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Firms' Financing Dynamics around Lumpy Capacity Adjustments

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Keywords

Lumpy Adjustment, Firm Capital and Employment Dynamics, Leverage, Debt, Cash

JEL Classification

G30, G32, E32

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1 Introduction

Firms respond to business conditions by adjusting their operations. This adjustment is not continuous and is often lumpy. A rich literature (see for example Cooper and Haltiwanger (1993), Cooper et al. (1999), Caballero and Engel (1999), Caballero et al. (1997)) has documented empirically the micro adjustment frictions that lead to lumpiness. More recently, Gourio and Kashyap (2007), Bachmann and Bayer (2014), Bachmann et al. (2013), Cooper et al. (2015), Winberry (2021) have emphasized again the view that lumpiness matters for aggregate dynamics. However, very little is known about the menu of finance margins that firms optimally choose when adjusting their operations in a lumpy fashion. Our paper seeks to fill this gap. Specifically, we seek to understand the patterns of financial policies in cash, debt and equity that are relevant in financing lumpy adjustment.

We use annual firm-level data from the U.S. Compustat to analyze the dynamics of finance margins before, during, and after lumpy adjustments in capital and employment. The flexible econometric methodology we employ enables to trace out dynamic responses in a rich set of firm specific variables in a 5-year window centered on a lumpy adjustment year. Specifically, it allows to identify meaningful dynamic patterns of adjustment in investment and employment rates, productivity and profitability indicators and finance margins at the same time. Our identification strategy rests on two pillars. First, we compare the identified dynamics to the behavior of the same group of firms during "normal" years outside the adjustment window. Second, and more importantly, we compare the identified dynamics to the dynamics estimated in a carefully constructed control group that has not undertaken lumpy adjustment. We provide evidence that the dynamics in the group that undergoes lumpy adjustment are significantly different to those in the group that does not. Lumpy adjustments in capital and employment correspond to approximately 20% of firm histories in our sample and they typically last for more than a year. We observe both positive and negative adjustments and adopt appropriate thresholds in investment rate, dis-investment rate, positive (negative) employment growth rates to define an episode as lumpy.[1]

[1]We define an investment spike when the investment rate exceeds 35%, a disinvestment spike when net investment rate is below 8%, positive and negative lumpy employment, when employment growth is above 15% and less than -7%

We illustrate the methodology by means of an example: a lumpy capital expansion undertaken by Schlitz Brewing company in 1974. This example illustrates how this company used their financial resources to finance a large expansion in the capital stock. Figure 1 displays the investment rate, cash and debt in a five-year window surrounding this expansion in operating capacity. We observe that capital adjustment is substantial and takes time to complete. The level of cash is already elevated in 1972 compared to "other", which captures the average behavior during "normal" years, those outside the five-year lumpy adjustment window. Cash is then de-cumulated significantly as the adjustment unfolds and drops below the average level. Relative to normal years, the level of debt is low in 1973 and then rises significantly in the following two years. These dynamic patterns turn out to be very robust qualitatively in our sample of Compustat firms. In order to motivate our empirical methodology and help sharpen its inference we employ a stylized model that links real and financial decisions in fixed investment, cash balances and costly external finance. We simulate the model and compute impulse response functions, discuss the dynamic patterns predicted by the model and compare them qualitatively with the empirical patterns we estimate from the data.

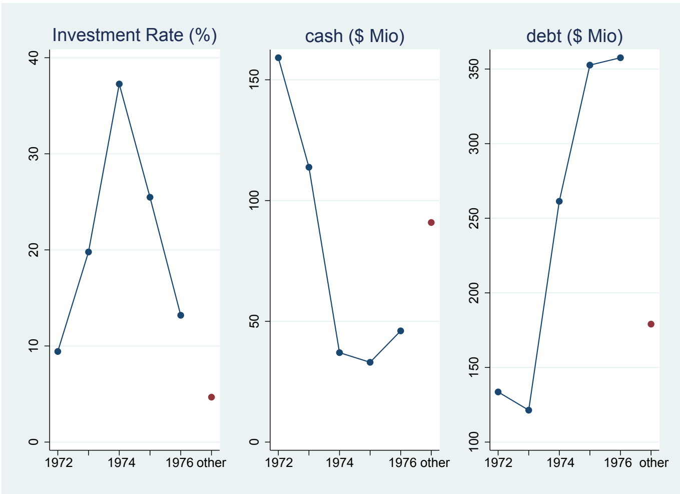

Figure 1: Behavior of investment rate, cash and debt around a lumpy capital adjustment episode for Schlitz Brewing. Lumpy capital expansion occurs in year 1974. *other* is the average value of the respective variable outside the 5-year adjustment window centered on 1974.

Our empirical analysis brings to light several new facts that connect lumpy adjustment with

respectively. Bai et al. (2022) also provide evidence for investment lumpiness in Compustat data.

dynamic patterns in finance margins and in profitability and productivity indicators. We document that firms anticipate the incipient lumpy adjustment and *prepare to finance* it a year in advance. Firm-specific fundamental indicators–captured by Tobin's Q, total factor productivity, and earnings-to-asset ratio–rise significantly one year ahead of lumpy expansions in capital or employment and remain elevated in the years subsequent to the expansion. These innovations in fundamental indicators are consistent with the notion that firms receive news about profitable investment opportunities and seek to capitalize on them by expanding capacity.[2] Firms respond to the predictability of the adjustment by building up cash balances while simultaneously reducing leverage. Then, during the expansion, associated expenses are covered by drawing down cash balances and increasing debt, thus driving up leverage. Interestingly, leverage continues to rise significantly for at least two years after the lumpy expansion was initiated. The joint movements of cash, debt and leverage suggest that firms actively create debt capacity in order to use it later as the expansion of assets unfolds. The dynamics of cash balances suggest the latter play a complementary role to the creation of debt capacity. Importantly, the identified dynamics described above are significantly different to the dynamics estimated for the control group of firms that have not undertaken a lumpy expansion. Our findings therefore provide strong evidence that both cash and unused debt capacity are actively manipulated before the ensuing expansion of productive assets.

The dynamics of cash balances and debt for lumpy expansions described above, are mirrored for lumpy contractions. Firms observe worse fundamentals the year before the contraction in capital or employment. At the same time, they experience reductions of cash balances, together with higher than average debt growth. During and after the contraction, firms rebuild cash and reduce debt growth significantly. However, relative to lumpy expansions these dynamics are more protracted and

[2]For example, firms may experience consecutive positive sales (cash flow) shocks which constitutes news about market opportunities. In the presence of adjustment costs and costly external finance as in the model described in section 2, firms may not immediately adjust in response to these favourable news, and this makes them more likely to adjust in the future when a high enough cash flow shock increases the productivity of capital to justify the adjustment cost. Thus, firms *anticipate* – in a probabilistic sense – that they will adjust and optimally prepare for the very likely expansion in capacity. In a recent contribution, Hou et al. (2020) emphasize the importance of taking into account expected investment growth opportunities.

suggest it takes time to restore a more healthy level of financial resources. The dynamic interaction between finance margins and productive assets surrounding lumpy contraction episodes is consistent with firms acting to restore financial resources by adjusting their productive operations. Again, these identified dynamics are significantly different to the dynamics estimated for the control group of firms that have not undertaken a lumpy contraction. We further document that for the vast majority of firms, equity issuance is not a major source of finance associated with lumpy adjustment, and it only has some importance for the very large firms in the Compustat universe. Interestingly, we show that the dynamic patterns for debt and cash described above are qualitatively robust even after conditioning on firm size.

In addition to the dynamics, which are silent on the quantitative relevance of different margins, we undertake an exercise to establish the relative importance of the latter. Quantitatively, our findings suggest the majority of firms uses either cash or debt as the main finance margin during lumpy adjustments. Cash accumulation or debt reduction are the dominant margins in almost 50% of the sample of lumpy adjustments in the preparation year across the firm size distribution. Debt accumulation is the dominant margin in the year of the adjustment for very large firms in over 50% of the sample, and it is also the dominant margin in approximately 40% of the sample for smaller firms. Cash decumulation in the year of the adjustment is the second most dominant margin for smaller firms, while equity reductions is the second most dominant margin for very large firms but play a very minor role for the group of smaller firms.

Our paper is related to several strands of literature. First, a strand on corporate liquidity management in the presence of financing constraints (see the survey by Almeida et al. (2014)).[3] Our findings on the dynamics of cash balances and leverage during lumpy adjustment suggests that cash

[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. Bacchetta et al. (2019) 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.

and leverage interact in a meaningful way. Cash build-up and leverage reductions go hand in hand during the preparation phase of an expansionary adjustment. This pattern indicates that firms do not prefer a rapid build-up in debt alone to finance an expansion. Cash plays a crucial role in retaining unused debt capacity and the joint dynamics are consistent with a strong value attached to financial flexibility, i.e. the desire to have access to financial markets at a low cost.[4] The role of cash balances is explored in the lumpy investment models of Riddick and Whited (2009) and Tsoukalas et al. (2017). These studies emphasize the value of retained earnings (savings) for firms that face costly external finance. Bayer (2006) emphasizes the complementary role of finance and productivity in driving the timing of lumpy investment decisions. Our findings on the concurrent and anticipatory rise of productivity and profitability indicators and finance margins is consistent with the main thrust of Bayer (2006)'s analysis.

Second, a strand of literature that emphasizes the importance of financing frictions for understanding aggregate patterns–and cross sectional differences–in debt and equity financing over the business cycle. Jermann and Quadrini (2012), Covas and Den Haan (2011) and Begenau and Salomao (2019) document the financial cycles of debt and equity and emphasize the cross sectional differences (small vs large firms) in the mix of debt and equity that suggest arise from differences in external finance costs. Eisfeldt and Muir (2016) study the joint dynamics of liquidity and external finance and provide an estimate for the aggregate cost of external finance. Our contribution relative to the studies above is the focus on firm level dynamics–beyond the aggregate patterns. We establish, at the firm level, the nature of adjustment that is driving the preparatory role of debt and cash and highlight the predominant role of the latter, especially for small firms, for the financing of lumpy adjustment. Our empirical findings on the use of debt and equity reductions for large firms during expansions are consistent with the cyclical financing pattern for large firms documented in Begenau and Salomao (2019).

Finally, our paper provides important empirical background in support of a recent line of work

[4]Graham and Harvey (2001) American CFO survey results suggest financial flexibility to be a key driver for corporate capital structure decisions. Gamba and Triantis (2008) analyze the value of financial flexibility in a model of investment and corporate liquidity.

that re-emphasizes the relevance of micro lumpy adjustment for shaping and understanding aggregate macroeconomic dynamics and the response of aggregate investment to policy stimulus (see e.g. Winberry (2021), Koby and Wolf (2020), Baley and Blanco (2021)).

The rest of the paper is organized as follows. Section 2 presents a simple theoretical model. Section 3 describes the data and methodology. Section 4 establishes the dynamic adjustment patterns during lumpy adjustment, and quantifies the relative predominance of finance margins used during the lumpy adjustments. Section 5 concludes and highlights implications of our paper.

2 A stylized model: dynamic patterns around lumpy adjustment

We present a simple theoretical model adopted from Tsoukalas et al. (2017). The model is useful as a guide for setting up our empirical framework and discussing the main empirical findings in relation to the predictions from a well established model. The model features an industry with many heterogenous firms that produce, invest in fixed capital and save in cash that earns a risk free rate of return. Investment in fixed capital is subject to both convex and non-convex adjustment costs. External finance is available at a premium over the risk free rate.

2.1 Firm's problem

Production and investment

The firm's j production (and sales) function is given by

$$y_{jt} = s_{jt} k_{jt}^{\alpha}, \qquad 0 < \alpha < 1, \tag{1}$$

where production, y_{jt}, depends on capital, k_{jt}, and a cash flow disturbance, s_{jt}. The latter can be thought as a stand-in for productivity, or demand shift that raises firms' sales – we call it a cash flow shock. The parameter α determines capital's share in production. The (log of) cash flow disturbance is assumed to follow an AR(1) process,

$$\ln(s_{jt+1}) = \rho \ln(s_{jt}) + \varepsilon_{jt}, \tag{2}$$

where, ρ is the autoregressive parameter, and ε_{jt} is assumed to follow an IID $N(0, \sigma)$.

The firm can accumulate capital according to

$$k_{jt+1} = (1 - \delta_k)k_{jt} + i_{jt}, \qquad 0 \leq \delta_k \leq 1, \tag{3}$$

where i_{jt} is fixed investment and δ_k denotes the depreciation rate of capital.

We assume the firm faces both convex and non-convex adjustment costs similar to the formulation in Cooper and Haltiwanger (2006). The adjustment costs consist of two components: the variable cost component, $c_v(i_t, k_t)$, which admits a quadratic form

$$c_v(i_{jt}, k_{jt}) = \frac{\gamma}{2}\left(\frac{i_{jt}}{k_{jt}}\right)^2 k_{jt}, \qquad \gamma \geq 0. \tag{4}$$

and the non-convex component which is given by,

$$c_f(k_{jt}) = \left\{ \begin{array}{cc} Fk_{jt} & \text{for } i_{jt} \neq 0 \\ 0 & \text{for } i_{jt} = 0 \end{array} \right\}, \qquad F \geq 0, \tag{5}$$

where F denotes a fixed cost incurred by the firm during investment or (dis)investment episodes. This component is scaled by the capital stock, k_t, to eliminate any size effects.

In addition to the real decisions described above, firms are also making a financial decision, namely, on the amount of cash to hold, b_{jt}. Saving earns a post-tax risk-free interest rate of r. Similar to Gomes (2001) we assume the firm can obtain external funds at a premium. Whenever the firm's expenditure exceeds the available sources of income the firm pays a premium over the risk-free rate. Formally, let

$$ncf_{jt} = s_{jt}k_{jt}^{\alpha} - k_{jt+1} + (1-\delta_k)k_{jt} - Fk_{jt} - \frac{\gamma}{2}\frac{(k_{jt+1} - (1-\delta_k)k_{jt})^2}{k_{jt}} + (1+r)b_{jt} - b_{jt+1} \tag{6}$$

denote the net cash flow. We assume the firm pays a cost of obtaining external finance as follows,

$$\begin{aligned}\phi_t^{ext}(-ncf_{jt}) =& \lambda(-ncf_{jt}) = \lambda(k_{jt+1} - (1-\delta_k)k_{jt} - s_{jt}k_{jt}^{\alpha} \\ &+ Fk_{jt} + \frac{\gamma}{2}\frac{(k_{jt+1} - (1-\delta_k)k_{jt})^2}{k_{jt}} - (1+r)b_{jt} + b_{jt+1})\end{aligned} \tag{7}$$

with $\phi_t^{ext}(\bullet) > 0$ if $ncf_{jt} < 0$, and $\phi_t^{ext}(\bullet) = 0$ otherwise. In the expression above, λ is a parameter capturing the premium the firm pays in order to use external finance.

Given the structure of the problem above, the firm will be in either of two investment regimes: an active investment where the firm invests or (dis) invests and an inactive investment regime where the firm does not undertake any investment. Let the value function describing each regime given by, $V^a(s_t, k_t, b_t)$ and $V^i(s_t, k_t, b_t)$ for activity and inactivity respectively (dropping the subscript j for convenience). The firm then solves the following problem,

$$V(s_t, k_t, b_t) = \max\{V^a(s_t, k_t, b_t), V^i(s_t, k_t, b_t)\}$$

The value functions for the active and inactive case are given respectively by,

$$\begin{aligned}V^a(s_t, k_t, b_t) =& s_t k_t^{\alpha} - k_{t+1} + (1-\delta_k)k_t - \frac{\gamma}{2}\frac{(k_{t+1} - (1-\delta_k)k_t)^2}{k_t} \\ &- Fk_t + (1+r)b_t - b_{t+1} - \phi_t^{ext} + \zeta E_{s_{t+1}|s_t} V(s_{t+1}, k_{t+1}, b_{t+1}),\end{aligned}$$

and

$$V^i(s_t, k_t, b_t) = s_t k_t^\alpha - \phi_t^{ext} + (1+r)b_t - b_{t+1} + \zeta E_{s_{t+1}|s_t} V(s_{t+1}, k_t(1-\delta_k), b_{t+1})).$$

In the value function formulation above, ζ denotes the discount factor and E the expectation operator. One particular and important feature of the solution concerns the behavior of cash, b_t. In the simulation below we assume that $\zeta(1+r) < 1$ so that absent any cost in obtaining external funds the firm will never hold positive cash balances–equivalently it will always distribute profits to owners. In fact cash balances will always be set equal to zero in this case. With a premium for using external funds—as captured by the ϕ_t^{ext} function—the firm will find it optimal to save in order to reduce the future external finance cost when investing. Due to the nature of the capital adjustment cost the firm will typically invest sporadically and will accumulate cash in periods of low investment or inactivity.

2.2 Calibration and Model Solution

We apply value function iteration to solve the model. Therefore, the state and control variables have to be discretized over a certain interval. The size of the intervals is chosen in a way that the variables do not leave the state space during the simulations. The number of grid points per interval guarantees that the results are insensitive to a finer grid. We discretize the state space of k_t into 171 grid points, b_t into 9 points and s_t into 7 points. The process for the productivity shock is approximated as a first order Markov process using the method of Tauchen (1986). We form a guess for the value function, and based on the guess we find policy functions that maximize the value function. We use the maximized value function thus obtained and repeat the procedure until convergence is achieved.

The parameter values set for the calibration of the model are set as follows. The time period corresponds to a year. The risk-free rate is equal to 3.7%, corresponding to the annual average of the 3-month T-bill rate from 1986 to 2013. $\zeta = 0.965$. As explained above the choice of discount factor implies $\zeta(1+r) < 1$ in order for cash to be dominated in the case without costly finance. This can be thought of as a higher discount rate of firm owners relative to the market's discount rate. We set the external finance premium parameter, λ, equal to 8%, corresponding to the annual average Moody's BAA corporate bond yield over the 1986 to 2013 period. We set the capital share in production, $\alpha = 0.7$. This is a common value used for example in Cooper and Haltiwanger (2006) and others. The depreciation rate is set at 0.15. The adjustment cost parameters are set to the values reported in Cooper and Haltiwanger (2006), namely, $\gamma = 0.049$, $F = 0.039$. The persistence and standard deviation of the idiosyncratic cash flow shock are equal to 0.75 and 0.2 respectively.

We compute dynamics for variables of interest, that have a direct analog in the data, namely, the investment rate, cash, external finance over assets and cash over assets. The dynamics are displayed in a series of impulse response functions to cash flow shocks; they can be thought of as formalizing — from the lens of a model — the dynamics displayed in Figure 1.[5]

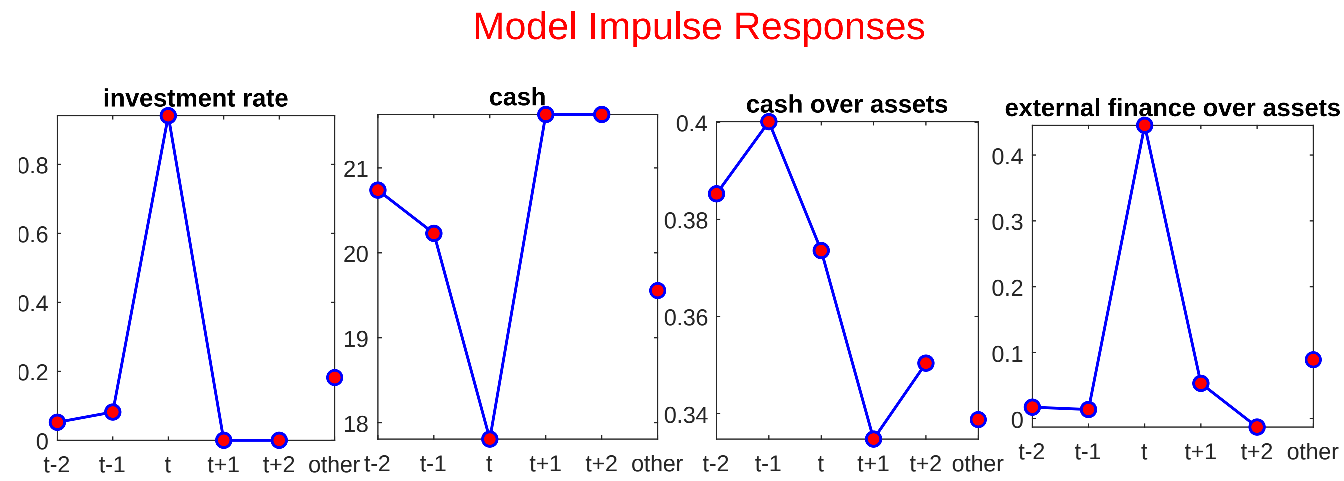

Figure 2: IRFs are computed as means over 12,000 replications corresponding to realizations of cash flow shocks. Each replication has 106 periods. We plot the last 5 periods of the simulation. The period t shock corresponds to the highest state in the shock grid space ($s_H = 2.47$). Finally, 'other' denotes the average value – over all replications and time periods – of each variable displayed above.

Figure 2 displays model-based impulse response functions (IRFs). The displayed IRFs are computed as means over 12,000 replications subject to cash-flow shocks, s_{jt}. For each of these replications,

[5]This stylized framework does not explicitly distinguish external finance between debt and equity. This does not qualitatively affect the outcome of the simulation and allows the model concept of external finance to have a flexible interpretation, either as debt or equity. The calibration of the external finance premium adopts a debt interpretation to the model concept.

we feed in the highest shock value ($s_H = 2.47$) in period t. This allows the model mechanism to trigger an investment spike. In addition, for each variable displayed, the Figure plots its average level and it is denoted as 'other'. This, similar to Figure 1, captures the average level of each variable outside this 5 period window. Investment rate rises modestly in periods $t-2$, $t-1$, followed by a large spike in period t when the firm experiences the highest value cash flow shock. Given the large expansion of capital, the investment rate reverts to zero after period t. The model is therefore able to generate the investment spike that we observe in Figure 1 above. Costly external finance implies the firm maintains high cash balances in preparation of a future investment opportunity. The preparatory role of cash is more clearly illustrated in the behavior of cash over assets. The latter are significantly elevated relative to 'other' in the periods preceding period t. Cash balances decline sharply in period t as the firm is using cheaper internal resources to finance the large expansion in operating capacity. Following period t, cash is accumulated rapidly and reaches a level that exceeds 'other'. This behavior is qualitatively similar, although the build up in cash in the model is more rapid, to the dynamics displayed in Figure 1. The dynamics of external finance (relative to assets) in Figure 2 is consistent with the creation of debt capacity; external finance relative to assets is below 'other' in the periods leading into the investment spike. This is followed by a large increase in external finance at the time of the spike, period t. This is due to the fact that the firm jointly uses internal and external finance to fund the investment spike. In sum, this stylized model generates dynamics consistent with a preparatory phase of building financial resources for the incipient capacity adjustment. Appendix D describes a model extension with employment. This extended framework provides some insight into the joint dynamics of capacity adjustment in capital and employment. Nevertheless, the simple model described here delivers the insight on the key mechanisms of adjustment in capital and finance in the presence of costly external finance.

In the next sections, we will empirically study firms' dynamics around investment spikes more systematically. This analysis will go beyond the illustrative example focusing on investment spikes and also study the firms' financing dynamics around lumpy adjustments in employment.

3 Data and Methodology

3.1 Data and definition of lumpy episodes

We use firm-level data from the Compustat (North-America) Fundamentals Annual Files. We focus on US 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.[6]

We examine four types of lumpy adjustment 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. 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).[7] 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.

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. Thresholds for positive (negative) types of adjustment are chosen so that approximately 20% of the observations in our dataset are above (below) the threshold.[8] This criterion implies that to qualify for a large positive adjustment in the capital stock the gross

[6] 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.

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

[8] This threshold is consistent with those applied in similar studies, e.g. Cooper and Haltiwanger (2006) and Gourio and Kashyap (2007). Our results are robust to reasonable variations in the thresholds. These results are available upon request.

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).[9]

We study three margins of finance, namely, debt, equity and cash. Our definitions for equity and debt follows Begenau and Salomao (2019). 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 as Cash and Short-Term Investments (CHE). Detailed information about variable construction and cleaning procedures is provided in Appendix C.

3.2 Empirical methodology: identifying dynamics around lumpy adjustment episodes

Our methodology, building on Sakellaris (2004), is flexible and rich in that it allows to study patterns in many firm level variables and to capture parsimoniously lead-lag relationships among them during lumpy adjustment episodes. 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

[9]Given the definition for a lumpy adjustment, which requires an observation to be below the threshold prior to a year with a realization above the threshold, not all observations above the threshold are classified as lumpy adjustments. This can e.g. be due to consecutive occurrences above the threshold. Appendix A provides details about the frequency of the different lumpy adjustments in our dataset, which ranges from 8% to 14%. This appendix also provides evidence on that firms adjust multiple production factors in a lumpy fashion relatively rarely in the same period or in consecutive periods. Our empirical results discussed in Section 4.1 are robust to excluding those episodes. We thank an anonymous referee who invited us to investigate the influence of joint occurrences on the dynamics of financial policies. Results are available upon request.

$k+2$. To identify dynamic patterns around lumpy adjustments, we estimate the regression,

$$X_{i,t} = \mu_i + \nu_t + \sum_{j=-2}^{+2} \beta_j \cdot ADJUSTD_{i,t}^{k+j} + \beta_{other} \cdot OTHERD_{i,t} + \varepsilon_{i,t}, \quad (8)$$

where $X_{i,t}$ is the variable of interest – for example the investment rate – for firm i in year t and μ_i and ν_t denote firm and year fixed effects. $ADJUSTD_{i,t}^{k+j}$ is a dummy variable which equals 1 if firm i experienced a lumpy adjustment in year $t-j$.[10] 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 that starts two years before and ends two years after the adjustment.[11]

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. Due to the inclusion of fixed effects, nominal coefficient magnitudes are not meaningful, whereas relative magnitudes are. $OTHERD_{i,t}$ is a dummy variable that equals 1 if and only if firm i has experienced at least one lumpy adjustment and $ADJUSTD_{i,t}^{j} = 0$ 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 adjustment window for firms that have experienced at least one adjustment episode. It therefore 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. We can therefore compare the behavior within the adjustment window with a variable's average level in normal times, as captured by $OTHERD$. Notice that equation (8) can be thought of as the analog of the IRF concept in the model presented in Section 2. It captures the dynamics of any variable of interest following agnostic shocks within the 5 year window. We do not identify the source of the shock in the empirical framework above, however as will become evident from the findings below, a natural

[10]We examine the responses to the four adjustments separately, so $ADJUSTD$ refers to the corresponding lumpy adjustment studied, namely SPIKE, DISINV, POSEG or NEGEG.

[11]Note, that we only consider lumpy adjustment episodes if variable $X_{i,t}$ has non-missing observations for all five periods of the adjustment window, $k-2$ to $k+2$, or at least for periods $k-1$ to $k+1$.

interpretation is cash flow shocks. Moreover, the richness of the data in combination with the flexibility of the empirical method allows us to examine employment adjustment margins.

3.3 Identifying a Control Group of Firms Not Undertaking Lumpy Adjustment

The patterns around a lumpy adjustment could potentially be influenced by other factors and characteristics not controlled for in our empirical specification. We therefore build a control group of firms that did not undertake lumpy adjustment. We use matching techniques to choose firms that are similar in key characteristics to those undertaking lumpy adjustment.[12] We compare the dynamic patterns estimated for the firms undertaking lumpy adjustment to those dynamic patterns estimated for the control group. If there are discernible differences in dynamic behavior between the two groups of firms we are confident our empirical specification has identified dynamic patterns related purely to lumpy adjustment episodes.

For each type of lumpy adjustment, we employ propensity score matching, using logit, to estimate a conditional expectation function serving as a measure of distance between firms. For a lumpy adjustment in year k of firm i, we identify the single best match by using nearest neighbor matching without replacement. This is the least biased, but simultaneously the least precise estimate of a counterfactual. We match firms by a number of key characteristics used in the literature. We use exact matching on the year of the lumpy adjustment. We use a firm's return on assets and log-leverage as a measure for financial efficiency to capture opportunities or necessities for an expansion or contraction. Log-sales is used as a measure for firm size.[13]

For every firm i that undergoes a particular type of lumpy adjustment in year k, we have identified a similar firm m in year k that does not feature this lumpy adjustment. We then have for each year k a cohort of firms that define the control group for that year. We examine firm specific variables

[12] For a review of these methods see Imbens and Wooldridge (2009).

[13] As is standard with nearest neighbor matching, the size of the data set limits the number of dimensions upon which one can match. Our results are robust also to considering other matching variables, e.g. if firm size is measured using the log of the number of employees.

in a five-year window around year k and pool the data across cohorts. If a firm undergoes any lumpy adjustment within this five year window, we drop this firm from the matched sample to avoid any potential influence of the lumpy adjustment in the matched sample. We use the regression specification in equation (8) on this sample of matched firms to generate dynamic patterns during a five-year window around year k. These dynamic patterns of the matched sample will be displayed in Section 4.1 as a counterfactual next to those dynamics of firms that undergo a lumpy adjustment.

Table 1 reports descriptive statistics that speak to the quality of the matching. We present those for each of the four adjustment categories among our baseline "lumpy adjustments" sample, the matched sample, and the "non-lumpy adjustments" sample of firms. The observations in "non-lumpy adjustments" are not part of lumpy adjustment episodes but do not belong to firms that have been matched with those in the "lumpy adjustments" sample. The variable means of the matched sample (line four) are much closer to the means of observations in lumpy adjustment episodes (line two) than to those of five-year windows without a lumpy adjustment (line three). This is also confirmed by t-tests for differences in means between adjusters and non-adjusters (line five), which are all significant with the exception of log sales for lumpy employment increases. In contrast, t-tests for differences in means between observations in adjustment episodes and those in the matched sample are insignificant in almost all cases (line six). After matching, only the means of return on assets for DISINV and NEGEG remain significantly different. Means of log sales for POSEG are significantly different only at the 5% level.

4 Results

4.1 Dynamic adjustment patterns

We display the results from the regression specified in equation (8) 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 adjustment. Each figure contains four graphs, one for each type of lumpy adjustment: 1) Investment spike (SPIKE), 2) Disinvestment (DISINV), 3) Positive employment burst (POSEG),

Table 1: Matching properties

	Log Leverage	Return on Assets	Log Sales	Log Leverage	Return on Assets	Log Sales
	Investment spike			**Large pos. employment adj.**		
all observations	0.116	-0.658	4.451	0.116	-0.066	4.451
lumpy adjustments	-0.046	-0.007	4.240	0.063	-0.016	4.450
non-lumpy adjustments	0.124	-0.687	4.462	0.120	-0.070	4.452
matched sample	-0.042	0.009	4.238	0.063	0.012	4.470
t-test (adjusters vs non-adjusters)	0.000	0.000	0.000	0.000	0.000	0.940
t-test (adjusters vs matched)	0.765	0.601	0.316	0.495	0.288	0.074
	Disinvestment spike			**Large neg. employment adj.**		
all observations	0.116	-0.066	4.451	0.116	-0.066	4.451
lumpy adjustments	0.144	-0.102	4.056	0.197	-0.088	4.502
non-lumpy adjustments	0.115	-0.064	4.470	0.109	-0.064	4.447
matched sample	0.149	-0.034	4.204	0.222	-0.038	4.462
t-test (adjusters vs non-adjusters)	0.000	0.000	0.079	0.000	0.000	0.026
t-test (adjusters vs matched)	0.754	0.023	0.956	0.213	0.001	0.263

Notes. The first four lines show population means. Rows five and six show p-values from t-tests of differences in means.

and 4) Negative employment burst (NEGEG). As mentioned above in the description of the methodology only relative coefficient magnitudes are meaningful. Therefore, we plot the difference of each estimated value β_j (for $j = -2$ to 2), as well as of β_{other} from β_0.

In the figures below, the x-axis label 'other' displays the difference of β_{other} from β_0. A positive value of 'other' therefore indicates that the level of the variable under scrutiny, in year 'k', is below its normal level, and a negative value indicates that the level of the variable under scrutiny, in year 'k', is above its normal level.

For each of the point estimates we also display ± 1.645 standard error bars associated with the corresponding β coefficient. This 90% confidence band serves as a metric of whether the differences between the βs are significant. Throughout the study, we define economic significance whenever coefficients differ by at least 1.645 standard error.

Each graph displays two sets of dynamic patterns around the adjustment window. The first set refers to the sample of firms that undertakes lumpy adjustment. The second set refers to the control group that has not undertaken lumpy adjustment.

4.1.1 Lumpy adjustments and firms' finance margins

We first study the dynamic behavior of cash, leverage, and debt around lumpy adjustments. The analysis suggests that finance margins adjust in a meaningful way and with a distinct preparation phase ahead of the lumpy adjustment in capital or employment. Figure 3 displays cash balances relative to total assets. In positive adjustment episodes, firms rapidly accumulate cash in year 'k-1'. Following the adjustment, in years 'k' to 'k+2', cash-to-assets declines gradually and returns to normal levels. The cash dynamics suggest a deliberate action in anticipation of the lumpy adjustment. In negative adjustment episodes, the pattern is largely symmetric, although the return to normal cash-to-asset ratios is slower compared to positive episodes. The dynamic pattern we identify for negative adjustments suggests that sales of capital and the reduction in employment contributes to rebuild the balance sheet. Importantly, the dynamic responses of the control group show none of the described patterns as movements are insignificant around year 'k'.

Our results suggest that 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. The dynamic pattern of cash is consistent with the dynamic pattern predicted by the model in Section 2 where costly external finance incentivizes firms to actively manipulate valuable internal resources to finance lumpy investment.[14]

Figure 4 corroborates the pattern of cash adjustment displayed in Figure 3. The growth rate of cash is higher for lumpy capital expansions in year 'k-1' compared to 'other' and then drops further in years 'k' and 'k+1'. Also for positive lumpy employment adjustments, the years leading to the adjustment exhibit a substantially higher growth rate than years 'k+1' and 'k+2'. For both negative lumpy adjustment episodes the growth rate of cash drops off substantially in the year leading to year 'k' and then slowly recovers in subsequent years, although it falls short of 'other' periods. Again the comparison with the dynamic behavior of the control group (orange lines) provide confidence that the identified dynamics are causal and the preparation phase of cash adjustment is a meaningful

[14] Appendix D displays an array of IRFs that have a direct analog to those estimated from the data.

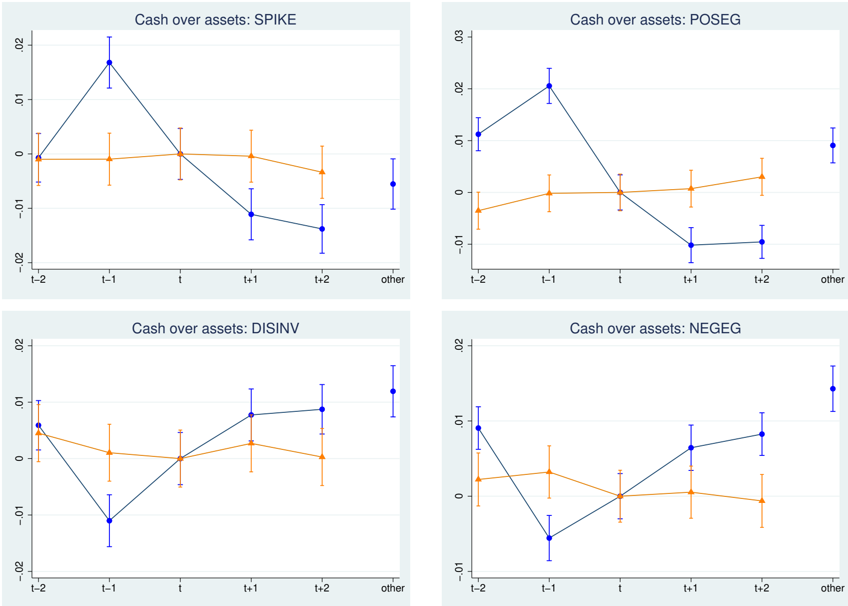

Figure 3: Behavior of cash over contemporaneous assets around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

decision.[15]

Figure 5 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 of equity. 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. Therefore in expansions firms start with plentiful debt capacity, which they use freely to expand physical assets. For negative adjustments, leverage rises substantially to levels higher than 'other' up to period 'k'. The sale of capital, or the reduction in the number of employees, then contributes to a decline in leverage in the following years. The lumpy contractions,

[15] An alternative explanation for the increase in cash before an expansion episode is given by a Jensen (1986) agency framework. In the run-up to lumpy expansions firms are performing well as evidenced by the pattern in profitability (see Figure 11). The firm manager, who is interested in 'building an empire', would retain the free cash flow in order to invest in possibly unproductive projects. In this theory, the financial situation drives the investment decision rather than the other way around. This hypothesis is, however, inconsistent with the behaviour of TFP in Figure 12. We would expect that TFP under this hypothesis will be flat or even falling during the expansion episode.

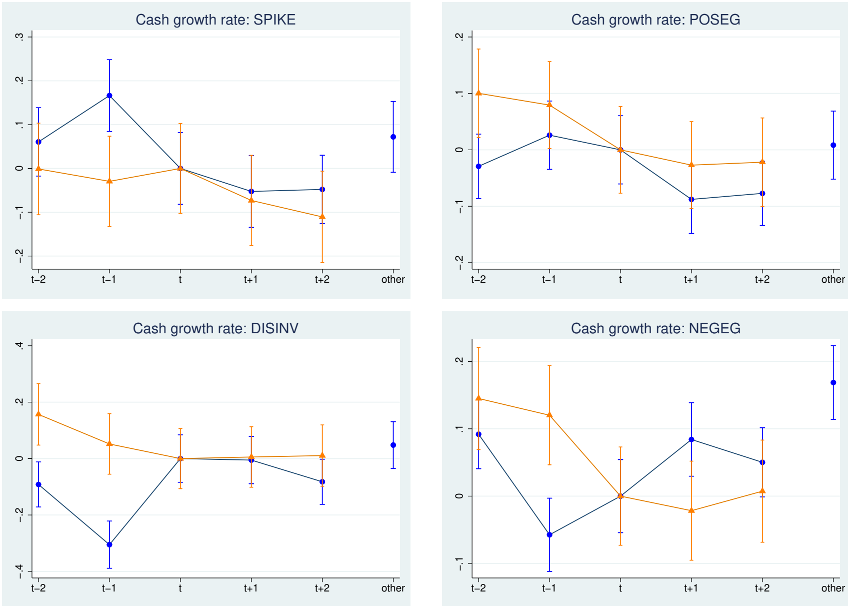

Figure 4: Behavior of growth rate of cash around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

undertaken in situations with leverage significantly above normal levels, rebuilds firms' debt capacity. Interestingly, the reversion of leverage to the level of 'other' is quite slow, as firms are still way above 'other' even two years following the adjustment.

Figure 6 displays the behavior of book leverage, i.e. debt over assets. The patterns identified above for market leverage are qualitatively very similar for book leverage. This further corroborates our argument that firms actively seek to create debt capacity in preparation and during lumpy adjustments. This is consistent with the dynamics predicted by the model in Section 2. This is corroborated by the fact that in Figures 5 and 6 the dynamic patterns of the control group show largely insignificant movements over the entire five year window. Therefore, during expansion episodes firms have unused debt capacity before and even during the episode. This finding combined with the preparatory behavior of cash documented above, suggests that firms use the latter to further increase their financial capacity and it is informative in that it suggests that the tax dis-advantage of cash relative to debt is outweighed by the option value to retain financial flexibility, i.e. the ability to access capital markets at a low cost. The fact that firms de-cumulate cash balances once the expansion is underway is evidence that firms value financial flexibility. This option value could reflect a need to reduce reliance on costly external finance, avoid debt issuance costs, or alternatively because of managerial fears for distress costs associated with high leverage.[16] During contractionary adjustments, undertaken to renew financial capacity, we observe a similar interaction of cash and debt. The increase in cash and reduction in debt contributes to firms' rebuilding their balance sheets.

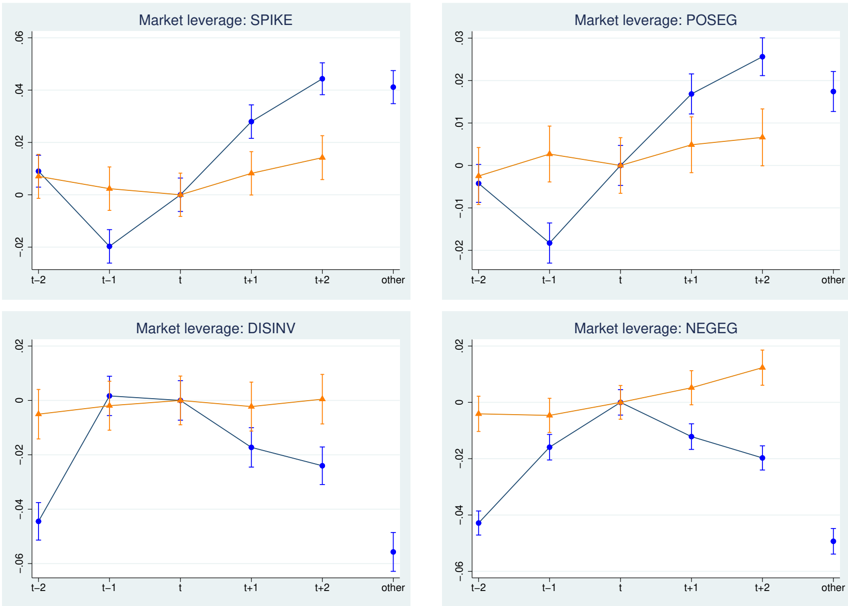

Figure 5: Behavior of market leverage around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

We have also examined the behavior of net equity issuance around lumpy adjustments. The dynamic patterns for lumpy adjustments indicate that net equity issuance is not a major source of finance; in Appendix B.1 we show that net equity issuance during lumpy adjustment is persistently below normal levels. In sum our empirical findings suggest the significant relevance of debt (leverage) and cash as the key margins in lumpy capital and employment adjustment.

Appendix B.2 examines the robustness of the dynamics identified above when we group firms with different initial financial resources and different size distributions one year before the lumpy

[16]Gamba and Triantis (2008) show that firms value financial flexibility in their capital structure for reasons associated with distressed costs, costly external finance among others.

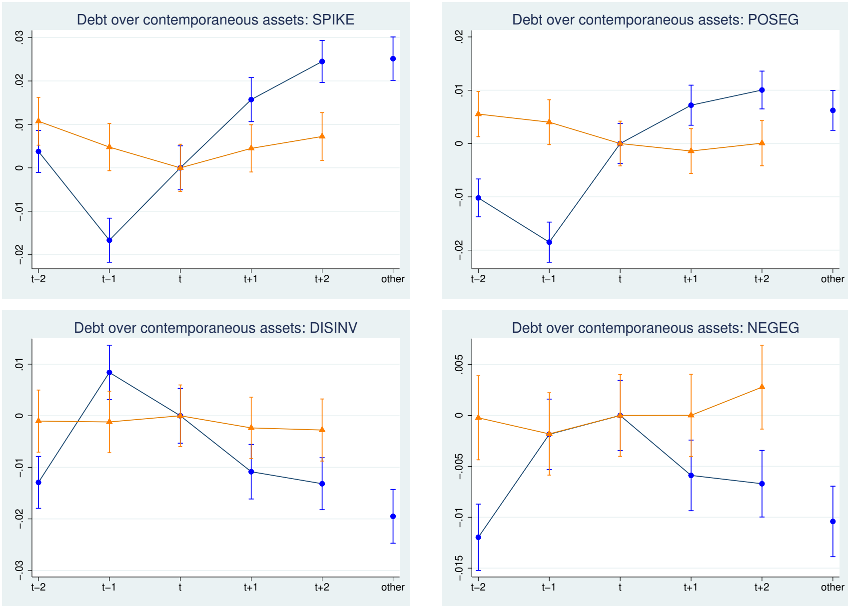

Figure 6: Behavior of book leverage around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show ±1 coefficient standard error. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

adjustment. Our goal is to assess whether the preparation phase in finance is conditional on firms having plentiful or scarce financial resources or if it varies conditional on size. For example, firms with low market leverage may not need to build up cash balances as they, in principle, have plentiful debt capacity to finance the real adjustment and cash is expensive relative to debt.[17] In sum our main findings are robust to the different sortings of fimrs we have examined. We now turn to examine the relative quantitative importance of the different finance margins in lumpy episodes.

4.1.2 Lumpy adjustment in productive assets

Figures 7 and 8 are based on the econometric setup introduced in section 3.2 and display the behavior of investment rates, and employment growth, in each of the four lumpy adjustment episodes. Both

[17]We sort firms according to: i) market leverage, (ii) cash over assets, and (iii) size (measured by total assets). The reference period for this sorting is the year before the adjustment ('k-1'). We distinguish four parts of the respective distributions: 0-33%, 34-66%, 67-90%, and top 10%. We compute the dynamic plots by re-estimating the regression in equation (8) and conditioning on the criteria described in (i), (ii), and (iii), for a total of twelve different regressions.

variables rise (fall) sharply on the year of the positive (negative) adjustment, 'k', and return to normal levels (captured by 'other') only gradually. The dynamics around year 'k' are economically significant relative to the average behavior outside this window, i.e. 1.645 standard error variation in β_0 falls short of this variation in 'other', which captures the difference between β_0 and β_{other}. Moreover, the dynamic patterns suggest that lumpy adjustments, especially in capital, take time to complete. Again, in comparison to these described patterns, the dynamic patterns observed for the control group are largely insignificant or go even in the opposite direction, as e.g. for POSEG in Figure 8. Overall, the dynamic patterns of adjustment are 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 that smooth out part of the adjustment.

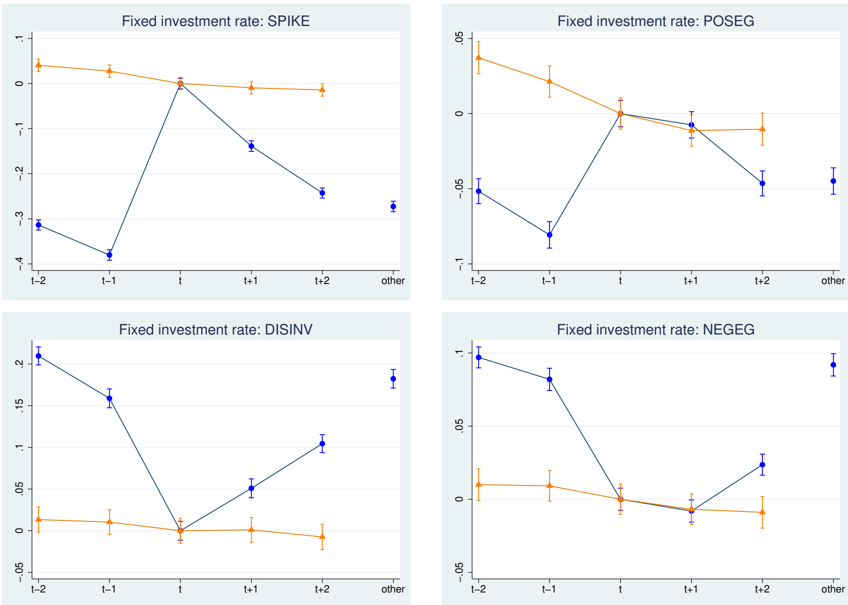

Figure 7: Behavior of fixed investment rate around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

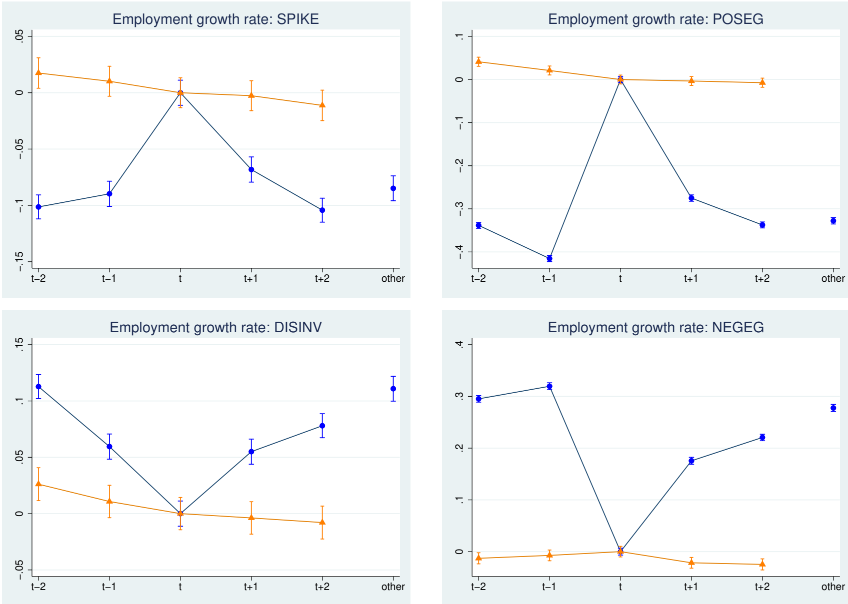

Figure 8: Behavior of employment growth rate around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

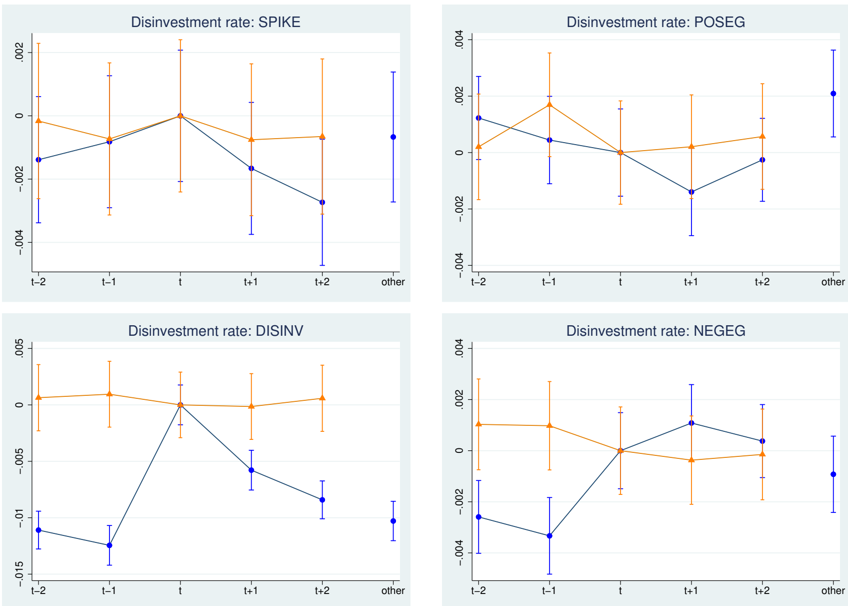

Figure 9: Behavior of fixed disinvestment rate around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

4.1.3 Dynamics of Tobin's Q, profitability, TFP, and sales

We examine the dynamic behavior of variables capturing firm fundamentals. We focus on Tobin's Q, operating income before depreciation, total factor productivity (TFP), and sales growth.[18]

Figure 10 displays the behavior of Tobin's Q. We first focus on the behavior of firms undergoing lumpy adjustment, which is shown using the blue lines.[19] At times of expansions (i.e. SPIKE and POSEG at time 'k'), Tobin's Q is high relative to normal levels (captured by 'other'). Importantly, Tobin's Q is already significantly elevated in year 'k-1' for capital SPIKES, compared to normal periods, providing an early indicator of favourable investment opportunities. Throughout the five-year windows of negative lumpy adjustments, Tobin's Q is significantly lower compared to normal periods. It declines towards the adjustment year 'k' after which it slowly rises. Next, we examine whether the dynamics of Tobin's Q in the matched sample (orange lines) tell a similar story. Looking at episodes of expansions in the capital stock and employment, the control group shows a very different pattern. Tobin's Q falls over the entire five year window, albeit, in comparison to period k, this decline is not economically significant. While lumpy expansions are undertaken at times of elevated Tobin's Q (relative to normal times), no such pattern can be detected in the control group of firms who don't adjust in a lumpy fashion.[20] For lumpy contractions (i.e. DISINV and NEGEG), changes in Tobin's Q are largely insignificant for the control group, relative to time k, over the adjustment window.

Figure 11 displays the behavior of operating income before depreciation (EBITDA) over lagged total assets. The shape of these dynamic plots are similar to those of Tobin's Q discussed in Figure

[18]Details about the definition and construction of all variables are available in Appendix C.

[19]In presence of non-convex adjustment costs, financial frictions or market power, the one-to-one relationship of the Hayashi (1982) framework of Tobin's Q and the firm's optimal capital accumulation schedule does not hold. However, Tobin's Q continues to provide information about future investment opportunities (see e.g. Abel and Eberly (1994), Barnett and Sakellaris (1998) and Hennessy et al. (2007)).

[20]It is important to state that due to fixed effects, comparisons across different lumpy adjustments are not meaningful quantitatively. The same also holds for quantitative comparisons between the dynamic patterns based on the "lumpy-adjusters" and the matched sample. What is quantitatively meaningful though is the comparison of outcomes at k-2,...,k+2 and 'other' for a particular type of adjustment.

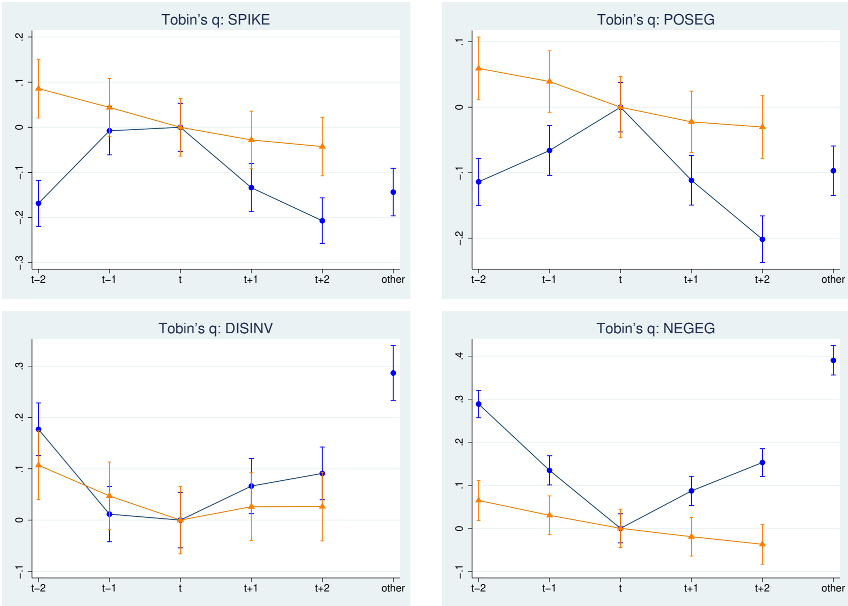

Figure 10: Behavior of Tobin's Q around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

10 above. It is worth emphasizing that for both types of lumpy expansions, EBITDA is already significantly elevated both in year 'k-2' and 'k-1' and the indicator remains elevated for the years following the adjustment year. Therefore, firms experience a persistence rise in profitability, compared to normal times (captured by 'other'), and the latter anticipates the expansion in capital and employment. This is interesting insofar as it provides evidence that profitability is leading the incoming expansion, rather than just tracking it, and corroborates the evidence on the prognostic ability of Tobin's Q. For contractions, from periods 'k-2' to 'k', profitability declines substantially to just below normal levels (for DISINV), or shows a decline (for NEGEG) that is not economically different from normal times as indicated by the standard errors. In contrast, the dynamic patterns of the control group are very different, as they are largely economically insignificant relative to period k.[21]

Figures 12 and 13 display the behavior of log TFP and the growth rate of sales. These variables display dynamics largely similar to profitability and Tobin's Q (see Figures 10 and 11). Specifically,

[21]Note that for the matched sample, we do not show an estimate for 'other' as this sample only consists of periods corresponding to the five year windows.

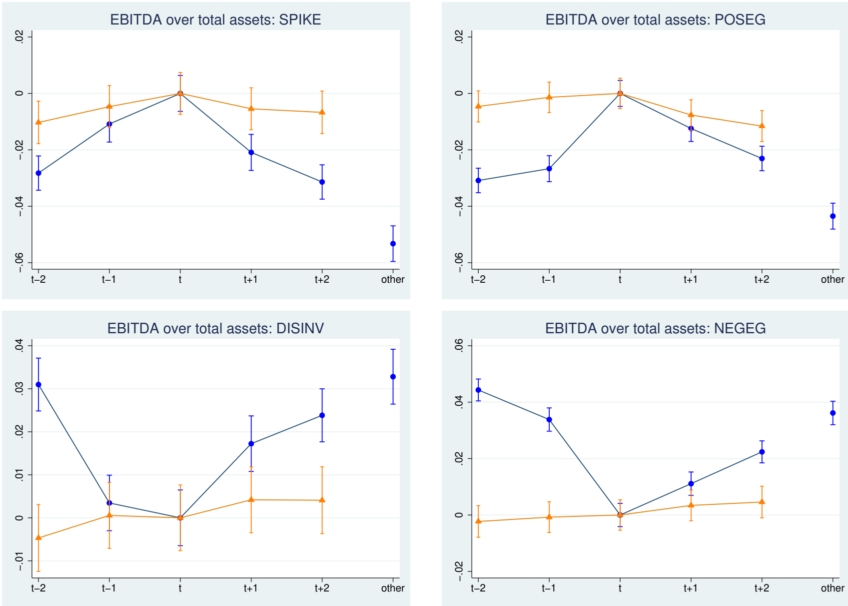

Figure 11: Behavior of EBITDA over total assets around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

they display a hump-shaped (inverted hump-shaped) behavior for positive (negative) adjustments centered on the year of adjustment. Movements in TFP can be a force as well as a consequence of lumpy adjustment. For capital and employment expansions TFP is substantially elevated, relative to normal years, in the years preceding the adjustment. This is consistent with the notion that the lumpy factor adjustment is due to surprise or anticipated shocks to TFP. At the same time TFP displays an (inverted) hump-shaped pattern during positive (negative) adjustments; this dynamic is consistent with earlier evidence that points to TFP declines following an investment spike.[22] The TFP and sales growth dynamics corroborate the evidence on the prognostic ability of Tobin's Q and profitability indicators displayed above. In contractions, relative to normal times, sales growth is persistently below the normal 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

[22]Huggett and Ospina (2001) provide evidence from the Colombian manufacturing sector, while Sakellaris (2004) provides evidence from a sample of US Manufacturing plants. The inverted hump shaped is probably likely due to firm adjusting its capacity utilization using margins that are not captured in the production function estimation.

year. These patterns are materially different when considering the control group which displays a flat pattern which is mostly insignificant relative to year 'k'.

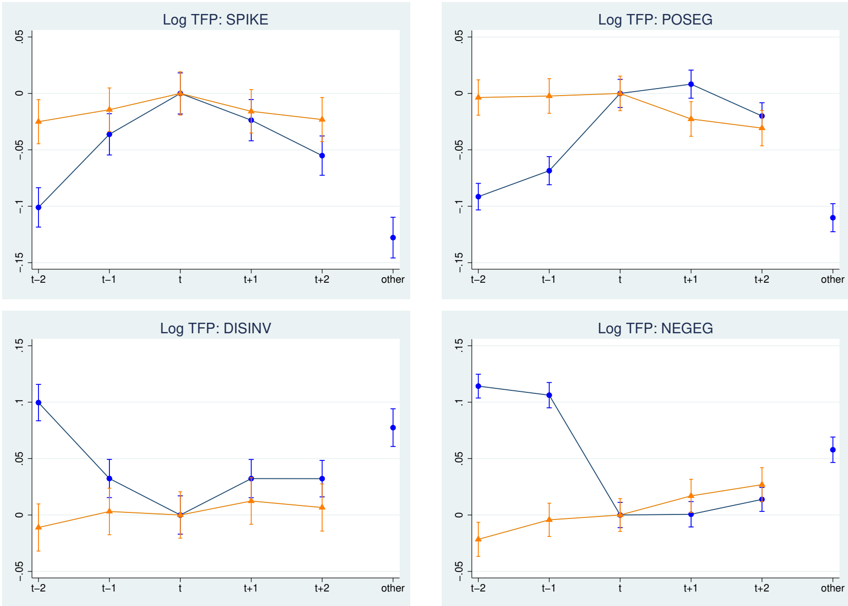

Figure 12: Behavior of log TFP around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

The evidence above suggests that profitability, and Tobin's Q are important leading indicators for lumpy adjustment in capital and employment, especially for expansions. These dynamic patterns are consistent with persistent profitability shocks that signal investment opportunities. And our findings suggest that innovations to fundamental variables are informative for future fundamentals in a way that makes the lumpy adjustment largely anticipated.

4.2 Quantifying finance margins during lumpy adjustments

In this section we quantify the importance of finance margins to complement the dynamic analysis of section 4.1. For this part of the analysis we incorporate equity as a potential finance margin to obtain a precise answer of the quantitative relevance of different margins. With equity in the mix firms can adjust finance margins via positive and negative changes in cash, debt or equity, respectively. For each firm-year observation we evaluate whether one of the six margins dominates the others. We

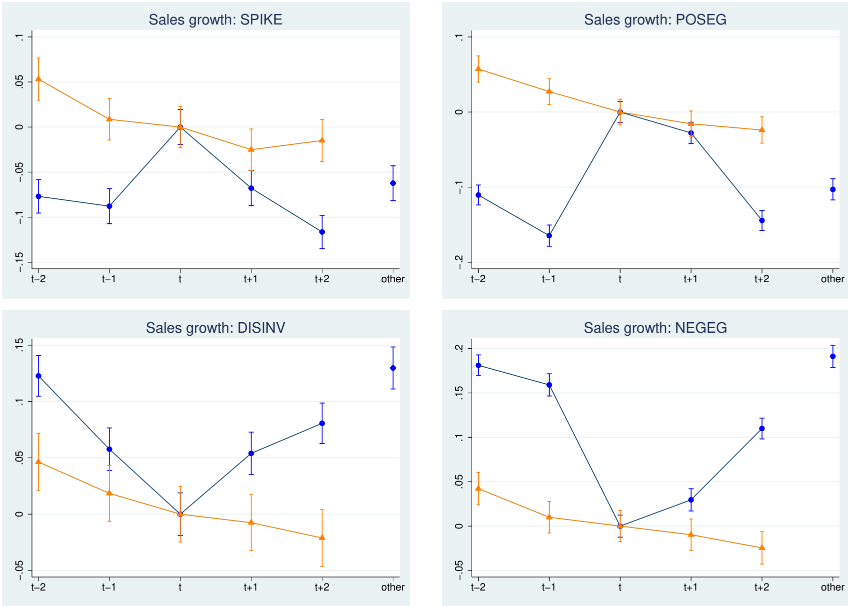

Figure 13: Behavior of the growth rate of sales around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

define such dominance when the absolute adjustment in one of the finance margins accounts for at least 50% of the sum of the absolute adjustment of all margins. For example, we consider an increase in cash balances to be the dominant margin of finance, if it accounts for more than half of the sum of the absolute values of changes in cash and in debt, as well as equity issuance.

We consider movements in the finance margins described above in years 'k-1' and 'k' of the adjustment window, motivated by the preparatory role of cash and debt documented above. Tables 2 and 3 report the share of firm-year observations for which one of the six financing margins plays a predominant role (as defined above). 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).[23] Overall, summing the shares of the most important three dominant margins reported in the tables indicates that these account for about over two thirds of all lumpy episodes. There is a relatively small number

[23]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.

of adjustment episodes that do not have a dominant finance margin. For the bottom 90% (top 10%) of firms the share of SPIKE, DISINV, POSEG, NEGEG adjustments that do not have a single dominant margin is approximately equal to 10% (20%).

Preparatory financing phase ('k-1') around expansions. Table 2 shows that 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. Debt reduction, which makes room for debt capacity, is the dominant margin in 23% of all SPIKE adjustments for smaller firms and 20% of all SPIKE adjustments for very 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. In sum, across all expansion episodes and for both the 90% and 10% size distribution of firms cash accumulation and debt reduction are dominant in almost 50% of the sample of lumpy adjustments, highlighting the fact that they are used very frequently as the preferred financial policy. Importantly, Table 2 demonstrates that cash reductions (not just slower cash accumulation relative to assets)—are a vital finance margin in a large number of expansionary episodes. Similarly, debt reductions in the preparatory year make room for additional debt capacity which is then used during the adjustment year.

A notable difference between small and large firms is that in employment bursts, negative equity issuance becomes a dominant margin for large firms in a high proportion (32%). Consistent with the evidence on dynamic patterns in B.1, equity issuance (positive or negative) does not feature among the top three most observed financing margins for the bottom 90% of firms.[24] Overall, Table 2 highlights the fact that the qualitative patterns documented through the dynamic analysis in the sections above are of quantitative significance.

Adjustment year ('k') during expansions. For smaller firms, the most observed margin during year 'k' is debt accumulation accounting for 37%, and 39% of adjustments in SPIKE, and

[24]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.

POSEG episodes respectively. Cash reduction in year 'k', is the second most observed margin where it accounts for 21%, and 19% in SPIKE, and POSEG 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 very large firms, the dominant margin in over 50% of positive adjustments is debt accumulation. Cash reduction is not as dominant as it is for smaller firms, being dominant in a significantly lower proportion of positive employment episodes compared to smaller 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 very large firms as compared to smaller firms. As in Covas and Den Haan (2011), this finding suggests that very large firms may be substituting equity for debt during the adjustment year of lumpy expansions. Our analysis, relative to Covas and Den Haan (2011), unearths 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. Yet, there is some heterogeneity present in that we also have episodes where there are a non-negligible number of firms which reduce debt, both in years 'k-1' and 'k'. Cash reductions are also prevalent in either lumpy adjustment margin and both at times 'k' and 'k-1'. For the largest 10% of firms negative equity issuance is the most observed margin 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.

A recurring finding across contractionary and expansionary episodes is that equity issue as a margin of financial adjustment plays an important role for the largest 10% of firms, but is much less relevant for smaller firms. In this dimension, our findings complement those in Covas and Den Haan (2011). There are several possible explanations for the importance of equity as a financing margin for only the largest firms and we briefly mention three of these. In the model of Myers (1984) and Myers and Majluf (1984), asymmetric information between managers and investors about risky securities leads managers to forgo financing profitable investments through equity issuance but rather through internal funds or debt. This pecking order may not be applicable for large firms if asymmetries of information are less severe than for smaller ones. A second possible explanation is that agency problems may be stronger in large firms leading their managers to ignore equity issuing costs (Jung et al. (1996)). A final hypothesis is within the dynamic tradeoff model of DeAngelo et al. (2011), that argues that firms want to preserve financial flexibility and avoid issuing debt that may result in distress and prevent them from exercising future investment options. If for some reason large firms are more concerned about preserving financial flexibility, they would resort more to issuing equity than smaller firms.

In sum, the main differences in the financing patterns across the size categories are: 1) relatively more smaller firms use the cash margin in the preparation year 'k-1' of the adjustment, supporting the view that costly external finance makes firms actively manipulating cash in anticipation of a lumpy adjustment, and 2) relatively more of the largest firms use the equity issuance margin before and during the lumpy contraction episode.[25] The results in this section complement and support the dynamic analysis, in that the dynamic patterns identified around lumpy capacity adjustments are of quantitative importance.

5 Conclusions and Implications

This is the first paper, to our knowledge, that studies the firm-level joint dynamics of financing margins and lumpy adjustment in both employment, and in capital. We employ a rich and flexible empirical methodology that enables the identification of important and novel dynamic relationships among financing margins, profitability and productivity indicators, and productive assets. We iden-

[25]We have decomposed the movements in equity issuance within all episodes described in Tables 2 and 3 and found, using the same definition of dominance as above, that dividend payments, not share repurchases or issuance, are the dominant component driving movements in equity issuance for large firms in both expansions and contractions.

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 3 other margins	0.34		0.27	Sum of 3 other margins	0.34		0.27

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 3 other margins	0.35		0.18	Sum of 3 other margins	0.29		0.20

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 3 other margins	0.29		0.23	Sum of 3 other margins	0.29		0.30

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 3 other margins	0.20		0.17	Sum of 3 other margins	0.17		0.17

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.

tify systematic patterns in the movements of different finance margins. Lumpy adjustment in capital and employment is preceded by a finance preparatory phase with large and meaningful movements in cash and debt. The timing of these movements coincides with significant innovations in profitability and productivity indicators and the latter serve as leading indicators of the incoming lumpy adjustments. During lumpy adjustment episodes, cash balances play an important and complementary role that facilitate the creation of debt capacity. Prior to lumpy expansions, cash gets accumulated and leverage declines. This 'dry powder' gets used up during the adjustment and up to two years afterwards as cash balances go down and leverage is increased towards normal levels. In lumpy contraction episodes, firms start with impaired financial resources and attempt to restore them to normal levels. Firms undergoing employment reductions have more impaired financial health than firms undergoing disinvestment. The process of rebuilding financial resources is protracted and is not complete two years after the adjustment episode.

The empirical findings are informative as they can guide micro-foundations in models at the intersection of macroeconomics and corporate finance and in particular in models that study lumpy adjustment. We can draw two broad implications stemming from our findings. First, models that attempt to jointly study real and financial decisions should seriously consider cash and debt as two distinct finance margins that do not offset each other, but are complements in the finance of the lumpy adjustment. Our findings suggest that cash should be treated as an important financial asset that allows firms to build financial flexibility, either because they have an incentive to avoid costly external finance or because of managerial fears (and distress costs) of high leverage. Recent evidence by Giroud and Muller (2021) suggest leverage cycles are associated with boom-bust employment growth cycles. In future work it will be interesting to examine whether financial flexibility conferred by cash can mitigate those cycles. Gamba and Triantis (2008) emphasize the additional value to financial flexibility conferred by cash when the latter saves on future debt issuance costs. An equally appealing interpretation of our findings is the precautionary demand for cash seems to be an important motive to meet possible future funding needs. Our findings also imply that as cash resources are very valuable to firms preparing to finance a lumpy adjustment the design of policy stimulus should focus on the availability of immediate cash flows to facilitate such adjustment. This is consistent with the evidence in Zwick and Mahon (2017) who find stronger responsiveness of investment when bonus depreciation allowances generate readily available cash resources and when applied to a cross section of firms with low cash holdings. Second, our findings suggest that persistent innovations in profitability and Tobin's Q are prognostic for future market opportunities and anticipate the incipient adjustment. This is consistent with the view that firms possess advance and valuable information about growth opportunities. It therefore seems natural to introduce richer information sets–in the form of anticipated shocks–that incorporate advanced firm specific information about market opportunities when firms make decisions to invest in productive assets. Recent macro models that emphasize the importance of lumpy investment for aggregate dynamics–as in recent work by Winberry (2021), Koby and Wolf (2020)–study dynamics following contemporaneous shocks and will be interesting to explore the implications of anticipated shocks in the TFP process (see e.g. Görtz and Tsoukalas (2017) and Görtz et al. (2022)) or forecast error and noisy information (see e.g. Görtz and Yeromonahos (2022) and Botsis et al. (2021)).

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Supplementary Appendix (not for publication)

A Basic statistics about lumpy adjustments

Thresholds for positive (negative) types of adjustment are chosen so that approximately 20% of the observations are above (below) the threshold. However, the actual lumpy episodes considered occur with a lower frequency. The reason is that for a lumpy episode to be classified as such, we impose the target variable (e.g. the investment rate) in year k to be above the threshold and to be below the threshold in year $k-1$. This implies that e.g. of consecutive high investment rates that are above the threshold, only the first one would be classified as a lumpy adjustment episode. It has been documented in the literature that investment projects often take multiple years to complete and this is also confirmed by the dynamic plots showing the investment rate, Figure 7, where the investment rate remains substantially elevated above normal levels also in year $k+1$. Table 4 shows the occurrence of lumpy episodes as share of observations that can potentially be classified as lumpy episode.

Table 5 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 21.8% of the times, and sales of the capital stock coincide with lumpy reductions in the number of employees in 22.1% of the cases. It is much less frequent that a contractionary episode coincides with an expansionary episode in another margin.

Table 6 reports the joint occurrence of *dynamic* lumpy adjustment episodes in our sample. In particular, this table shows the probability of an adjustment in a column conditional on an adjustment in a row occurring in the preceding period. For example adjustments in the capital stock occur relatively rarely directly in the period after a lumpy adjustment in either employment margin. In the period after POSEG (NEGEG), the probability of a SPIKE is only 8.6% (5.2%) and the probability of DISINV is only 4.6% (9.1%).

Table 4: 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 5: Joint occurrence of lumpy adjustment (in percent)

	SPIKE	DISINV	POSEG	NEGEG
SPIKE	100.0	0.0	23.3	7.3
DISINV	0.0	100.0	5.3	22.9
POSEG	15.6	3.3	100.0	0.0
NEGEG	4.2	11.8	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.

Table 6: Dynamic joint occurrence of lumpy adjustment (in percent)

	SPIKE	DISINV	POSEG	NEGEG
SPIKE(-1)	0.0	4.6	10.3	12.2
DISINV(-1)	3.8	0.0	10.1	11.1
POSEG(-1)	8.6	4.6	0.0	17.3
NEGEG(-1)	5.2	9.1	13.4	0.0

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

B Additional evidence on dynamic financing patterns

B.1 Equity Issuance

Figure 14 shows the dynamic patterns of equity issuance scaled by total assets around lumpy adjustment episodes. For lumpy expansions in the capital stock and employees, equity issuance increases towards time 'k', yet it is still substantially below normal levels. For negative adjustments, equity issuance relative to assets drops below normal levels and reaches a trough at time 'k'. These patterns suggest equity issuance is not a major source of finance for lumpy adjustments.

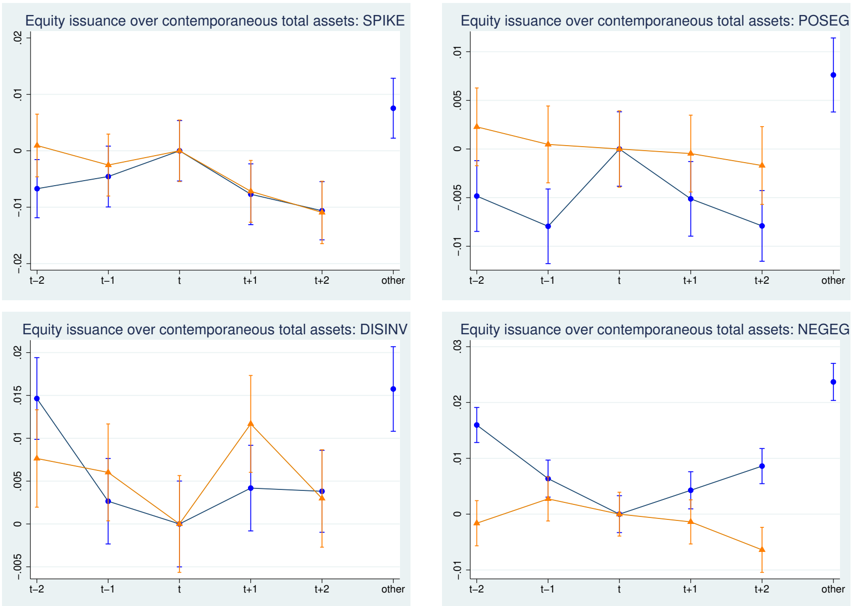

Figure 14: Behavior of equity issuance scaled by contemporaneous total assets around lumpy adjustment episodes: (1) investment spike (top-left), (2) positive employment burst (top-right), (3) disinvestment (bottom-left), (4) negative employment burst (bottom-right). Error bars show 90% confident bands. Blue lines show the dynamic pattern based on the sample with lumpy adjusters. Orange lines show patterns based on the matched sample of non-adjusters.

B.2 Sorting firms by financial position and size

We discuss the dynamic financing patters when we sort firms according to the three criteria described in section 3.1, namely, i) market leverage, (ii) cash over assets, and (iii) size. For each of these sortings we estimate equation (2) and plot the dynamics of cash-to-assets and leverage. When we condition the analysis according to the position of market leverage in the year preceding the adjustment, 'k-1' we observe the following. The dynamic pattern of cash-to-assets in Figure 15 is remarkably similar across firms and consistent with Figure 3. In positive episodes firms increase cash-to-assets significantly above 'other' and reduce cash-to-assets as the expansion unfolds. The exception is firms that belong to the top 10% of leveraged firms, where despite the increase in year 'k-1' their cash-to-assets is below 'other' throughout the positive adjustment. For negative episodes cash-to-assets declines in year 'k-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 16 displays the behavior of market leverage. It is interesting to see that in positive adjustments firms behave broadly similar in terms of creating debt capacity. They all reduce leverage in year 'k-1' and slowly increase it thereafter. Firms in the top 10% of the distribution 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, 'k-1', we observe the following. In Figure 17, 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 part of the distribution behave broadly similar to the behavior we have documented in Figure 3. It is remarkable that even firms that are cash rich seem to prepare for positive adjustments in year 'k-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 'k-1' for capital contractions. Figure 18 displays the behavior of market leverage. For positive episodes, the dynamic behavior of leverage is remarkably similar to the behavior discussed in Figure 5 — 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 5. 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 19 displays the dynamics of cash-to-assets for firms sorted on different size. For positive adjustments cash-to-assets behaves qualitatively similar for different firm sizes and is consistent with the dynamic behavior observed in Figure 3. The dynamics of cash-to-assets are also similar for negative employment episodes, 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 20 demonstrates that smaller and very 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.

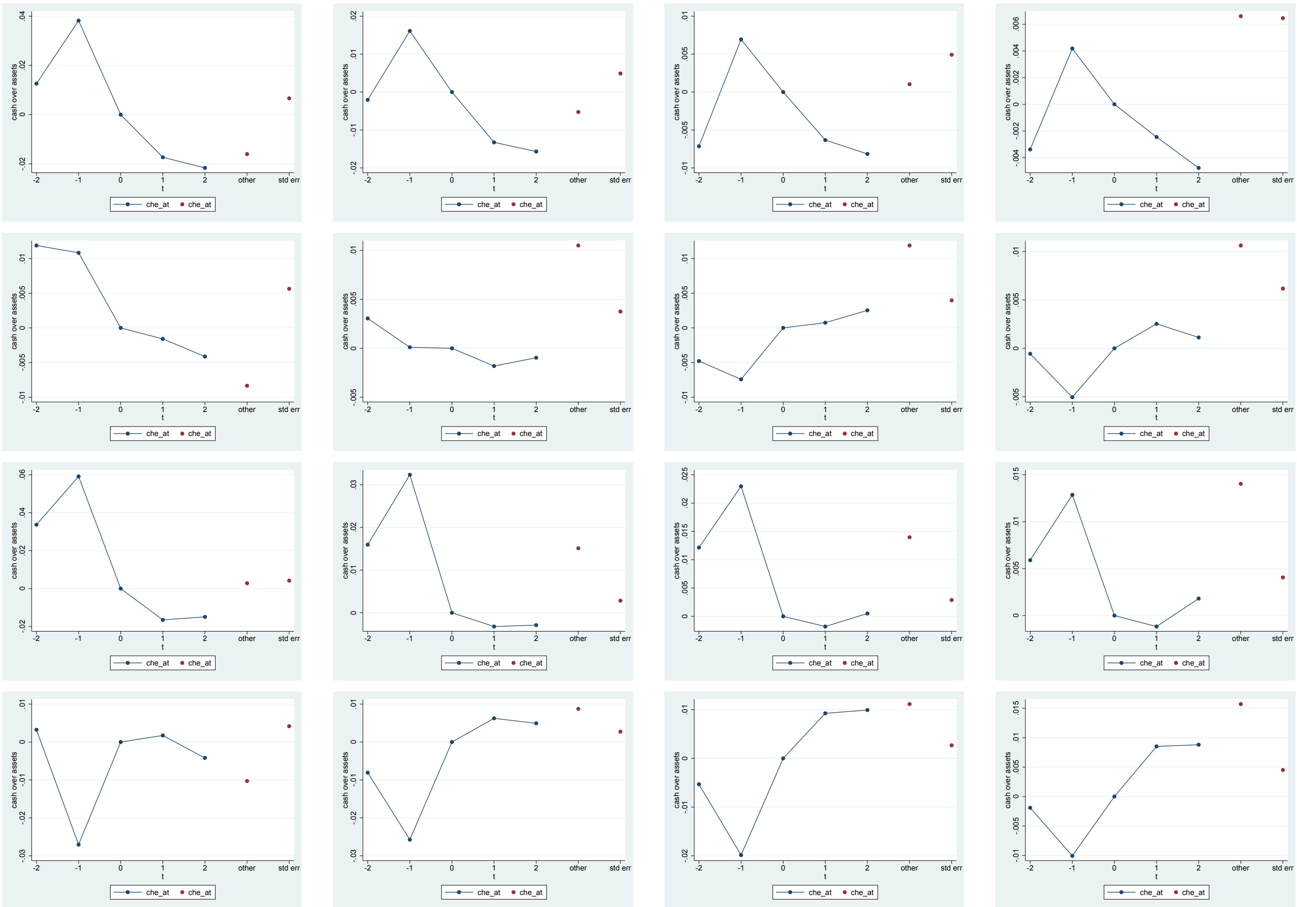

Figure 15: Behavior of cash over contemporaneous assets around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to market leverage at window position t-1,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

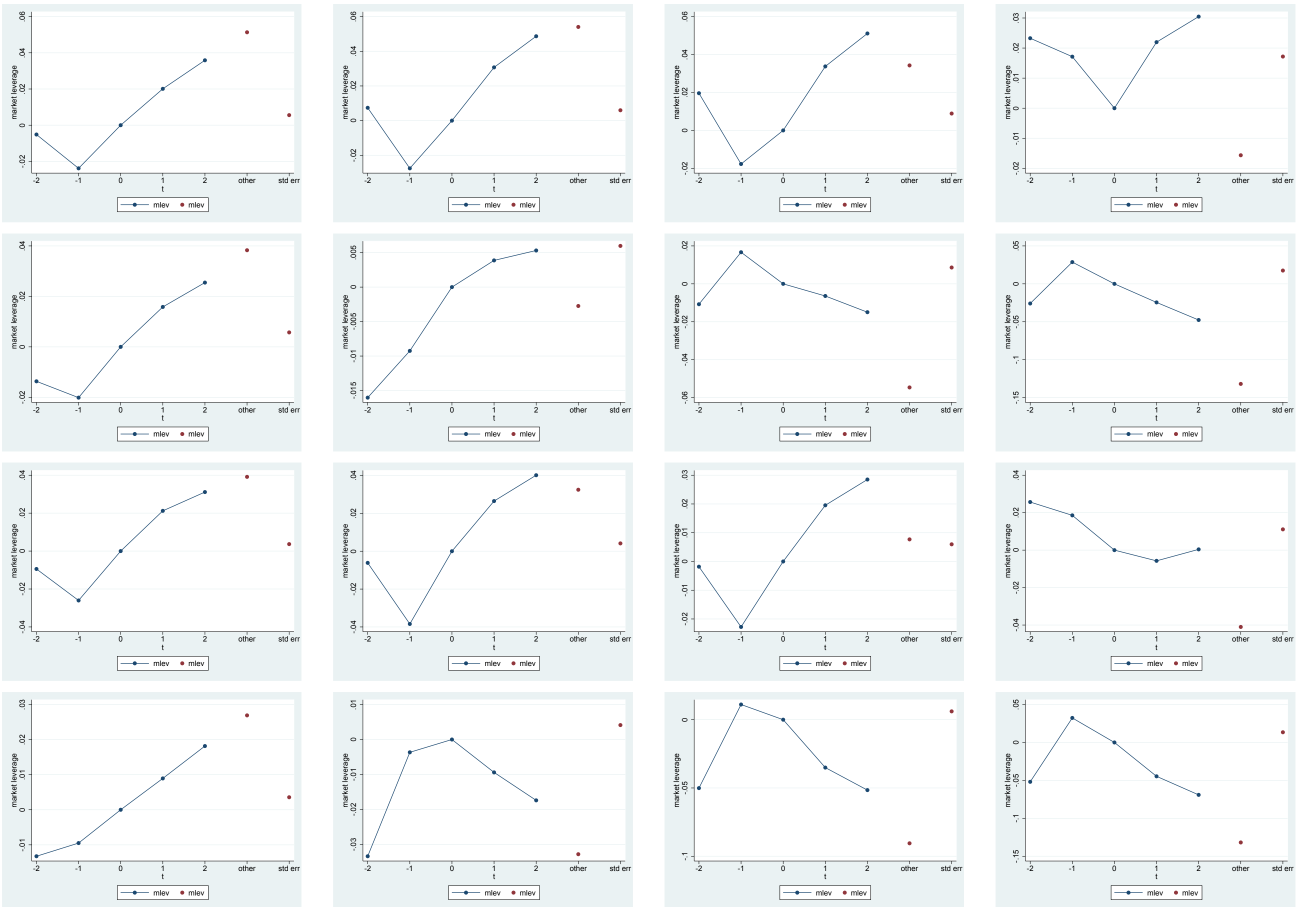

Figure 16: Behavior of market leverage around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4), (5) large positive inventory adjustment (row 5), (6) large negative inventory adjustment (row 6). Figures from left to right show results according to market leverage at window position t-1, 0-33%, 34-66%, 67-90%, 90-100%.

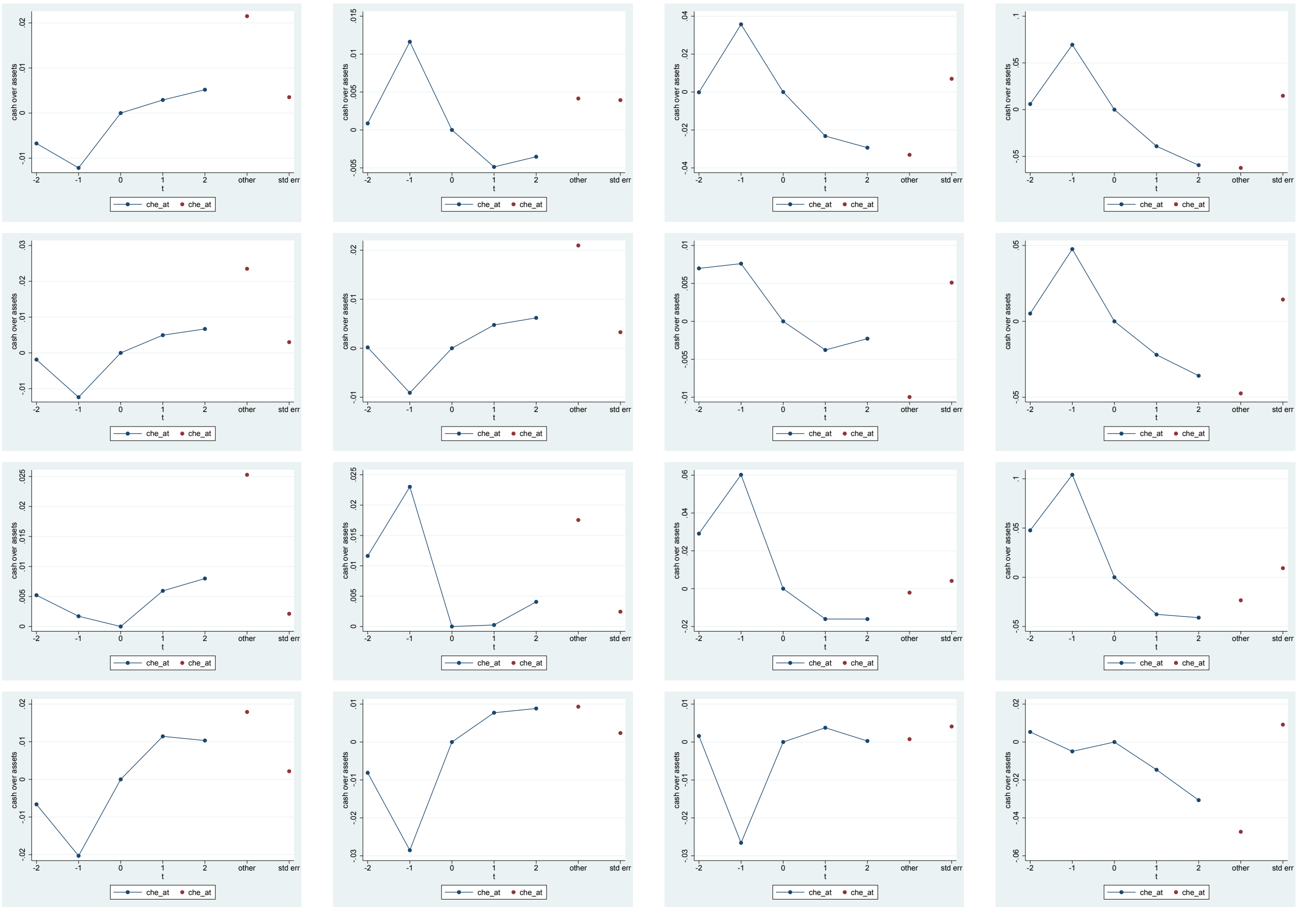

Figure 17: Behavior of cash over contemporaneous assets around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to cash over assets at window position t-1,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

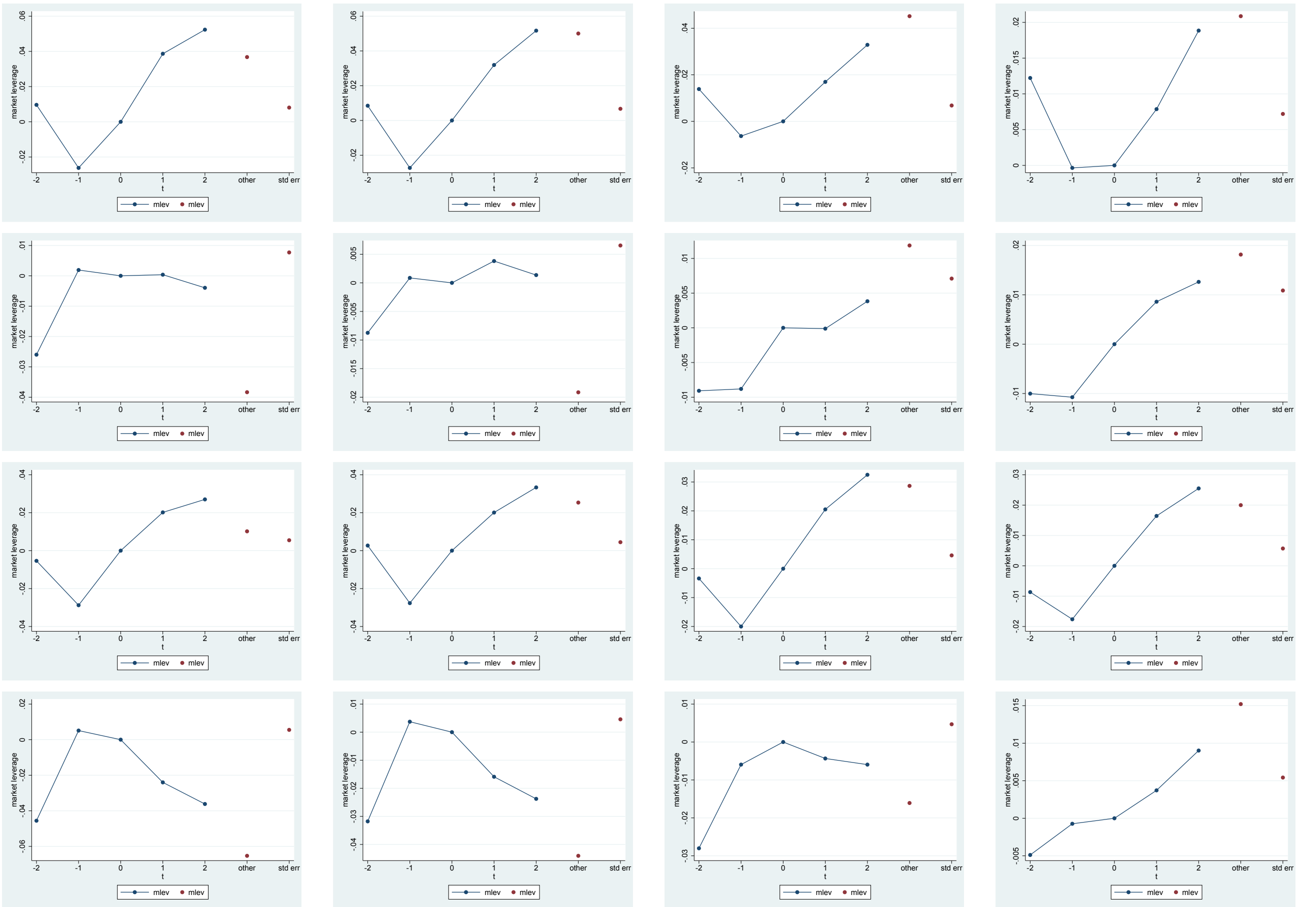

Figure 18: Behavior of market leverage around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to cash over assets at window position t-1, 0-33%, 34-66%,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

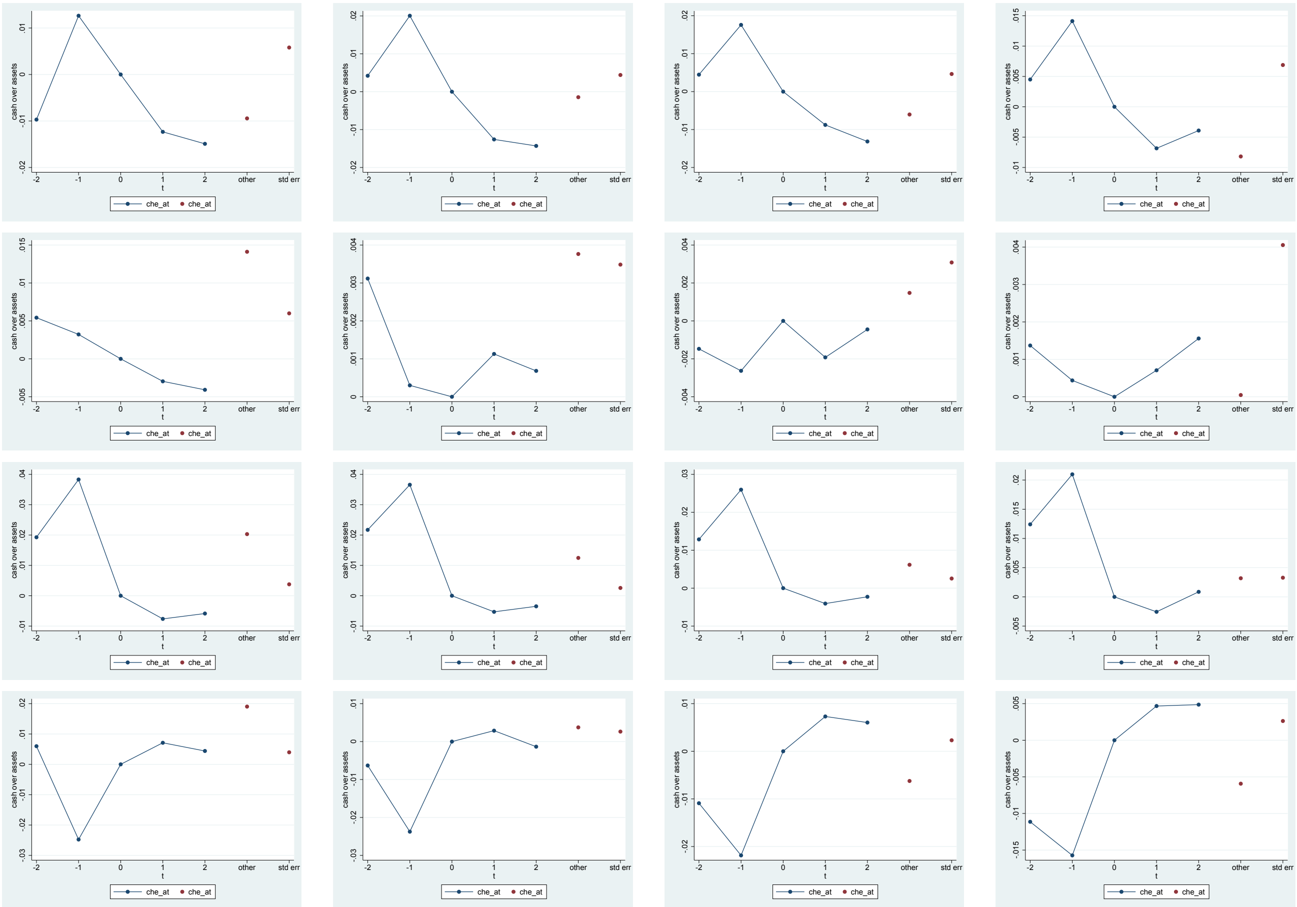

Figure 19: Behavior of cash over contemporaneous assets around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to size, 0-33%, 34-66%, 67-90%, 90-100%.

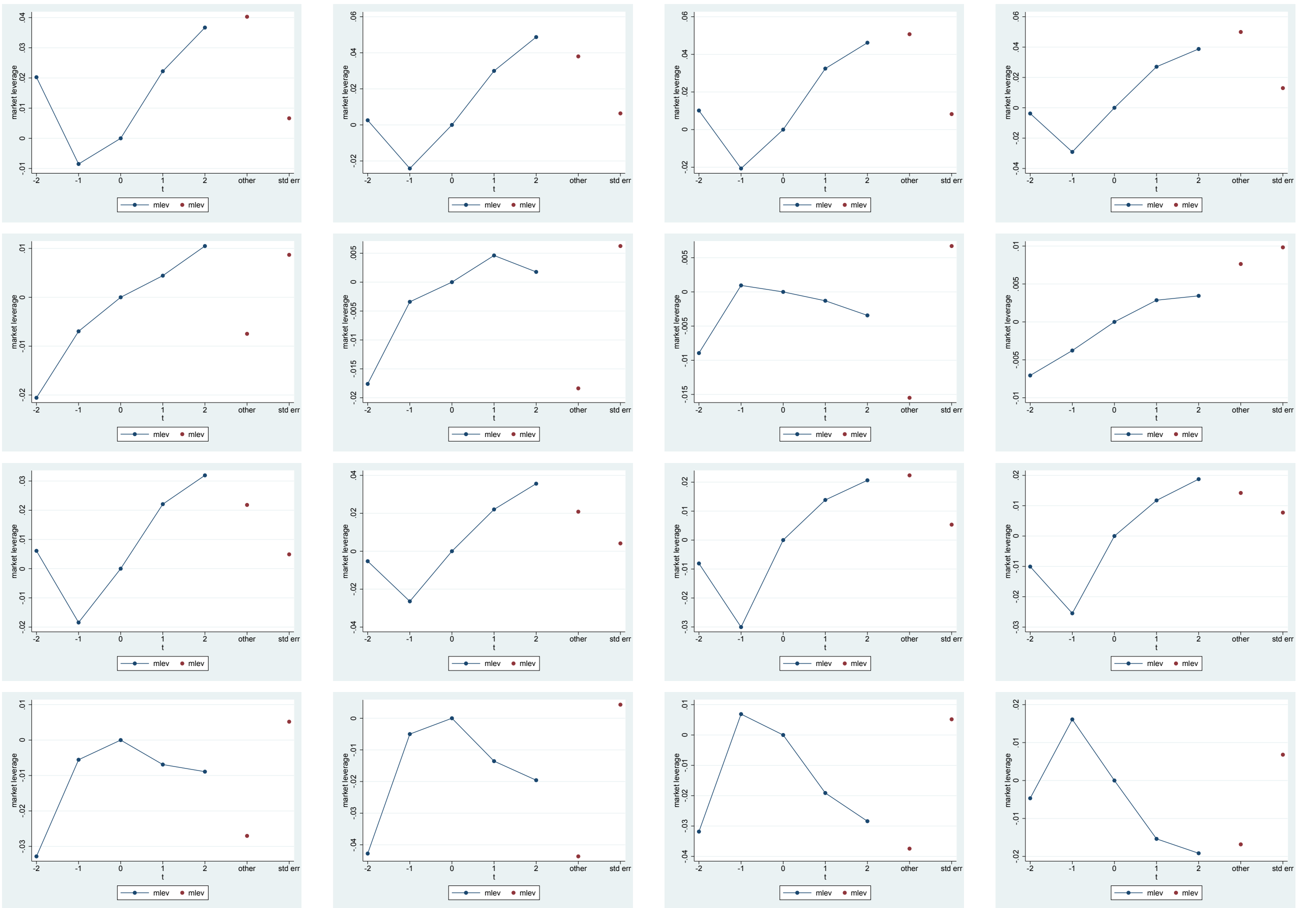

Figure 20: Behavior of market leverage around events: (1) investment spike (row 1), (2) disinvestment spike (row 2), (3) positive employment burst (row 3) (4) negative employment burst (row 4). Figures from left to right show results according to size, 0-33%, 34-66%, 67-90%, 90-100%.

C 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.

C.1 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).
- Net total sales is Total Sales (SALE).
- For cash holdings we use the COMPUSTAT variable Cash and Short-Term Investments (CHE).
- Total debt (DEBT) is constructed as the sum of Long Term Debt Total (DLTT) and Debt in Current Liabilities (DLC). Thereby we only consider observations for which book equity is larger than zero so that DEBT over contemporaneous assets is bounded between zero and one. Book equity (BE) is defined as Stockholder's Equity (SEQ) as in Covas and Den Haan (2011).
- EBITDA is Operating Income before Depreciation (OIBDP).
- Tobin's q (Q) is defined as (AT+(PRCC·CSHO)-CEQ)/AT, where PRCC is the Annual Price Close (fiscal year end), CSHO is Common Shares Outstanding, AT is Total Assets and CEQ is Common Equity.
- Market leverage (MLEV) is constructed in line with Denis and McKeon (2012) as total debt over the sum of total debt and market value (DEBT/(DEBT+MVAL), where market value MVAL is given by the product of the Annual Price Close (fiscal year end), PRCC, and Common Shares Outstanding, CSHO.

- (External) equity issuance is defined according to Begenau and Salomao (2019) 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 (2014)) 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.[26]

- 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.

[26] This limitation of Compustat data is widely documented, see e.g. Imrohoroglu and Tuzel (2014), 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.

- 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 (2014) we calculate the average age of the capital stock as the quotient of accumulated depreciation (DPACT) by current depreciation (DP).[27] Inventory variables are deflated using, P_{invt}, the price deflator for finished goods (PPI). It is the finished goods PPI obtained from the Bureau of Labor Statistics, Producer Price Index: Finished Goods (PPIFGS). All other relevant variables are deflated using, the GDP deflator, P_{GDP}, available from the Bureau of Economics Analysis.

C.2 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.
- 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%

[27]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.

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.

C.3 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, net debt over lagged total assets, change in net debt over lagged total assets, growth rate of shares outstanding, growth of net debt, 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, change in CHE over lagged assets, debt over lagged assets, change in debt over lagged assets, asset sales over debt) [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.

D Model Appendix

A model extension with employment choice.

In this section we present an extension of the baseline model dscribed in the main body of the paper. We introduce an employment margin and study dynamics of investment, employment adjustment and finance. This serves to gain an insight around lumpy capacity and finance adjustment when the firm has control over two factors of production. Since all other model ingredients are identical to the baseline model, we describe the equations that differ from the baseline model.

The firm's j production (and sales) function is given by

$$y_{jt} = s_{jt} k_{jt}^{\alpha} l_{jt}^{\beta}, \qquad 0 < \alpha < 1, 0 < \beta < 1, \tag{D.1}$$

where production, y_{jt}, depends on capital, k_{jt}, employment, l_{jt}, and a cash flow disturbance, s_{jt}.

The net cash flow,

$$ncf_{jt} = s_{jt}k_{jt}^{\alpha}l_{jt}^{\beta} - k_{jt+1} + (1-\delta_k)k_{jt} - Fk_{jt} - \frac{\gamma}{2}\frac{(k_{jt+1} - (1-\delta_k)k_{jt})^2}{k_{jt}} + (1+r)b_{jt} - b_{jt+1} \tag{D.2}$$

Notice in the formulation above we assume employment is a frictionless choice.

We assume the firm pays a cost of obtaining external finance as follows,

$$\begin{aligned}\phi_t^{ext}(-ncf_{jt}) =& \lambda(-ncf_{jt}) = \lambda(k_{jt+1} - (1-\delta_k)k_{jt} - s_{jt}k_{jt}^{\alpha}l_{jt}^{\beta} \\ &+ Fk_{jt} + \frac{\gamma}{2}\frac{(k_{jt+1} - (1-\delta_k)k_{jt})^2}{k_{jt}} - (1+r)b_{jt} + b_{jt+1})\end{aligned} \tag{D.3}$$

with $\phi_t^{ext}(\bullet) > 0$ if $ncf_{jt} < 0$, and $\phi_t^{ext}(\bullet) = 0$ otherwise. In the expression above, λ is a parameter capturing the premium the firm pays in order to use external finance.

The firm then solves the following problem,

$$V(s_t, k_t, b_t) = \max\{V^a(s_t, k_t, b_t), V^i(s_t, k_t, b_t)\}$$

The value functions for the active and inactive case are given respectively by,

$$\begin{aligned}V^a(s_t, k_t, b_t) =& s_t k_t^{\alpha} l_t^{\beta} - k_{t+1} + (1-\delta_k)k_t - \frac{\gamma}{2}\frac{(k_{t+1} - (1-\delta_k)k_t)^2}{k_t} \\ &- Fk_t + (1+r)b_t - b_{t+1} - \phi_t^{ext} + \zeta E_{s_{t+1}|s_t}V(s_{t+1}, k_{t+1}, b_{t+1}),\end{aligned}$$

and

$$V^i(s_t, k_t, b_t) = s_t k_t^{\alpha} l_t^{\beta} - \phi_t^{ext} + (1+r)b_t - b_{t+1} + \zeta E_{s_{t+1}|s_t}V(s_{t+1}, k_t(1-\delta_k), b_{t+1})).$$

D.1 Calibration and Model Solution

We apply value function iteration to solve the model. Therefore, the state and control variables have to be discretised over a certain interval. The size of the intervals is chosen in a way that the variables do not leave the state space during the simulations and we use interpolation when we compute simulations. Given the computational complexity of the extended model we discretize the state space of k_t into 81 grid points, b_t into 9 points, s_t into 7 points and l_t into 41 points. The process for the productivity shock is approximated as a first order Markov process using the method of Tauchen (1986). We form a guess for the value function, and based on the guess we find policy functions that maximize the value function. We use the maximized value function thus obtained and repeat the procedure until convergence is achieved.

The parameter values set for the calibration of the extended model are exactly identical to the baseline model except the capital coefficient and employment coefficient. These are set as, $\alpha = 0.45$, and $\beta = 0.45$.

D.2 Impulse Response Functions from the Extended Model

To compute the IRFs displayed in Figure 21 below we follow the same procedure as in the baseline model. The IRFs displayed are computed as means for the different variables of interest across the 12,000 replications. For each of these replications, we feed in the highest shock value ($s_H = 2.47$) in period t. In addition, for each variable displayed, the Figure plots its average level and it is denoted as 'other'. This, similar to Figure 2, captures the average level of each variable outside this 5 period window. The dynamics of investment rate, cash, cash over assets, external finance (levels and relative to assets) are qualitatively very similar to those reported from the baseline model. The extended model allows to study employment dynamics and get an insight of its interaction with investment. We notice that employment growth is subdued relative to 'other' up to and including time t when an investment spike occurs. However, there is a large spike in employment growth in period $t + 1$. Notice that the spike in employment growth occurs in the absence of employment adjustment costs. The intuition for this result is simple. At time $t + 1$ more capital is installed (following the spike in

t) and this causes a big productivity jump in employment. As a result the firm chooses to increase employment. Abel and Eberly (1998) present a simplified investment model with variable capital utilization and friction-less labor. The fixed invstment costs make the firm adjust labor in a lumpy fashion even if the latter is not subject to adjustment costs. Thus capital adjustment costs only are sufficient to generate spikes in investment and employment and the extended model IRFs illustrate this result neatly.

Its worth noting the model is not successful at predicting the smoothing of investment activity following the investment spike that we identify in the empirical patterns. This could be achieved by adapting the nature of investment adjustment costs. The model does not feature investment adjustment costs as in the specification of Christiano et al. (2005) (or time to build elements) which as Eberly et al. (2015) found are successful at generating more investment persistence. We conjecture this feature will enable the model to come closer to the empirical patterns identified in section 3.1.2 above, yet it would come at the cost of higher computational complexity.

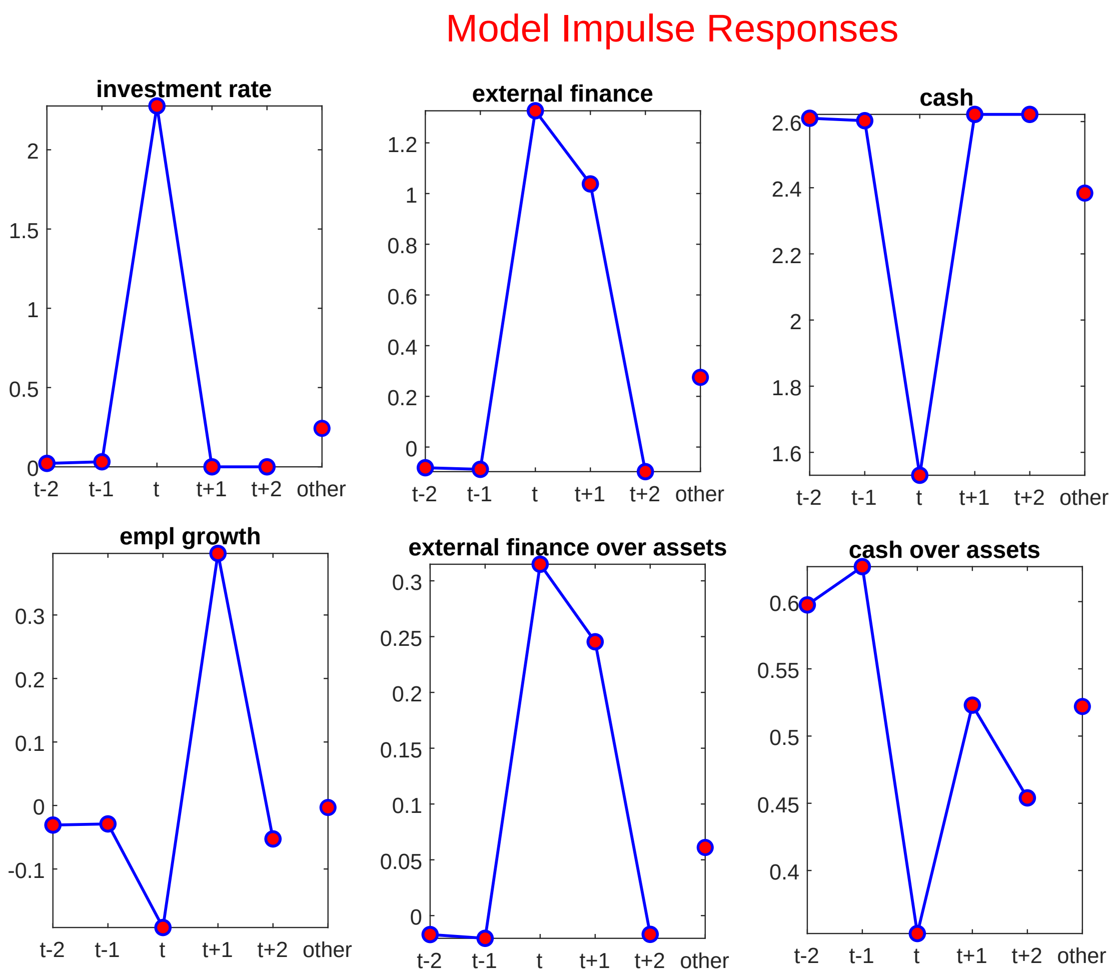

Figure 21: IRFs are computed as means over 12,000 replications corresponding to realizations of cash flow shocks. Each replication has 106 periods. We plot the last 5 periods of the simulation. The period t shock corresponds to the highest state in the shock grid space ($s_H = 2.47$). Finally, 'other' denotes the average value – over all replications and time periods – of each variable displayed above.