experience a lumpy adjustment or belong to the adjustment window. Grey bars denote NBER recessions dates.

considering any one of the three positive adjustments. The corresponding correlation is negative for negative adjustments. The same pattern of correlations holds for the aggregate value of the variable used in defining the adjustments conditioned on observations that are classified as adjustments.

Table 8: Correlations with GDP

	GDP(-1)	GDP	GDP(+1)	GDP(-1)	GDP	GDP(+1)
	SPIKE			**DISINV**		
Lumpy adjustment rate	-0.37	0.47*	0.49*	0.07	-0.62*	-0.46*
	POSEG			**NEGEG**		
Lumpy adjustment 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 adjustments x denotes investment (SPIKE), net investment (DISINV), employment growth (POSEG, NEGEG).

.3 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 4 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.[20]

The estimates reported in Table 9 confirm the intuition on the behavior of leverage and profitability displayed in Figures 4 and 8. First, as implied by the coefficient of the "Lumpy adjustment" 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 windows, the correlation between leverage and profitability is significantly negative as found in FF and several other empirical studies. However, as implied by the coefficient on the "Lumpy adjustment x Profitability" interaction term, when we condition on the year of the lumpy adjustment (expansionary or contractionary), the correlation between leverage and profitability becomes significantly *higher*. In fact, the importance of conditioning on lumpy adjustments can be seen when taking the sum of the coefficients on profitability and the interaction between profitability and the lumpy dummy. These sums are significantly greater than zero, indicating that the correlation between profitability and leverage does not only change quantitatively when conditioning on lumpy adjustments but also qualitatively. 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

[20] Size is measured as log total assets and 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 defined as dividends paid over total assets. The latter is included as a control since both the pecking order and trade-off theory predict a negative relationship between payouts and leverage.

dividend payouts exhibit a negative correlation with leverage.

.4 The significance of lumpy adjustment for aggregate Compustat variables

Tables 10 (the bottom 90% of small firms), and 11 (top 15% of large firms) display the decompositions discussed in the main text for all firms by firm size. For each year we categorise firms by percentile of total assets into different size classes. A firm is classified as belonging to the bottom 90%, top 15% by the median size classification of its history.

Tables 10 and 11 report the variance shares by aggregating together the year 't-1', 't' and 't+1'. The following Tables report a finer level of detail by reporting the shares of variance accounted for by each of 't-1', 't' and 't+1' window positions during the adjustment.

Fixed investment adjustments. Table 12 shows that capital adjustments explain quite well the variability in capital asset expansions. The last two columns, namely SUM(SPIKE) and SUM(DISINV) display the total share of variance accounted for by the positive adjustment and negative adjustment respectively throughout the 3-year adjustment window. The column denoted OTHER shows the share of variability accounted for by observations which do not belong to an lumpy adjustment. 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 episodes (SPIKE and DISINV) explains more than 50% of the variance in the real adjustment variables. Investment adjustments also account for approximately 50% of the variance in Tobin's Q. The overwhelming share of the latter is accounted for by the SPIKE. When it comes to financing variables these adjustments combined account for less than 50% of the variance in any financing variable. For most of these variables the positive and negative adjustments 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 adjustments, 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

Table 9: Leverage and profitability

	(1) SPIKE	(2) POSEG
Profitability	-0.048***	-0.0233***
	(-9.53)	(-5.36)
Lumpy adjustment	-0.106***	-0.058***
	(-30.75)	(-19.54)
Lumpy adjustment x profitability	0.064***	0.039***
	(5.48)	(4.16)
Dividend rate	-2.169***	-2.217***
	(-55.45)	(-50.79)
Size	0.013***	0.016***
	(29.77)	(33.75)
R&D dummy	-0.0862***	-0.087***
	(-36.71)	(-33.54)
Observations	61,596	50,997
	(1) DISINV	(2) NEGEG
Profitability	-0.008***	-0.019***
	(-2.57)	(-5.49)
Lumpy adjustment	0.127***	0.104***
	(38.67)	(41.39)
Lumpy adjustment x profitability	0.134***	0.110***
	(9.67)	(9.37)
Dividend rate	-1.253***	-1.612***
	(-33.20)	(-39.49)
Size	0.016***	0.017***
	(35.68)	(38.51)
R&D dummy	-0.091***	-0.095***
	(-34.59)	(-38.16)
Observations	46,487	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 adjustment dummy takes the value of one if it coincides with year 't' of the adjustment (SPIKE, POSEG, DISINV, NEGEG). It takes the value of zero in all other observations that do not belong to a five year adjustment window and observations that cannot by construction be classified as lumpy adjustments (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.

Table 10: Volatility of aggregate Compustat variables accounted for by lumpy adjustment

Bottom 90% firms	Capital expansions	Capital contractions	'Other'	Employment expansions	Employment contractions	'Other'
Real adjustment variables:						
Fixed investment	76.6	-7.5	31.0	84.5	4.0	11.5
Change in employment	29.2	37.7	33.1	45.3	41.8	12.9
Fundamentals/profitability variables:						
Change in Sales	22.1	43.3	34.4	35.3	42.2	22.5
Tobin's Q	53.4	10.9	35.7	73.3	-5.3	32.0
Financing variables:						
Change in Cash	41.7	21.6	36.7	50.0	24.0	26.0
Change in debt outstanding	29.4	32.5	38.1	47.5	30.9	21.5
Equity issuance	36.8	16.9	46.3	41.2	23.5	35.3
Change in Total Liabilities	37.1	21.5	41.4	50.4	27.2	22.4
Asset weighted frequency	25.8	25.2	49.0	36.2	27.7	36.1

'Other' refers to all periods outside adjustment windows (expansions or contractions). All variables are divided by total assets with the exception of Tobin's Q.

Table 11: Volatility of aggregate Compustat variables accounted for by lumpy adjustment

Top 15% firms	Capital expansions	Capital contractions	'Other'	Employment expansions	Employment contractions	'Other'
Real adjustment variables:						
Fixed investment	66.0	4.8	29.2	51.3	22.0	26.8
Change in employment	12.5	37.1	50.4	31.7	41.5	26.8
Fundamentals/profitability variables:						
Change in Sales	7.8	25.3	66.9	15.2	31.4	53.4
Tobin's Q	49.1	2.0	54.9	74.3	7.2	18.5
Financing variables:						
Change in Cash	18.7	21.8	59.5	20.7	29.4	49.9
Change in debt outstanding	15.0	18.5	66.6	31.9	28.4	39.7
Equity issuance	23.3	17.3	59.4	20.4	25.1	54.5
Change in Total Liabilities	21.1	14.0	64.9	34.3	20.6	45.1
Asset weighted frequency	14.2	15.3	70.5	18.7	26.5	54.8

'Other' refers to all periods outside adjustment windows (expansions or contractions). All variables are divided by total assets with the exception of Tobin's Q.

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.

Table 12: Detailed decomposition for investment adjustment 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
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
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
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, SPIKE(-1) and SPIKE(+1) denote the periods in the window before and after the adjustment. Similarly for the DISINV. OTHER refers to all periods outside adjustment 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 13: Detailed decomposition for employment adjustment 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
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
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
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 adjustment, POSEG(-1) and POSEG(+1) denote the periods in the window before and after the adjustment. Similarly for the NEGEG adjustment. OTHER refers to all periods outside adjustment 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.

Employment adjustments. Table 13 reports the decomposition for employment adjustments. Positive and negative adjustments are quite important for the variability of real adjustment variables. The share of variance in many variables accounted by these lumpy adjustments exceed by a large margin their proportions of asset weighted observations. Lumpy expansions in employment account for over 50% of the variability of fixed investment. Lumpy expansions in employment account for 78% of the variability of Tobin's Q. For financing variables positive adjustments 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.

.5 Robustness of dynamic financing patterns

When we condition the analysis according to the position of market leverage in the year preceding the adjustment, 't-1' we observe the following. The dynamic pattern of cash-to-assets in Figure 12 is remarkably similar across firms and consistent with Figure 6. In positive events firms increase cash-to-assets significantly above the 'other' and reduce cash-to-assets as the episode unfolds. The exception is firms that belong to the top 10% of leveraged firms, where despite the increase in year 't-1' their cash-to-assets is below 'other' through out positive adjustment. For negative episodes cash-to-assets declines in year 't-1' and slowly recovers towards the 'other' (an exception being firms in the 0-33% of leverage for DISINV, where cash-to-assets drops monotonically from a high level relative to 'other'). Figure 13 displays the growth rate of debt. The dynamic patterns we observe are again broadly similar to the ones displayed in Figure 9. For positive adjustment, there is a surge in the growth of debt at the year of the adjustment across different firms, even for those who are in the top 10% of market leverage during the previous year. For negative adjustments, there is a drop off in the growth rate in year 't'. This is certainly more apparent for firms in the upper two bins of the distribution. Interestingly, firms in the lowest 0-33% of the distribution exhibit a rise in the growth rate in DISINV, in year 't'. We conjecture these are firms which have high cash-to-assets ratio relative to 'other' (see Figure 12) and they seem to use debt even in contractions given they have the debt capacity. Figure 14 displays the behavior of market leverage. It is interesting to see that in positive adjustments firms behave broadly similar in terms of preparing debt capacity. They all reduce leverage at 't-1' and slowly increase it thereafter. Firms in the top 10% have leverage way above the 'other' at the beginning of the window but still reduce it up to the time of the adjustment. For negative capital adjustments, firms in the bottom two thirds of the distribution of leverage increase it monotonically towards the 'other', and this is different to the behavior of the top one third percent of firms in terms of market leverage. When we condition the analysis according to the position of cash-to-assets in the year preceding the adjustment, 't-1', we observe the following. In Figure 15, firms in the 0-33% of the distribution of cash-to-assets do not seem to exhibit differences, at least qualitatively, with respect to the dynamic pattern of cash-to-assets whether they undertake positive or negative adjustments. These firms are way below the 'other' and attempt to slowly rebuild cash balances as the episodes unfold. Firms in the remaining of the distribution behave broadly similar to the behavior we have documented in Figure 6. It is remarkable that even firms that are cash rich seem to prepare for positive adjustments in year 't-1'. An exception here is the behavior of the top 10% of firms in the distribution where they do not seem to reduce cash-to-assets in year 't-1' for capital contractions. Figure 16 displays the growth rate of debt. For positive episodes the behavior is broadly similar to the average behavior we discussed in Figure 9. For negative episodes there are some differences with respect to the DISINV episode where we do not observe a drop-off in growth rates of debt for firms in the top one third of the distribution. Finally, Figure 17 displays the behavior of market leverage. For positive events, the dynamic behavior of leverage is remarkably similar to the behavior discussed in Figure 8—firms create debt capacity in advance of the adjustment and this does not seem to be conditional on the level of cash-to-assets they hold. This finding is further evidence that debt and cash are not good substitutes during lumpy episodes. For negative adjustments and the bottom two thirds of firms in the distribution of cash-to-assets the dynamics are very similar to those in Figure 8. However, for firms in the one third of the distribution of cash-to-assets they typically increase leverage monotonically, although they begin the negative adjustment way below the 'other'. Figure 18 displays the dynamics of cash-to-assets for firms sorted on different size. For positive adjustments cash-to-assets behaves qualitatively similar for different size firm and consistent with the dynamic behavior observed in Figure 6. The dynamics of cash-to-assets are also similar for negative employment events, with cash to assets dropping a year prior to the negative adjustment. A difference seems to arise in capital contractions where there is not strong evidence of reversion to the 'other' within the episode window. Figure 19 displays the growth rate of debt. Again we observe dynamic patterns which are very consistent with the one we have discussed in Figure 9: positive adjustments see a surge in the growth of debt in the adjustment year and negative adjustments a reduction in the growth of debt, although the timing is not always uniform across firms of different sizes. Figure 20 demonstrates that small and large firms behave very similar with respect to the dynamics of leverage during positive adjustments: firms seek to create debt capacity in the year preceding the adjustment and increase debt in the year of the adjustment. It is remarkable that the largest firms behave in a similar fashion to small firms in terms of leverage and debt.

.6 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).

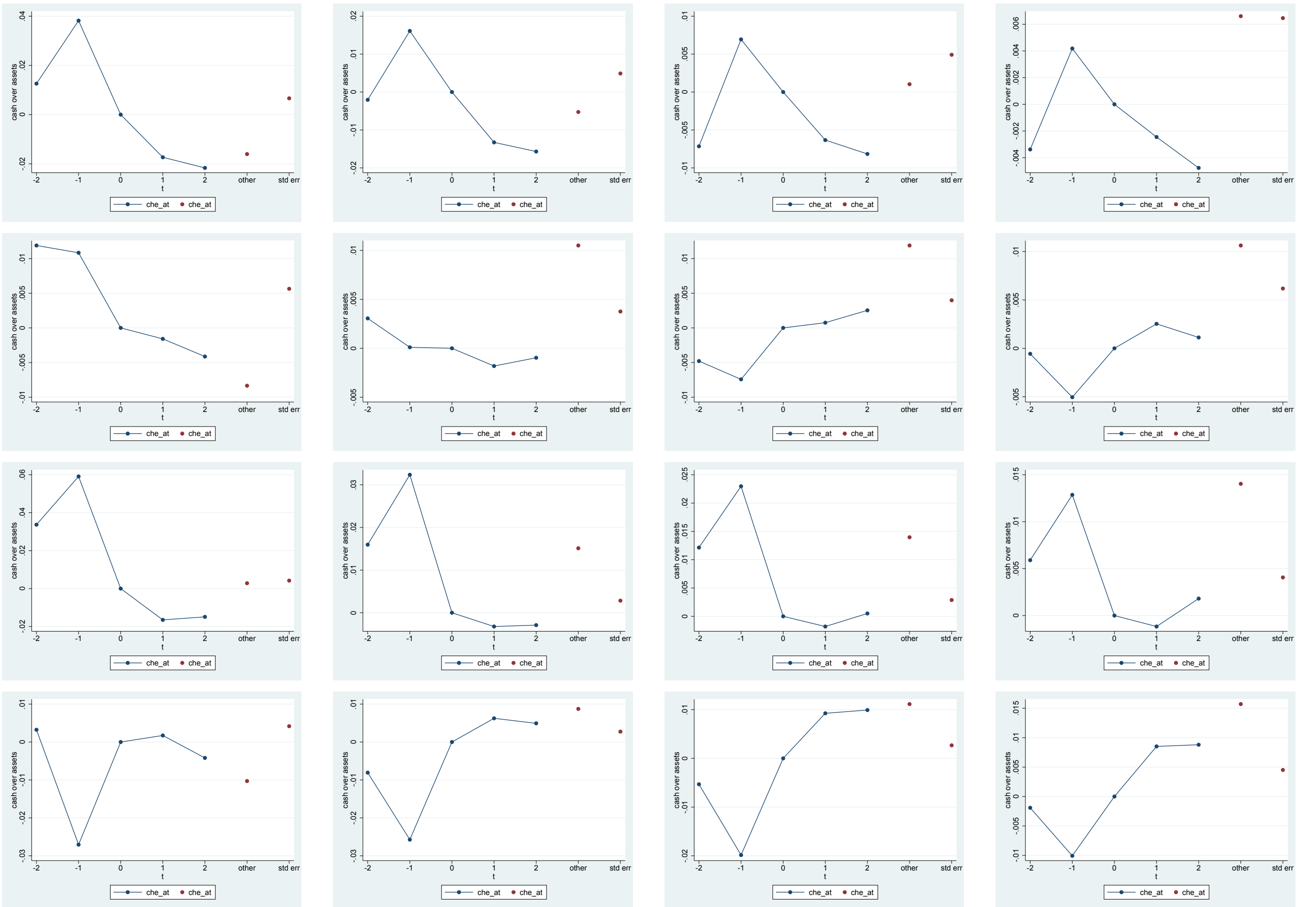

Figure 13: Behavior of cash over contemporaneous assets around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to market leverage at window position t-1, 0-33%, 34-66%, 67-90%, 90-100%.

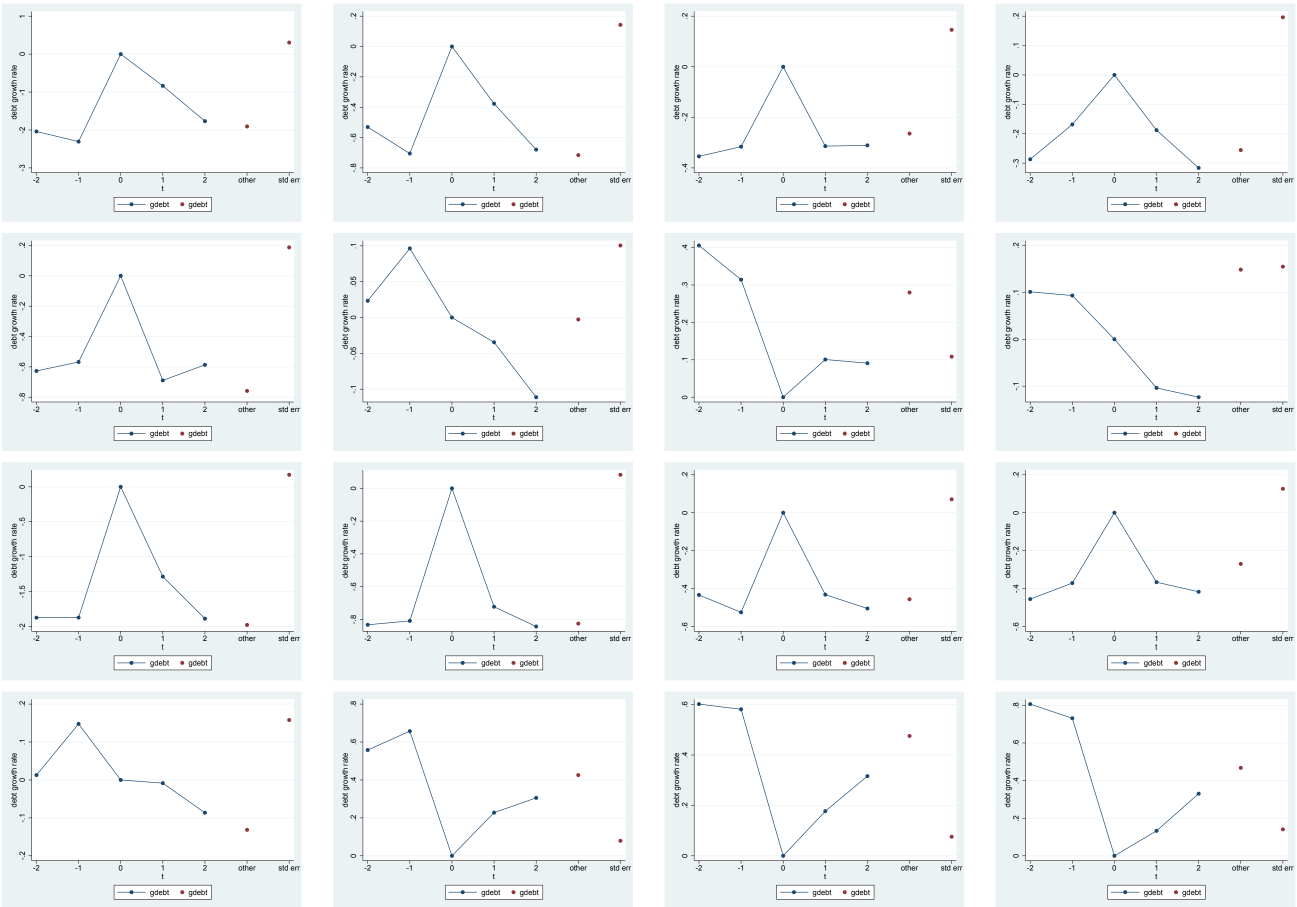

Figure 14: Behavior of the growth rate of debt around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to market leverage at window position t-1, 0-33%, 34-66%, 67-90%, 90-100%.

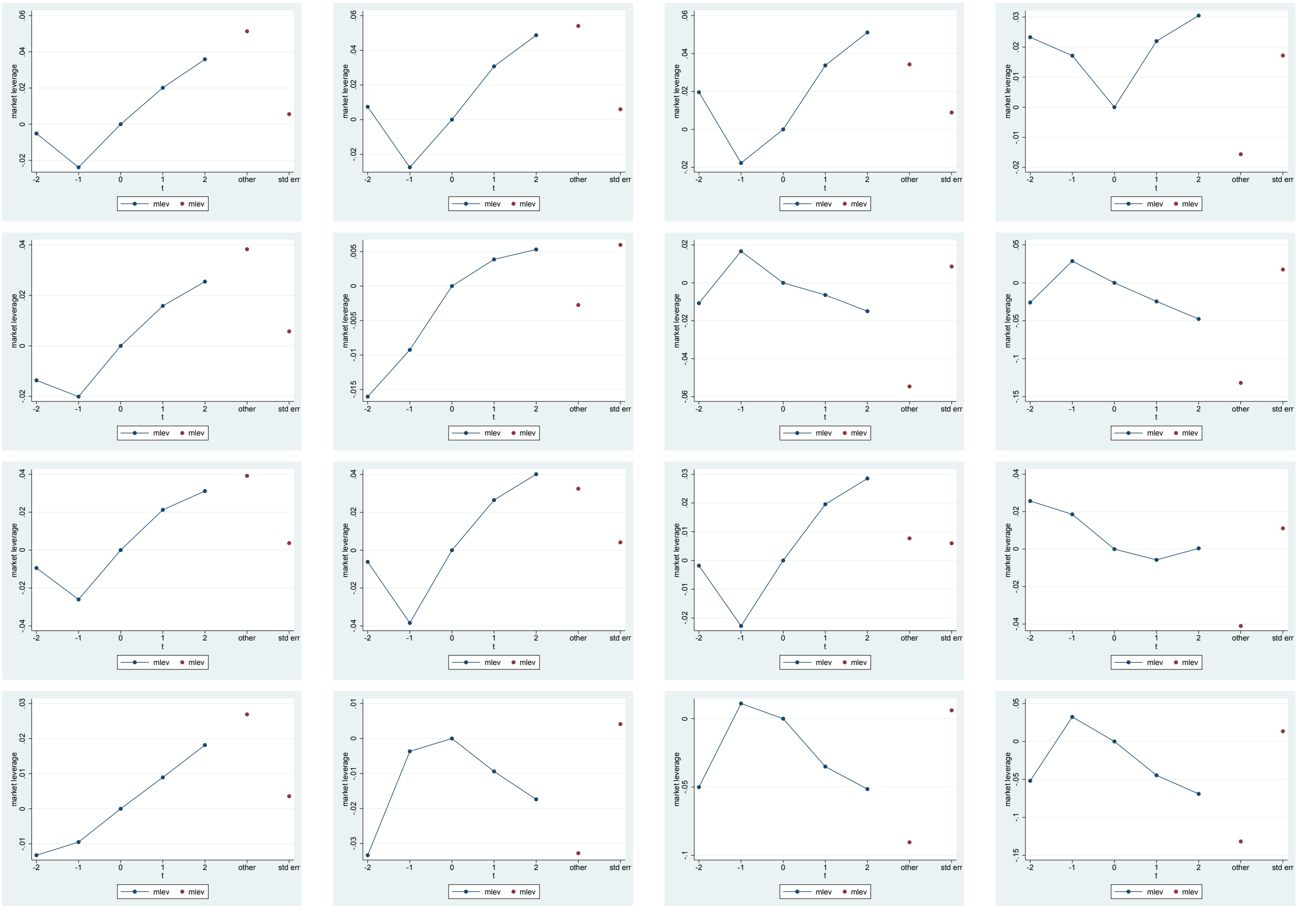

Figure 15: Behavior of market leverage around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4), (5) large positive inventory adjustment (row 5), (6) large negative inventory adjustment (row 6). Figures from left to right show results according to market leverage at window position t-1, 0-33%, 34-66%, 67-90%, 90-100%.

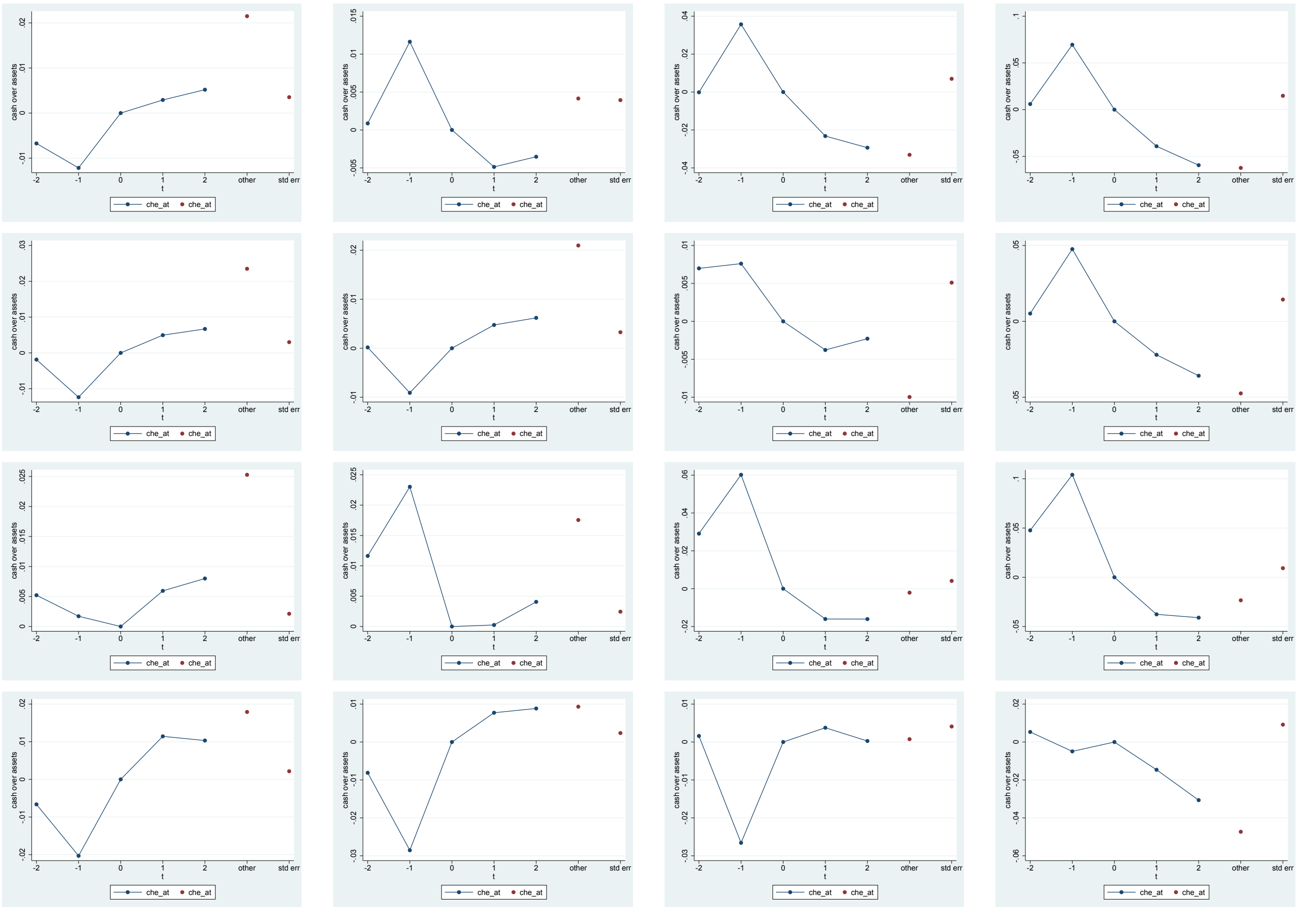

Figure 16: Behavior of cash over contemporaneous assets around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to cash over assets at window position t-1, 0-33%, 34-66%, 67-90%, 90-100%.

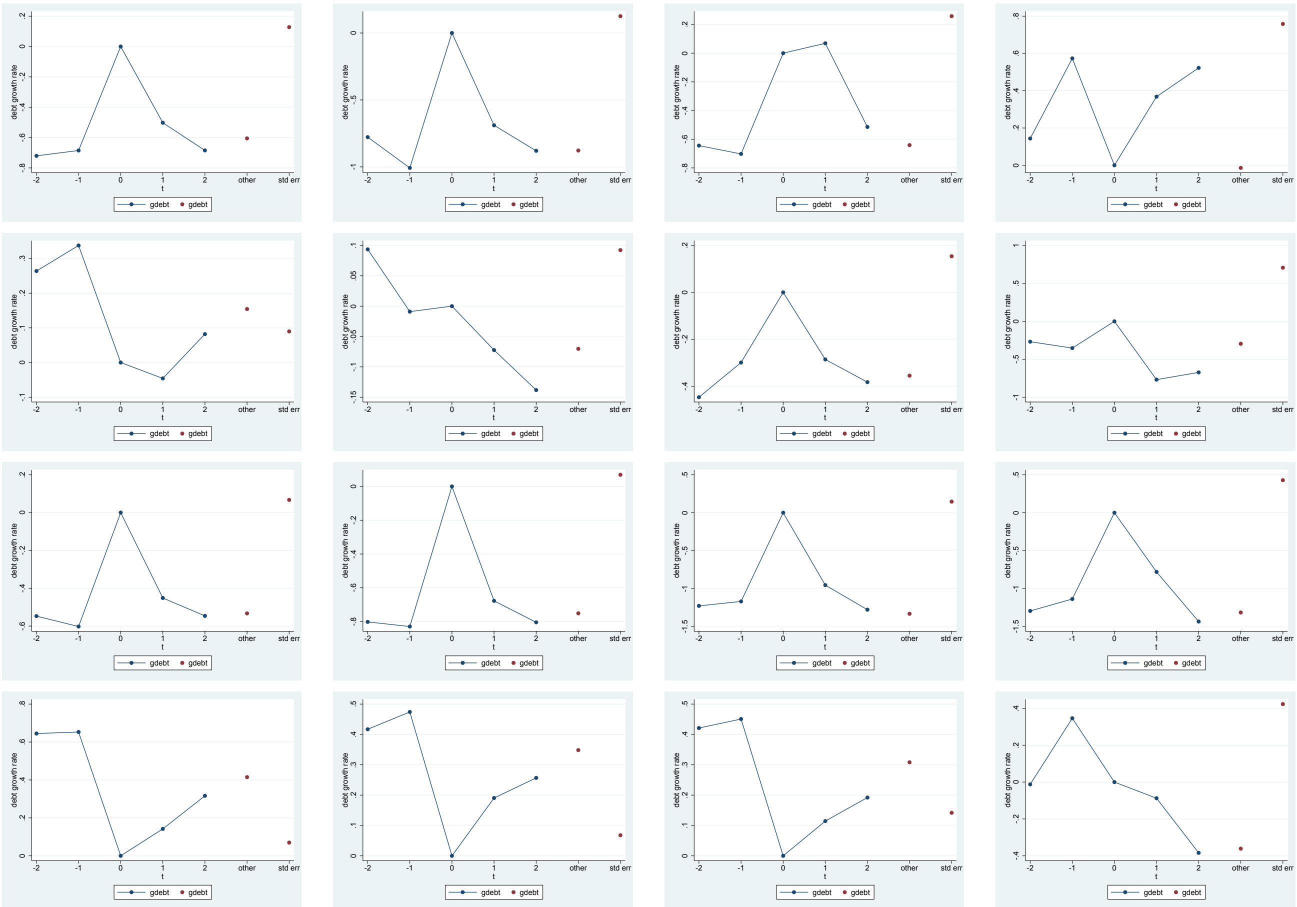

Figure 17: Behavior of the growth rate of debt around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to cash over assets at window position t-1, 0-33%, 34-66%, 67-90%, 90-100%.

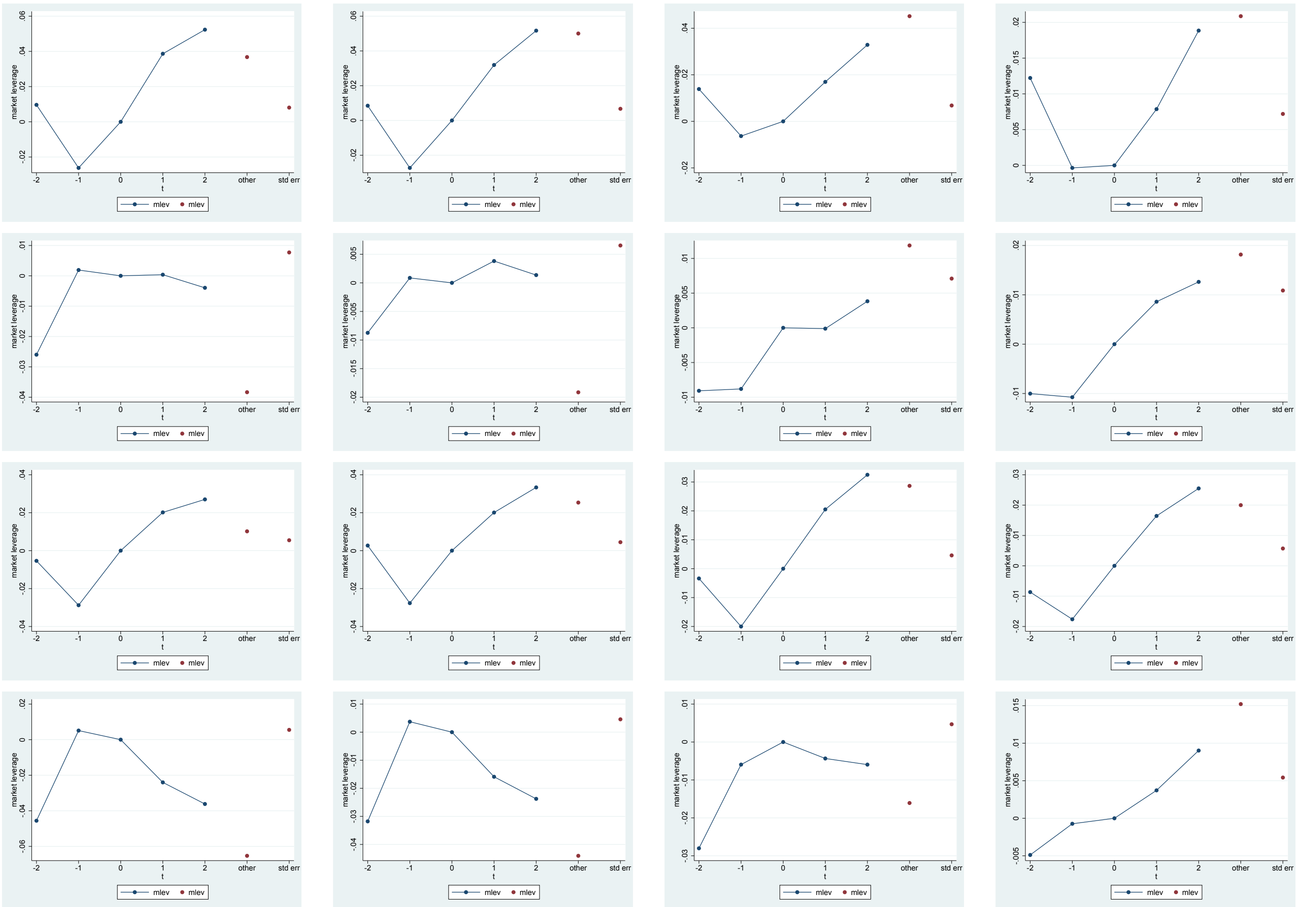

Figure 18: Behavior of market leverage around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to cash over assets at window position t-1, 0-33%, 34-66%, 67-90%, 90-100%.

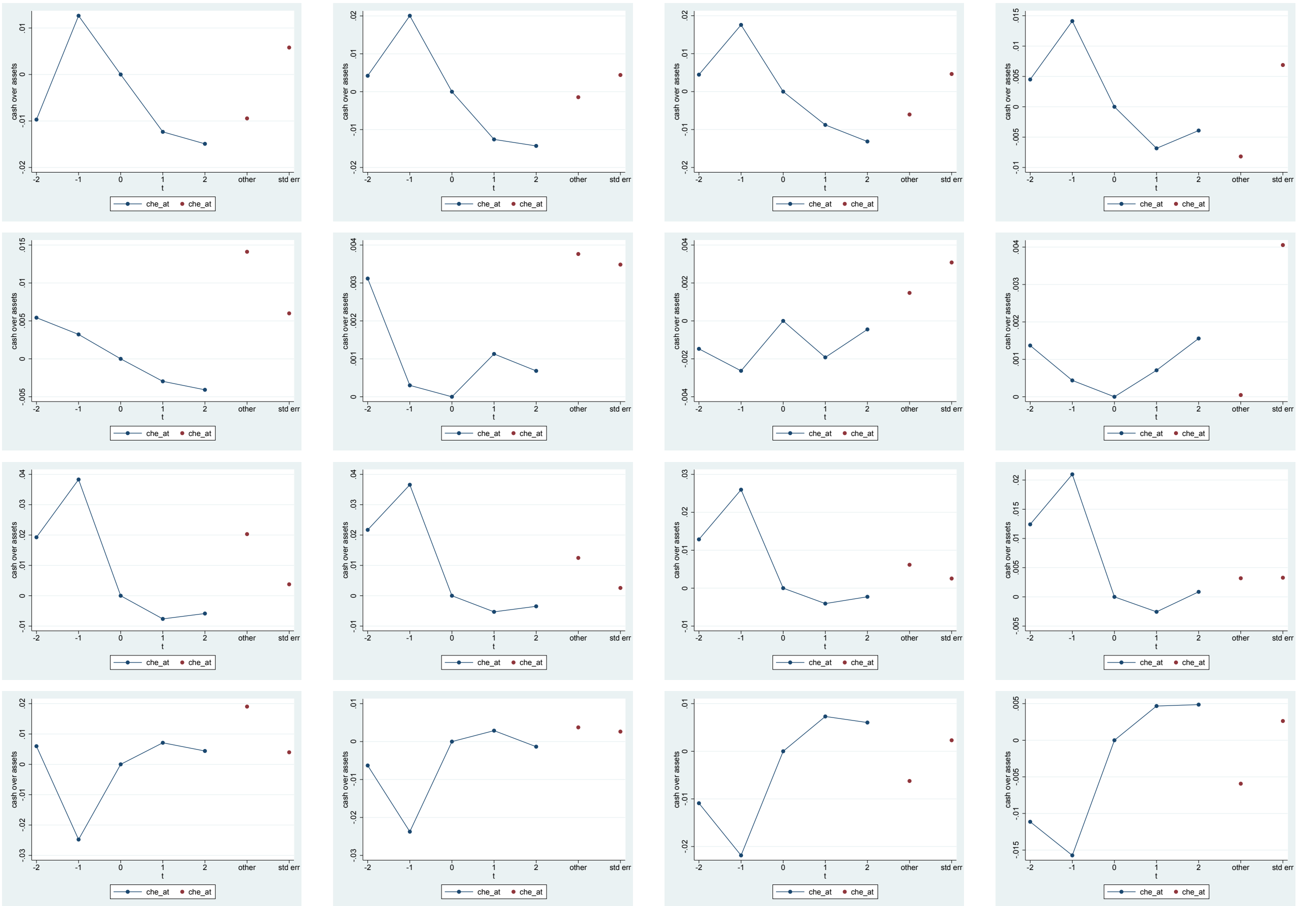

Figure 19: Behavior of cash over contemporaneous assets around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to size, 0-33%, 34-66%, 67-90%, 90-100%.

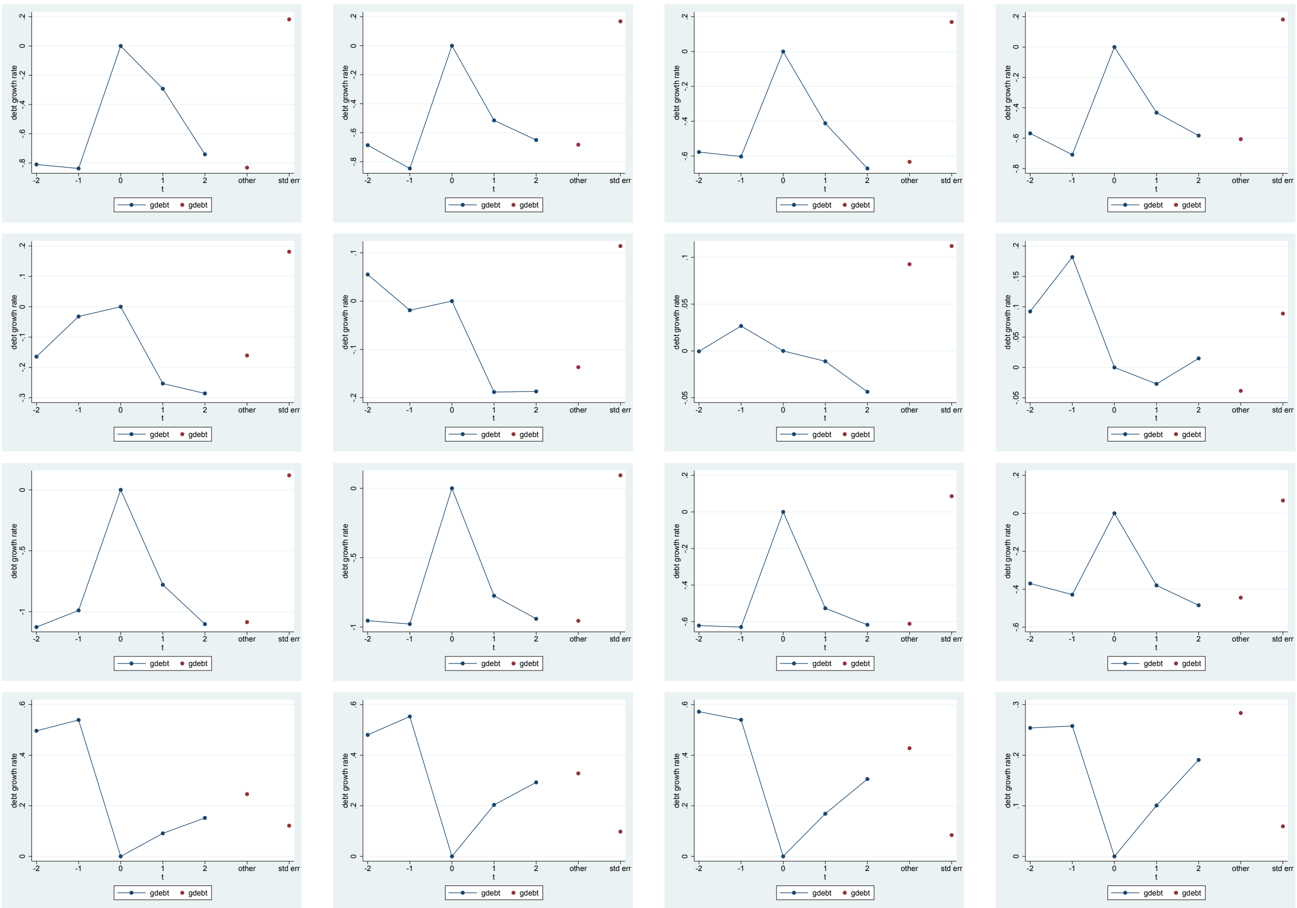

Figure 20: Behavior of the growth rate of debt around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to size, 0-33%, 34-66%, 67-90%, 90-100%.

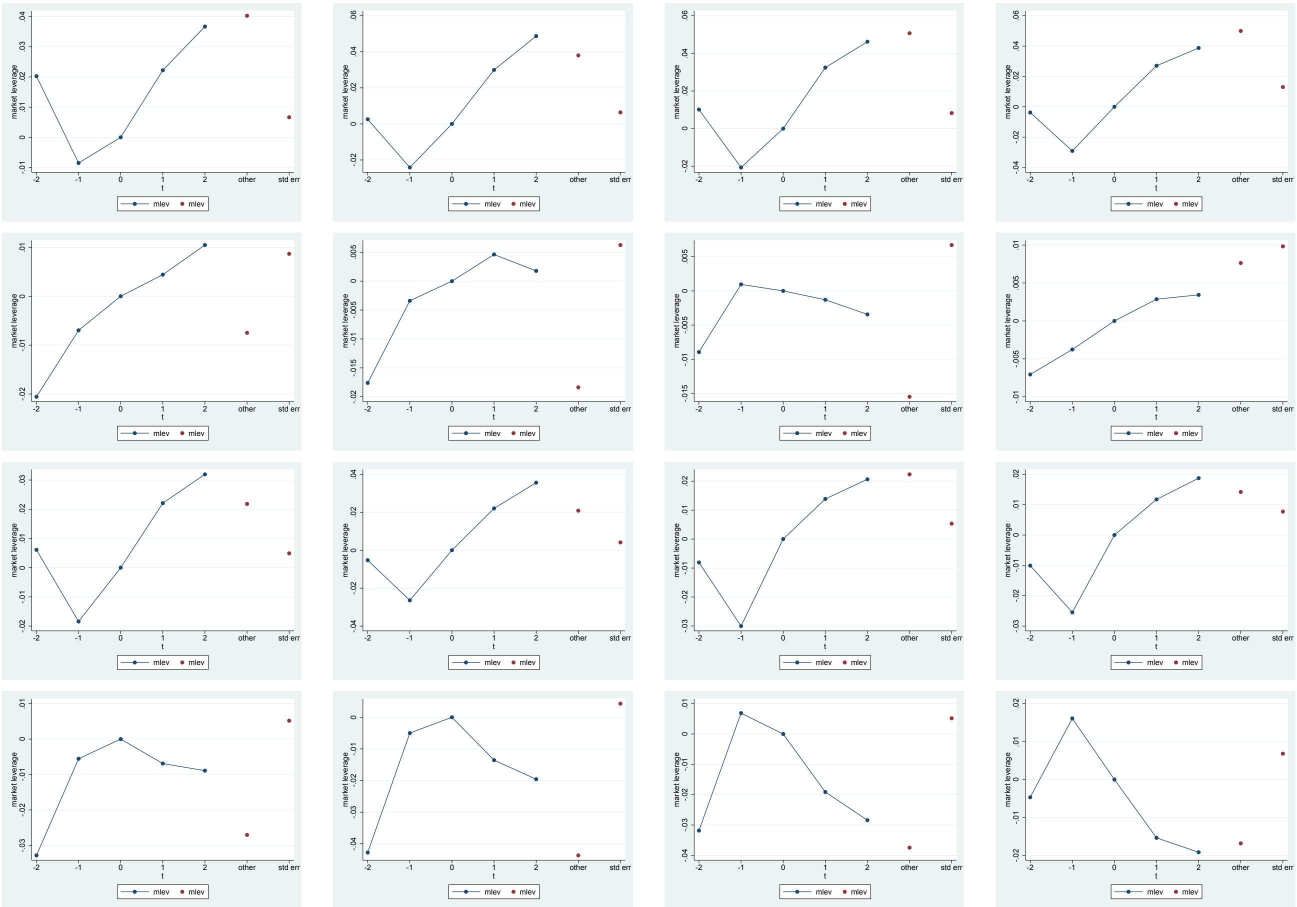

Figure 21: Behavior of market leverage around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to size, 0-33%, 34-66%, 67-90%, 90-100%.

- 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.[21]

- 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'. 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).[22] Inventory variables are deflated using, P_{invt}, the price deflator for finished goods (PPI). It is the finished goods PPI

[21] 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.

[22] 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.

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).
- 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.