Constraints and Costs

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SCHOOL OF
ECONOMICS AND
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Constraints and Costs

Essays in Corporate Finance

NICK CHRISTIE | DEPARTMENT OF BUSINESS ADMINISTRATION

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Constraints and Costs

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Essays in Corporate Finance

by Nick Christie

DOCTORAL DISSERTATION
Thesis advisors: Hossein Asgharian, Håkan Jakensgård, Niclas Andrén
Faculty opponent: Martin Holmén

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Abstract

This dissertation consists of four self-contained empirical studies that contribute to the field of corporate finance by examining how firms respond to internal and external financial pressures.

The first study investigates the role of asset tangibility in shaping corporate investment behaviour. By analysing variation across industries and over time, it demonstrates that firms with a greater share of physical assets show stronger sensitivity of investment to cash flow, suggesting that asset tangibility is a fundamental determinant beyond standard financial constraint explanations.

The second study examines the connection between financial resources and cost stickiness. Using a large panel of firms, it shows that companies with more financial flexibility are more likely to retain underused resources during periods of declining demand, resulting in higher cost stickiness. This highlights how financial strength affects firms' ability to absorb short-term shocks.

The third study explores how financial buffers influence labour retention during periods of severe and unexpected revenue decline. Using long-term firm-level data, the analysis shows that liquidity, rather than equity or operational flexibility, is the main factor behind firm resilience. This underscores the importance of internal financial strength in avoiding employment losses during major disruptions.

The fourth study considers how the cost of adjusting labour affects financial constraints and the relationship between investment and cash flow. By drawing on legal changes in employment protection and building a labour skill index from survey data, the study finds that higher labour adjustment costs reduce the responsiveness of investment to available cash flow, reflecting a crowding out effect on financial flexibility.

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Financial constraints, financial resources, investment, risk management, tail risk, cost stickiness

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Constraints and Costs
Essays in Corporate Finance

by Nick Christie

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A doctoral thesis at a university in Sweden takes either the form of a single, cohesive research study (monograph) or a summary of research papers (compilation thesis), which the doctoral student has written alone or together with one or several other author(s).

In the latter case the thesis consists of two parts. An introductory text puts the research work into context and summarizes the main points of the papers. Then, the research publications themselves are reproduced, together with a description of the individual contributions of the authors. The research papers may either have been already published or are manuscripts at various stages (in press, submitted, or in draft).

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Dedicated to my parents
...and their granddaughter

Contents

Acknowledgements

They say it's all about the journey, not the destination. While the adage holds true in many circumstances, one could argue that the completion of a doctoral journey evokes particular sensibilities that, at least momentarily, prioritize the finish line over the marathon.

Reflection remains paramount, however. A retrospective glance often offers insights beyond the linear and logical order of things suggested by a neatly bound dissertation. The truth is, the world, as well as this thesis, has changed dramatically since this journey began. In many ways, the final result of this dissertation reflects this transformation.

A demagogue rose to lead the world's most powerful military, twice. An airborne virus originating in a little-known Chinese province spread across the globe, triggering a pandemic and confining large portions of the population indoors. Breakthroughs in artificial intelligence have placed generative capabilities into the hands of anyone with a smart phone. Interest and inflation rates have spiked to levels not seen in half a century. If someone had described all of this to the younger, more naive version of myself, the freshly minted PhD candidate, there would have been a heavy, very heavy, dose of skepticism. Russia invading a European country with ground troops and artillery? Surely you jest, good sir.

And yet, these impossible occurrences no longer seem impossible once they've passed. Our human tendency to seek explanations, for the physical and the abstract, renders the frightening unknown suddenly familiar. Once understood, the claws dull and the teeth lose their edge. What was once terrifying becomes routine.

Now, as this journey nears its end, the final result feels strangely logical. The unexpected bumps along the way, the countless darlings sacrificed in the name of progress, the setbacks and breakthroughs, all of it now feels like part of the adventure, remembered with a hint of nostalgia while conveniently forgetting the sharp rocks found on the road. My original predictions of what would fill these pages missed the mark. Yet something else took shape in their place. Unpredictability, as it turns out, shapes our actions, consciously and unconsciously, just as it has shaped this thesis.

Navigating this ambiguity would not have been possible without the support of many. It is said that it takes a village to raise a child. In my case, it took a community to lift a PhD candidate. It is only fitting that credit be given where credit is due.

I offer my deepest thanks to Håkan Jankensgård, who has been both my supervisor and mentor throughout this journey. Without his guidance and encouragement, this volume would likely remain in pieces. More than a brilliant mind and masterful storyteller, his patience and understanding, especially with stubborn PhD candidates, is without equal. I'm grateful for the opportunity to have co-authored two papers with Håkan and have learned much through the process. In addition to many acquired academic habits, I now drink my coffee black. Thank you, Håkan.

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I would like to extend my deepest appreciation to Hossein Asgharian who agreed to step in as supervisor towards the end of my PhD journey. Hossein taught me that the devil is in the details, that one cannot assume methodology is correct simply because it has been used before. I've learned that one should check, double check, and triple check, an equation and its subscripts before sharing it with anyone. Thank you Hossein for your wisdom, guidance, and insight into my research.

I want to thank all of the researchers and faculty in the Business Administration and Economics departments at the Lund University School of Economics and Management who have directly or indirectly aided me along my journey: Charlina Lunvald, Peter Svensson, Anders Vilhemsson, Alexander Hedlund, Anamaria Cociorva, Reda Moursli, Marco Bianco, Niklas Sandell, Jens Rennstam, Tomas Sjö, Anna Glenngård, and others who I may have forgotten. They say we are a product of our environment, and I couldn't think of a better group of individuals to be surrounded by.

A short walk from LUSEM is Forum Medicum, where I have been employed as a Research Engineer while writing my dissertation. I'd like to thank Susanne

Iwarsson, Giedre Gefenaite, and all the researchers and staff from the research groups of Ageing and Health, Active and Healthy Ageing, and Applied Gerontology for all their encouragement toward completing this journey. Working, starting a family, and writing a dissertation in the "downtime" was often overwhelming. Having a supportive group of co-workers who listened and encouraged me, even in the seemingly unrelated academic field of corporate finance, has been graciously appreciated.

Stepping off-campus, I'd like to thank my family near and far.

To my mother Nancy, who is no longer with us, I thank you for giving me your inquisitive nature and love for knowledge. To my father William, your love and support has carried me long and far. Gladly not too far - I am grateful that we are remain so close despite the 8,801 km distance.

To my sisters, Anna and Molly, and their husbands, Jason and Max: thank you for being there when I have needed you most. I am truly blessed to have you in my life.

To my Swedish family, Lars-Åke, Ingrid, Emi, Agnes, and Oskar. Thank you for all of the support along the way. Navigating a life in a new country can be challenging - you have made me feel at home and I couldn't have done it without you.

Lastly, and absolutely not least, I would like to extend a special debt of gratitude to my life partner-in-crime, Sofia. Thank you for standing by my side over these years. Without your constant support and encouragement, I would be lost. You are my heart.

And to Olivia, my daughter, you have given me the strength to push through tough times, and you brighten my day, every day.

Papa loves you.

Constraints and Costs: Essays in Corporate Finance

1 Introduction

1.1 Foreward

Sixty five years since Franco Modigliani and Merton Miller published the 1958 paper "The cost of capital, corporation finance and the theory of investment", the monumental publication continues to hold center stage in corporate finance research. To the casual observer, this may be surprising. After all, the authors show in their Proposition I that the choices managers make regarding financing decisions, albeit in a world of perfect capital markets, have no effect on the value of the firm.

The controversial "irrelevance theory" was met with a barrage of scepticism at the time of publication. However, as reflected by Miller (1988) thirty years after the original 1958 release, the key to understanding the theory lies on the "(other side of the) coin: showing what doesn't matter can also show, by implication, what does". By demonstrating the facets of capital structure which do not affect value, the authors created a framework to examine the frictions which do. As the implications of Miller and Modgliani's findings have spread to the fields of fiscal policy, international finance, banking, and law, it is hard to deny the impact the examination of market and financing frictions have had on the corporate finance world. Hennessy and Whited (2007) summarize it succinctly in that "Corporate finance is primarily the study of financing frictions."

Financial frictions and constraints now feature in every corner of corporate finance research, influencing investment decisions, resource allocation, labour force optimization, and risk management. They are crucial for understanding the factors that affect firm value in practice. Notably, many of the same questions asked three decades ago regarding financial constraints and frictions remain at the forefront of current debates: Which factors amplify or alleviate constraints? How should firms finance their investment needs? How do constraints influence labour decisions and cost behaviour? How do financial resources shape firm responses to adverse shocks and decision-making under uncertainty?

It is questions such as these which motivate the empirical investigations found within and are central to furthering our understanding of corporate finance. By examining financial constraints through various lenses, this work explores how constraints influence investment behaviour, cost behaviour, and firm resilience. Empirical in nature, the four essays in this dissertation aim to address current gaps in the literature on these core topics and offer contributions to our collective knowledge.

This introductory chapter provides an overview of the primary objectives, relevant literature, and conceptual frameworks addressed across the essays while highlighting the common themes that underpin the analyses to come. In the chapters that follow, each essay appears as a standalone empirical paper, representing a distinct but related investigation into corporate finance phenomena.

1.2 Financial resources - financial constraints

Financial resources, as conceptualized in this thesis, refer to the pool of funds and financing options available to a firm for meeting its operational, investment, and strategic objectives. These resources can be internal, such as retained earnings, cash holdings, or operating flexibility, as well as external, such as debt capacity or new equity issuances. Maintaining sufficient internal resources enables firms to address unexpected expenses, respond to shifting market conditions, and invest in promising opportunities without immediate recourse to costly external funding. In this way, strong financial resources serve as a buffer against downturns and spur future growth.

In addition to internal resources, firms also rely on debt capacity, the amount of borrowing they can feasibly undertake without compromising their long-term viability. This capacity is influenced by factors such as creditworthiness, collateral availability, and existing leverage, all of which ultimately affect a firm's cost of capital. When used sustainably, maximizing debt capacity can provide benefits such as tax shields and enhanced return on equity. However, excessive borrowing increases the risk of financial distress. Striking the right balance is the essence of the trade-off theory of capital structure (Myers, 1984), which underscores the importance of maintaining sufficient financial resources to preserve a firm's flexibility and competitiveness.

Conversely, financial constraints may generally refer to a *lack* of one or more financial resources. For example, where a cash shortfall could hinder some type of optimizing corporate behaviour or the ability to partake in an attractive investment opportunity. However, this simplistic definition ignores substitutive aspects which can contribute to a firm's overall financial condition. Different financing sources can act as replacements for each other. As a shortage of one resource, such as available cash, may be addressed with the availability of another resource, such as the ability to take on more debt. Ultimately, understanding financial constraints requires a holistic view of how firms generate, allocate, and preserve their resources.

The study of financial constraints has remained a core topic in the corporate finance literature for over three decades. While the concept of a financially constrained firm has long historical roots, Fazzari et al. (1988) sparked a new found interest that built on theoretical models of capital markets with asymmetric information (Myers and Majluf, 1984), moving past the perfect capital market world of Modigliani and Miller (1958) touched upon above.

On cursory examination, financial constraints are not difficult to conceptualize. Firms which face higher costs in raising funds externally, via taking on debt or issuing equity, may have difficulties pursuing cost-optimizing behaviour or profitable investment opportunities due to the external financing being prohibitively costly. In this sense, these firms would be considered more financially constrained. The deeper question then becomes: why would there be higher costs associated with external funds compared to internally generated funds, and what are the causes of these differences?

It is now generally accepted that there are indeed financial frictions in the capital markets and differences in the cost of internal and external sources of funds can be explained through the lens of information asymmetry problems. From an information asymmetry perspective, managers may have superior information about the value of the firm and its true investment opportunities compared to that of the firm's shareholders and creditors. For strategic reasons, managers withhold information from shareholders and investors in general, as making detailed investment opportunities public could tip off competition and lower the value of the firm. Thereby, the firm faces a predicament: without funds it cannot take on investment projects which are profitable, and it is impossible to sell securities to investors with no information (Myers and Majluf, 1984).

This information asymmetry dilemma renders equity issuance a costly endeavour. If investors are unable to view the true investment potential of the firm, they will under-price equity issuance. Management, who should be acting in the best interest of shareholders, would prefer to finance investment with equity if the current stock price is overvalued. Pricing the firm's shares extends Akerlof (1970) "market for lemons" problem resulting in overpricing. In contrast, debt would be preferable to equity financing as it would signal the inverse: that the firm's equity is undervalued and the investment is profitable. As a result, due to the information asymmetry problem, debt is cheaper than equity and therefore more preferable. Internally generated capital does not have the costs associated with debt or equity and would be the most preferable. This "pecking order theory", introduced by Myers and Majluf (1984), suggests firms follow a hierarchy of financing due to the cost of financing frictions: prioritizing internal funds before debt, and debt before equity.

Two characteristics are generally accepted regarding the nature of financial constraints. The first views constraints in terms of the effect that supply frictions have on the elasticity of the supply of external capital (Stiglitz and Weiss, 1981; Almeida and Campello, 2001; Whited and Wu, 2006). Moving along the supply of capital curve of a financially constrained firm, the cost of capital will increase to a point where it will be unable to raise an additional unit of external capital due to the verticality of the curve (see Figure 1).

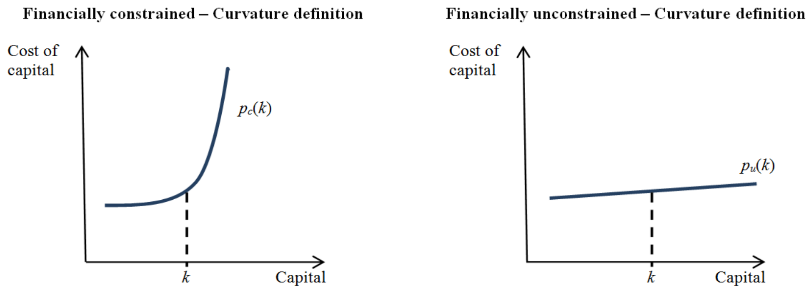

Figure 1: Illustraion of the curvature definition of financial constraints (Farre-Mensa and Ljungqvist, 2015)

A second characterization perceives financial constraints in terms of a wedge between a firm's internal and external cost of capital (Fazzari et al., 1988). Noting that all firms may in fact have a difference between their internal and external costs of capital, this notion of constraints infers that firms are considered more financially constrained as the wedge increases and is used as a way to examine firms to the extent that they are constrained (see Figure 2).

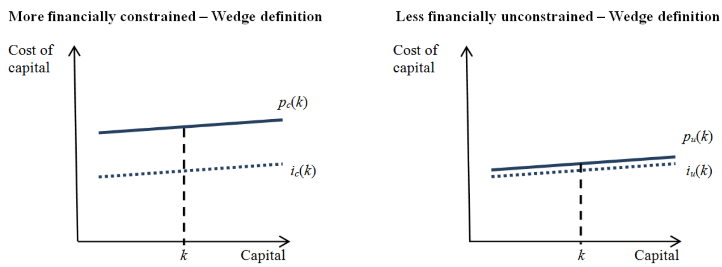

Figure 2: Illustration of the wedge definition of financial constraints (Farre-Mensa and Ljungqvist, 2015)

It is important to note that as financial constraints are seen to measure the magnitude of the internal-external cost wedge, they are conceptually different than that of financial distress. Financial distress is generally associated with costs due to the probability of default. The extent to which these two concepts overlap has yet to be fully examined (Cociorva, 2018), however, this thesis takes the traditional view that financial constraints, and the avenues to alleviate them, are primarily a problem due to financing frictions.

With these definitions of financial constraints, I now explore their influence and interaction with key areas of corporate finance research. From a firm's perspective, maintaining financial flexibility in the face of such constraints is essential to nearly every aspect of business, whether capturing investment opportunities, navigating cost adjustments, or withstanding stagnation or shocks to revenue growth, which have become increasingly relevant in an era of heightened volatility and systemic tail risk.

The following section provides background on corporate investment, leading into its conceptualization and connection to financial constraints. Special attention is given to investment-to-cash-flow sensitivities to offer a clearer understanding of key theoretical foundations that may only be briefly addressed in the included papers. This discussion also aims to orient the reader within a broad and evolving literature that spans several decades.

1.3 Investment under financial constraints

Investment is a central macroeconomic factor with its variation linked to significant proportions of country level output and income (Gomes, 2001). Our collective knowledge and understanding of investment behaviour, however, remains somewhat stifled. The early neoclassical theory developed by Jorgenson (1962) perceives firm investment in the context of an optimal level of capital stock. The idea is that there exists an optimal capital stock in which firms will invest and divest in order to maintain. The optimal level of capital stock in turn has a number of determinants affecting the supply and demand of capital. An increase in demand, suggests that a firm can increase production to generate higher profits. To expand production the firm may need to invest in more capital, hence, the optimal capital stock has increased and the firm should invest until unity. In the same regard, firms will divest if the current capital stock is greater than the optimal level, if for example a technological change renders an operational line obsolete.

Building on the neo-classical theory of investment, an alternative theory suggested by Tobin (1969) explains investment behaviour via an optimal rate of investment. According to Q theory, the rate of investment is a function of Q, which represents the ratio of the market value of an additional investment good to its replacement cost. If investors value assets at price levels that are greater than the replacement costs of said assets, there are strong motivations for investment in the reproduction of the assets in place and a firm will invest until the marginal cost of replacement equals the market value of assets. A baseline formulation of the Q theory posits that the investment-to-capital ratio is linearly related to marginal Q as follows:

$$\frac{I_t}{K_{t-1}} = \alpha_1 + \beta_1 Q_{t-1} + \epsilon_t \tag{1}$$

where $\frac{I_t}{K_{i,t}}$ is investment at time t deflated by beginning-of-period capital stock, and Q_{t-1} is beginning-of-period marginal Q. It is important to note that this model implies that investment should be unrelated to internal capital, or any other measure of liquidity, after controlling for Q, which is the sole determinant of investment.

At its core, Tobin's Q theory attributes fluctuations in investment to changes in the stock market. Compared to the neoclassical theory of investment, Q theory does not focus on the existence of an optimal capital stock *per se*, but rather an optimal adjustment path towards a new capital stock determined by the market.

In contrast to Q theory, Fazzari et al. (1988) find a significant sensitivity of investment to cash flow after controlling for Q in their investment regressions. They reason that the findings implied the existence of financial constraints, as a sub sample of firms identified *a priori* as constrained demonstrated higher investment-to-cash-flow sensitivities (ICFS). Their evidence suggests that internal funds do play a significant role in firm investment, especially so for firms facing financial constraints. Augmenting the standard Q equation in Eq.(1) with a measure of cash flow, the authors estimate the following:

$$\frac{I_t}{K_{t-1}} = \alpha_1 + \beta_1 Q_{t-1} + \beta_2 \frac{CF_t}{K_{t-1}} + \epsilon_t \tag{2}$$

where $\frac{CF_t}{K_{t-1}}$ represents a measure of firm cash flow at time t normalized by beginning of period capital. Fazzari et al. (1988)'s findings of a significant β_2 term suggests not only that Q may potentially be an inefficient predictor of investment, but more crucially, that there may indeed be a link between internal capital and investment decisions and this link may be due to the financial well-being of firms. Firms which have difficulty raising external finance, Fazzari et al. (1988) reason, should have investment which is more sensitive to fluctuations in their cash flow compared to firms which have relative ease in acquiring external funds.

Research has been quick to challenge the assumptions based on these initial findings, shaping arguments that form the backbone of the understanding of financial constraints, the interpretation of ICFS, and where effects should be observed. Indeed, Brown and Petersen (2009), commenting on the scope of this research, assert that the "study of investment-to-cash-flow sensitivities constitutes one of the largest empirical literatures in corporate finance".

Ultimately, the relative popularity of financial constraint research reflects the importance of understanding financial frictions in regards to capital markets and financial decision making. As Chirinko (1993) points out, "Given the critical implications for monetary, tax, and regulatory policies, further work relating investment and financing decisions to explicitly specified capital market frictions is clearly needed"

1.4 Investment to cash flow sensitivities

According to the Modigliani and Miller (1958) theory highlighted in the openings of this text, the choice of capital structure is irrelevant to firm value under certain conditions. In an efficient market with the absence of taxes, agency costs, bankruptcy costs, and asymmetric information, it can be shown that the value of a firm financed solely with equity equals that value of a firm which uses a proportion of leverage. This suggests that in a world of frictionless capital markets, internal and external sources of finance are perfect substitutes, and thus, firm investment decisions are independent of how they might be financed.

However, the restrictive conditions required in this framework are quite unrealistic in the real world. Elements such as asymmetric information, taxes, bankruptcy costs, agency costs, transactions costs, and the efficiency of the market are factors now known to affect the availability and cost of external funds. It is important to point out that as these assumptions become violated, the direction of where to look for the determinants of capital structure and the underlying mechanisms which drive them reveal themselves.

With these market imperfections in place, the divide between the internal and external costs of funds suggests that costlier external finance may indeed have an effect on investment, supporting the view that investment and financing decisions are affected by financing frictions. The extent and nature of this relationship, between financing and investment behaviour, forms the backbone of much research in corporate finance.

Fazzari et al. (1988) situate their findings in this theoretical concept. If Tobin's Q is assumed to capture investment opportunity, then a significant relationship between internal capital, in the form of cash flow, and that of investment suggests this link is evidence of financing frictions.

Subsequent research finds corroborating evidence in the link between investment and cash flow using natural experiments. For example, Lamont (1997) takes advantage of exogenous oil price shocks finding subsidiaries of oil companies reduced investment with a decrease in cash, while Rauh (2006) identifies dependence of corporate investment on internal funds while exploiting mandatory contributions of pension plans.

Indeed, significant ICFS are reported in an abundance of studies. The problem found in the literature is that of consensus regarding their interpretation.

Do ICFS measure financial constraints?

Critique of Fazzari et al.'s (1988) findings is widespread. One such prominent critique calls into question the interpretation of ICFS as a measure of financial constraints. Recall that Fazzari et al. (1988) report positive significant ICFS on a subset of firms *a priori* classified as financially constrained compared with their unconstrained counterparts. As such, their interpretation is that these greater ICFS observed for the constrained firms are indicative of the level of constraint.

Kaplan and Zingales (1997) respond to the claims of Fazzari et al. (1988) in their publication, "Do investment-cash flow sensitivities provide useful measures of financing constraints?", with a succinct response: "No". The authors manually read the annual reports of the firms classified as constrained by Fazzari et al. (1988), finding firms which appear less constrained in fact exhibit greater ICFS. This evidence suggest the relationship between ICFS and financial constraints are haphazard at best; if we see large ICFS in both constrained and unconstrained firms, the mere existence of ICFS clearly can not be a measure of financial constraints.

Subsequent research has further challenged the interpretation of ICFS as a reflection of financial constraints. Cleary (1999) classifies firms founded on firm characteristics reporting results in line with Kaplan and Zingales (1997) - that more constrained firms have lower ICFS. Gomes (2001) show that ICFS can be positive even in the absence of financing frictions. Similarly, Alti (2003) report that ICFS cannot be a valid measure of financial constraints as sensitivities are observed in frictionless markets. In a notable contribution, Chen and Chen (2012) show that ICFS do not increase even during the 2007-2009 financial crisis, a period where firms would face undeniable constraints to external finance. They proceed to demonstrate that sensitivities have dropped to insignificant levels, suggesting that firm-generated cash flow has little to no influence on investment at all. Despite the controversy surrounding this interpretation, many studies continue to use ICFS in various capacities, such as measures of "capital investment efficiency" (recent examples include Biddle et al., 2013; André et al., 2014; Benlemlih and Bitar, 2018) , underscoring the need to further understand this relationship.

One of the greatest challenges for researchers studying financial constraints is to actually identify these constraints. As financial constraints are not directly observable to the researcher, the literature resorts to estimating constraints via proxy. Indeed, over the past two decades, numerous researchers have proposed novel methods to measure financial constraints in the academic literature. Lamont et al. (2001) build on classification variables used by Kaplan and Zingales (1997) to estimate an ordered logit model relating to the degree of financial constraints in the KZ index. According to their model, financially constrained firms are more leveraged, have less cash holdings, pay out less dividends, have lower operating income, and have higher Q values. The WW Index (Whited and Wu, 2006) relies on the coefficients construed from accounting data and consists of six components - leverage, cash flow, paying dividends, total assets, firm sales growth, and industry sales growth. Subsequently, researchers Hadlock and Pierce (2010) estimate a simpler, more intuitive variation using only size and firm age with the SA index. The elusive nature of financial constraint identification has led to studies which propose an apparent combination of all variables previously mentioned in the KZ, SA, and WW indexes for private firms (Elsas and Klepsch, 2016), as well as novel techniques in textual analysis - classifying firms based on the word content of their financial statements (Buehlmaier and Whited, 2018; Bodnaruk et al., 2015; Hoberg and Maksimovic, 2015).

When faced with scrutiny, however, these popular measures struggle in their ability to yield consistent results. Farre-Mensa and Ljungqvist (2015) test a number of financial constraint measures found in the literature finding scant evidence in any ability to predict firms which behave constrained. They find that firms classified as constrained have no difficulty obtaining credit when the demand for debt increases exogenously. Furthermore, constrained firms were found to have no trouble accessing equity markets and tended to partake in equity recycling just as frequently as their unconstrained counterparts. Similarly, Bodnaruk et al. (2015) test measures by exploiting exogenous liquidity events associated with financing conditions: dividend increases, dividend omissions, equity recycling, and underfunded pension plans. Their results further call into question the efficacy of traditional measures to capture financial constraints. Taken together, these developments signal a consequential problem in the literature: while theoretical underpinnings are important in the development of financial constraint measures, they do not ensure the validity of such measures in practice.

Despite ongoing efforts to explain ICFS, an intriguing pattern has been observed - a significant weakening of ICFS over time.

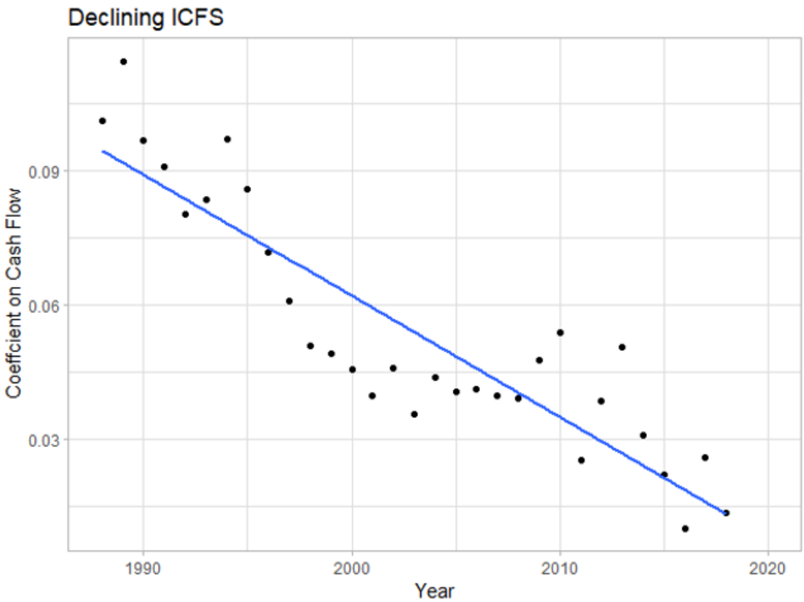

Figure 3: Declining investment-to-cash-flow sensitivities. Figure shows cash flow coefficients from yearly estimations of the standard model per Fazzari et al. (1988) .Compustat manufacturing firms from 1988-2019. Own calculations)

A consequence of this unexplained decline over time is that it offers the researcher a testing ground to further examine the properties of ICFS, and in the case of an international or industry setting, the cross-sectional variation in sensitivities. Recent studies have attempted to explain the cross-sectional variation of ICFS as a result of country-level financial development (Larkin et al., 2018) and declining investment in physical assets (Moshirian et al., 2017). Little consensus is found in explaining the extreme decline of ICFS, yet the collective findings propose sensitivities have plummeted to minuscule levels - suggesting the effect of cash flow on investment has become marginal over time.

Financial constraints or measurement error in Q?

One of the more prominent challenges to the existence of financial constraints and the link between investment and internal funds arises in the closer examination of the regression-based investment model of Fazzari et al. (1988) in Eq.(2).

The econometric problem can be briefly explained as follows. Ordinary Least Squares (OLS) is by far the most common tool in the toolbox of the empirical researcher and OLS estimators are attractive for a number of reasons, particularly for their ease of implementation and ability to accommodate fixed effects in panel data applications. In spite of their prevalence, OLS estimators are fairly weak in handling problems involving error-in-variables (Almeida et al., 2010). When explanatory variables are mismeasured in the model, coefficients estimated with OLS become inconsistent and suffer from attenuation bias (for a technical explanation see: Cameron and Trivedi (2005, p. 900)).

In the context of Eq.(2), this suggests measurement error in Q could render the interpretation of β_1 erroneous. Here, significant ICFS could merely be a result of the measurement error in Q (Erickson and Whited, 2000).

A particularly influential critique illustrating this controversy comes from Cummins et al. (2006) who estimate improved coefficients using analyst-based measures of Q. They report insignificant findings of cash flow's effect on investment after adjusting for measurement error in Q, claiming financial constraints should be already captured by Q and strongly challenging the ICF framework. Similar findings suggesting ICFS may be merely a result of measurement error in Q include Bond et al. (2004), Erickson and Whited (2002), and Erickson et al. (2014).

To address this issue and overcome the potential bias in the regression coefficients, models using dynamic panels (Arellano and Bond, 1991), higher-order estimators (Erickson and Whithead,2000,2002), cumulant estimators (Erickson, Jiang, and Whited, 2014) and general instrumental variable techniques (Lewellen and Lewellen, 2016) have been implemented to account for the attenuation bias in the estimators.

As Q is "arguably the most common regressor in corporate finance" (Erickson and Whited, 2012), the implications of these challenges are vast. If the common proxy for Q, the market-to-book ratio, has been consistently measured with error, statistical inference and the associated economic conclusions of substantial research papers are put into question.

The complexity of the econometric problem has warranted comparisons on the efficiency of these estimators (Almeida, Campello, and Galvao, 2010), along with corresponding rebuttals (Erickson and Whited, 2012). Moreover, the debate on the extent of the Q measurement problem continues. Peters and Taylor (2017), in the development of an improved Q proxy, find mixed results using their new measure in the ICFS framework, noting problems with manufacturing firms. As a testament to the prominence of Q theory development in corporate finance, you can now find Peter and Taylor's improved Q measure for download in Wharton Research Data Services (WRDS).

Consequently, research suggests that internal funds impact firm investment. In testing the numerous methods to tackle the error-in-variables problem, Ağca and Mozumdar (2017) find that ICFS can't be attributed to measurement error in Q alone. Taken as a whole, the collective empirical evidence points towards a weak ability for measurement error in Q to account for ICFS, suggesting there are other factors which may explain ICFS.

Measurement error in investment?

A further issue that has been revealed in the literature is that *investment* in the traditional ICFS framework contains only investments in physical assets. The origins of this reasoning can be generally attributed to the idea of a "representative firm" first brought forth by Alfred Marshall (1890) in Principles of Economics. In macroeconomics, many models rely on the examination of representative agents in order to derive individual supply or demand curves which are then supplemented as approximations of aggregate supply and demand curves. In this way, a particular focus on manufacturing firms has been emphasized in traditional studies as they represent a "typical" firm which generates revenues from a physical asset base and subsequently invests the profits in new physical capital.

Investment, however, has seen quite a transformation since the early days of economic theory. As companies have transitioned away from textbook-example manufacturers, into firms which rely on and invest in human capital, brands, trademarks, and research and development, intangible assets are now a standard focal point in firm analysis. Indeed, Corrado and Hulten (2010) estimate that as a portion of total capital, intangibles have exceeded 30% for firms in recent years.

This shift has not gone without notice in financial constraint research. Brown and Petersen (2009), noting the increase of R&D as a form of investment, find that R&D-cash flow sensitivities remain strong in periods when ICFS weaken. Chen and Chen (2012) augment their investment measure with R&D expense when estimating ICFS. Testing if the rising importance of R&D offers an explanation of declining ICFS over time, they report inconclusive results. Peters and Taylor (2017) construct a measurement of firm-level intangible asset stock that includes both R&D expenditures and a portion of SG&A. They report that incorporating intangibles improve the explanatory power of investment regressions in some firms. Nevertheless, the primary challenge in augmenting physical investment with investment in R&D lies in the difficulty of accurately estimating investment in intangibles. As R&D expenditure is inconsistently capitalized and may be estimated in a rather ad hoc manner, true investment in R&D on a large scale is unobservable to the researcher.

Measurement error in cash flow

Similar to the error in variables argument purporting that mis-measurement of Q or investment renders ICFS insignificant, a biased measure of cash flow may have consequences in the model specification. On the surface, this claim may appear inconsequential compared to the measurement error in Q problem. Compared to estimating the unobservable marginal Q, the accuracy of calculating a cash flow figure may seem trivial. However, recent studies have given credence to this area of examination. Investigating the decline of ICFS over time, Lewellen and Lewellen (2016) hold that an improved measure of cash flow has superior properties in estimating ICFS when looking at this phenomenon on a temporal basis. Reporting that the relationship between popular earnings measures and that of cash from operations has declined over time, the authors suggest this relationship may be the key to restoring current observations to historically-observed levels. Whether deduced from the income statement's earnings figure, or proxied by the operating cash flow line item, our ability to estimate the true value of a firm's cash flow is at the mercy of accounting-based identities and the accuracy of financial statements.

If there has indeed been a significant divergence between a firm's actual cash flow and the common earnings proxies used in research, a structural shift holds important implications for not only interpreting ICFS, but as Givoly and Hayn (2000) point out, for financial analysis and firm comparisons, particularly over time. However, Andrén and Jankensgård (2016) test a number of cash flow measures on a large US data set, reporting that more comprehensive measures of cash flow do not restore ICFS to levels claimed by Lewellen and Lewellen (2016). This suggests that while measurement error in cash flow may have some effect on ICFS, it can not explain the observable patterns of these sensitivities.

1.5 Unexpected revenue shocks

While investment patterns offer one lens to examine firm behaviour in the face of financial constraints, the ability to survive rare and extreme revenue shocks is perhaps the ultimate test of resilience. In the domain of corporate risk management, one of the most pressing challenges is preparing for highly unpredictable, low-probability but high-impact events. Coined by Taleb (2007), the term *Black Swan* refers to events that defy expectation, disrupt established systems, and are often rationalized only after they occur. Drawing from Taleb's notion of the *Black Swan*, the term may be used to describe business events that may manifest as severe shocks to revenue or operations that cannot be anticipated or insured against using conventional tools like derivatives or traditional hedging. Unlike ordinary fluctuations, these tail-risk events test the very resilience of a firm's financial and operational structure.

Firms that experience a sudden, dramatic loss in revenue may find themselves struggling to maintain operations, meet financial obligations, or retain their workforce. Since *Black Swans* are by nature outside the scope of ordinary risk models, their impact reveals which firms are truly prepared to weather unforeseen adversity. This preparation centers on what is often referred to as "risk capital", a set of financial and organizational resources that can absorb shocks and enable the firm to survive and continue executing its strategy during periods of acute distress. What makes this more relevant is when the frequency of drastic drops in revenue have been increasing over time. Figure 4 shows the development in the yearly mean value of revenue drops of firms found in the Compustat universe, which is to say the proportion of firms that experience a 30-90%[1] fall in yearly revenue. The graph also shows the trend using an alternate threshold of a 50-90% drop in revenue, representing firms that lose more than half of their revenue relative to the preceding year. Both series suggest that these extreme drops in revenue have been increasing over time, highlighting the growing uncertainty which firms must navigate.

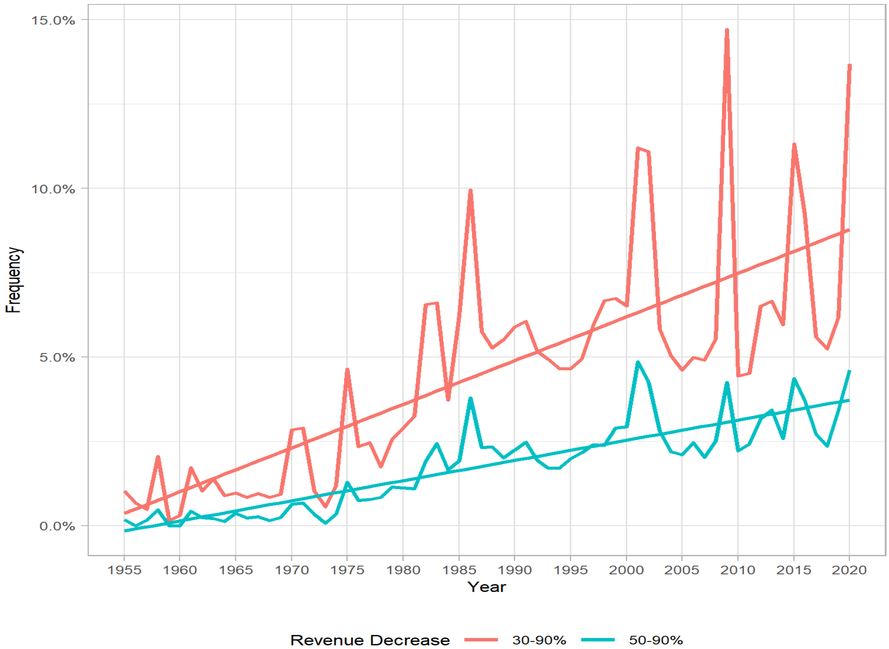

Figure 4: Figure shows frequency of extreme revenue drops over time: firm observations with negative revenue growth between 30 and 90 percent (red line), along with the frequency of firm observations with revenue declines of 50 to 90 percent (blue line). Sample consists of all firms, excluding financial and utilities, in the US Compustat universe from years 1955-2020.

Dealing with *Black Swans* introduces a strategic dilemma. Risk capital and financial resources, particularly cash reserves, come with an opportunity cost. Holding large cash balances or maintaining under-leveraged balance sheets may be viewed

[1]Firms with revenue decreases greater than 90% are excluded to account for irregularities such as corporate restructuring. Further motivation for these thresholds is found in Paper three

as inefficient in normal times. Shareholders and analysts may pressure firms to optimize capital structure and return excess liquidity. However, in extreme circumstances, these "inefficiencies" become lifelines. This tension underscores the importance of balancing short-term efficiency with long-term resilience.

In this conceptual framework, financial resources become paramount in enduring catastrophe when it arrives. The extent to which a firm can absorb a severe revenue shock often determines its survival and long-term viability. As the frequency and severity of such tail-risk events appear to be increasing, the case for maintaining strategic buffers becomes more compelling. Ultimately, a firm's resilience lies not only in how it operates during stability, but in how it endures and adapts when faced with worst case scenarios.

1.6 Financial constraints and costs behaviour

Financial constraints may also influence the way firms adjust, or fail to adjust, their cost structures in response to changes in business activity. A central concept in this reasoning is cost stickiness: the asymmetric adjustment of costs in response to revenue increases versus decreases. This behaviour, far from a managerial oversight, reflects deeper financial realities. Firms with financial resources may strategically retain resources during downturns, anticipating future rebounds. In contrast, financially constrained firms may engage in harsher, faster cost-cutting.

The concept of cost stickiness represents a departure from the traditional cost accounting framework, which has long classified costs into two distinct categories: fixed and variable. In this classic view, variable costs are assumed to fluctuate in direct proportion to changes in business activity, while fixed costs remain unchanged. As explained by Noreen (1991), the implication of this model is that costs increase and decrease symmetrically as business activity expands or contracts. That is, the degree of cost change is expected to be identical in magnitude regardless of whether activity is rising or falling. This assumption forms the basis for much of the conventional wisdom in cost management.

Empirical research over the past two decades has challenged the symmetry implied in this traditional cost model with the idea that costs always adjust proportionally to fluctuations in activity being increasingly called into question. The key insight emerging from this newer body of literature is that costs do not always respond equally to increases and decreases in business activity, a phenomenon known as cost stickiness.

Although the idea of asymmetric cost behaviour can be traced as far back as the 1920's in Germany (see Brasch (1927)), a revival in the literature came with the influential work of Anderson et al. (2003). Their study offered not only empirical evidence but also a compelling theoretical rationale for why cost stickiness occurs. According to the authors, the way that selling, general, and administrative (SG&A) costs respond to changes in sales reflects managerial discretion and decision-making, rather than a rigid cost function determined solely by volume.

Anderson et al. (2003) argue that when demand increases, managers are generally quick to commit additional resources to support growth. These actions, such as hiring personnel, expanding capacity, and increasing marketing lead to a rise in costs. However, when demand declines, the response is less immediate and more nuanced. Managers must evaluate whether the downturn is likely to be temporary or persistent before deciding to scale back previously committed resources. Furthermore, reducing resources often involves significant adjustment costs, such as severance pay for laid-off employees, costs associated with terminating leases, or lost efficiency when later rebuilding operations. There may also be intangible costs, including the loss of employee morale or organizational knowledge.

The authors define cost stickiness as the tendency of managers to retain underutilized resources rather than incur these adjustment costs when business activity falls. In their empirical analysis of SG&A costs, they find strong support for this model. When revenues increase by 1%, SG&A costs rise by approximately 0.55%. However, when revenues decrease by the same amount, SG&A costs decline by only 0.35%. This asymmetric response suggests that costs are "sticky" as they do not fall as quickly as they rise.

The publication of Anderson et al. (2003) sparked a broad and growing literature aimed at identifying the conditions under which cost stickiness is more or less pronounced. One important stream of research explores how operational characteristics, such as capacity utilization, influence cost behaviour. For example, Balakrishnan et al. (2004) investigate cost stickiness in U.S. physical therapy clinics and find that the degree of excess capacity moderates the response of costs to declining activity. When clinics operate with significant unused capacity, they can more easily absorb reductions in demand without having to cut costs aggressively. Conversely, when excess capacity is limited, cost reductions are more likely to occur. Interestingly, they also find that clinics respond to falling demand by lowering prices, rather than adjusting resources, contributing further to cost stickiness.

Another key factor influencing cost stickiness is demand uncertainty. Banker et al. (2014) argue that when future demand is unpredictable, managers are more likely to commit to fixed resources preemptively in order to avoid the so-called congestion costs that arise when demand unexpectedly surges. Institutional and regulatory environments also play a significant role. Banker and Chen (2006) explore how differences in labour market regulations across countries affect cost stickiness. Their research shows that in countries with more rigid labour laws, where laying off workers is more expensive or bureaucratically challenging, firms exhibit greater cost stickiness.

Importantly, managerial incentives and behavioural traits further complicate the picture. For example, Kama and Weiss (2010) examine how managerial incentives to meet short term earnings targets influence cost decisions. They find that managers under pressure to hit earnings benchmarks are more likely to cut resources aggressively in response to declining sales, thereby reducing cost stickiness, suggesting this behaviour is shaped by strategic decision-making and performance targets. Kuang et al. (2015) investigate how managerial overconfidence affects cost stickiness. Their findings suggest that optimistic managers, who expect revenue to rebound quickly, are more likely to retain slack resources during downturns, contributing to greater cost stickiness. Xue and Hong (2016) show that stronger corporate governance structures reduce managerial opportunism and discourage earnings management behaviours that might otherwise sustain cost stickiness. Effective oversight encourages more disciplined cost control, particularly during periods of declining performance.

In sum, the literature since Anderson et al. (2003) has expanded the understanding of cost stickiness by moving beyond a simple dichotomy of fixed versus variable costs. The decision to retain or shed resources in response to changes in demand is neither automatic nor uniform across firms. Instead, it reflects a web of strategic trade-offs, shaped by expectations about the future, the cost of adjustment, and the external environment in which firms operate.

As this literature continues to evolve, one thing remains clear: cost stickiness cannot be fully understood without considering the motivations, expectations, and constraints faced by managers.

1.7 Summary of the research problem

By no means exhaustive, the above presentation reveals a research area rich in contributions yet containing a number of theoretical challenges that remain in need of development. The attention given to the financial constraints and ICFS literature stems not only from the strong implications it has on firm-level dynamics, but also due to their role in understanding larger economic activity.

Emphasised above, a key area in pushing our collective knowledge of the ICFS framework lies in a closer examination of what drives ICFS. Does the empirical disappearance of ICFS suggest that firms today face less financial hurdles than thirty years ago, or can the drastic decline in sensitivities be explained by an improved model or exogenous factors? If ICFS are not reflective of financial constraints, what is their significance and what exactly may explain them?

While ICFS remains a central topic, its limitations as a constraint proxy and its declining empirical relevance call for a broader understanding of how financial frictions shape firm behaviour. This dissertation responds to these challenges by expanding the analytical lens. Financial constraints and resources are explored not only through investment patterns, but also through how firms manage costs and respond to extreme revenue shocks. These additional perspectives reflect the broader relevance of financial resources in shaping firm behaviour.

1.8 Contributions and future research

This dissertation contributes to the literature on corporate finance by expanding understanding and implications of financial constraints. While much prior research has focused on their impact on investment, particularly through the lens of investment-to-cash-flow sensitivities, this work adopts a broader perspective. It emphasizes the role of financial flexibility not only in capital budgeting decisions, but also in shaping cost behaviour, determining resilience in the face of shocks, and influencing a firm's overall fragility under uncertainty.

A key contribution of this dissertation lies in re-examining the interpretation of ICFS as a measure of financial constraints. The first and fourth essays revisit this assumption by investigating how firm-level characteristics, specifically asset tangibility and labour adjustment costs, affect observed ICFS. The evidence suggests that sensitivities to internal cash flow may often reflect structural or operational attributes, such as capital intensity or reliance on skilled labour, rather than being direct indicators of financing frictions. These findings call for a more cautious and nuanced use of ICFS in empirical research and underscore the need to refine how financial constraints are identified and measured.

The second essay links financial resources to asymmetric cost behaviour. It explores the idea that cost stickiness, a firm's tendency to reduce costs less aggressively during revenue downturns than it increases them during upturns, is influenced by the availability of financial resources. Firms with greater liquidity or untapped debt capacity exhibit more pronounced cost stickiness, indicating a strategic choice to preserve organizational capacity. In contrast, firms with limited financial flexibility are compelled to adjust costs more reactively, potentially undermining long-term efficiency.

The third essay investigates the role of financial flexibility in managing extreme revenue disruptions, so-called *Black Swan* events. Using long-term data, it finds that liquidity plays a central role in determining how firms cope with large, unexpected revenue shocks. While operational flexibility and equity buffers may offer some protection, it is cash reserves and strong internal liquidity that most consistently mediate the effects of such events. This insight contributes to the literature on financial fragility and corporate risk management, offering new empirical evidence on the importance of liquidity as a buffer in times of crisis.

Taken together, these contributions advocate for a more expansive view of financial constraints, one that moves beyond traditional investment frameworks to include cost dynamics and firm resilience.

Several avenues for future research emerge from these contributions. First, there is a need to refine how financial constraints are measured. Given the empirical limitations of ICFS and commonly used constraint indexes (such as the KZ, WW, and SA indexes), future work could develop new identification strategies. Advances in machine learning, natural language processing, and the availability of large-scale textual data offer opportunities to detect constraint-related signals from financial reports, earnings calls, or broader firm disclosures. Additionally, new natural experiments and exogenous liquidity shocks may serve as more reliable tools for causal inference.

Second, the relationship between financial flexibility and cost behaviour deserves further exploration. Cost stickiness likely varies across industries and economic cycles. Disaggregating these effects, and examining the role of corporate governance or firm ownership structures in moderating them, could yield deeper insight into how firms hold on to precious resources while under constraint.

Finally, while this dissertation focuses on short-run firm responses to revenue shocks, the long-term strategic consequences of *Black Swan* events remain understudied. Case-based approaches could illuminate these outcomes, particularly in settings where firms fail to recover fully.

I next give a short summary of the essays before presenting them in order.

1.9 Summary of essays

Asset tangibility and investment: explaining Investment-to-cash flow sensitivities

The first essay is a sole-authored paper which explores how asset tangibility may account for differences in ICFS. According to traditional argument, observed ICFS after controlling for Tobins's Q in investment models are solely the result of financial constraints (Fazzari et al., 1988). In light of its vast influence, this theory has received mounting evidence contrary to its predictions, leaving the question of what determines ICFS if not financial constraints. This essay explores whether asset tangibility may explain differences in observed ICFS across industry and time in a large set of Compustat firms from 1977 to 2018. I estimate panel regressions along a variety of cross-sections and time periods finding ICFS are consistently greater in firms with higher proportions of physical assets as well as those located in capital intensive industries. These results hold among a series of robustness tests and checks offering compelling evidence in asset tangibility as a first-order determinant of investment-to-cash flow sensitivities.

Do financial resources determine cost behaviour?

This paper is a joint effort with Håkan Jankensgård. My main responsibilities included data collection, project management, modelling and analysis. Håkan Jankensgård wrote the first draft and we took joint responsibility for finalizing the paper. According to previous research, firms prefer to temporarily maintain unutilized resources when business activity decreases, thereby reducing future "congestion costs" that occur when revenue growth resumes. We argue that such optimizing behaviour – referred to in the literature as sticky costs – is conditional on financial resources that support the increase in risk that results from maintaining additional costs. Using data from US manufacturing firms between 1984 and 2018, we find overwhelming support for the hypothesis. Across a range of tests, the most financially constrained firms have the least sticky costs. Firms that lack financial resources such as debt capacity and cash holdings essentially do not exhibit sticky cost behaviour. Large firms with significant financial slack, in contrast, display cost stickiness that exceed the baselines results by a factor of three. While the latter finding is suggestive of poor cost discipline, our findings show that these firms are in fact associated with superior cost efficiency. Our results are consistent with the view that excessive adjustment to cost structure is an important component of financial distress.

The Black Swan problem: the role of capital, liquidity and operating flexibility

This paper is a collaborative effort with Håkan Jankensgård and Nicoletta Marinelli. My main responsibilities included data collection, project management, modelling and analysis. Håkan Jankensgård wrote the first draft and all authors took joint responsibility in development, robustness testing, and finalizing the paper. How firms cope with tail risk is an under-researched problem in the literature on corporate risk management. This paper presents stylized facts on the nature of revenue shocks based on 65 years worth of Compustat data. We define a *Black Swan* as an unexpected year-on-year drop in revenue between 30-90%. The rate of *Black Swans* has increased markedly since the 1970's and there are more pronounced cyclical peaks in the three most recent decades. We also examine the role of three general determinants of firms' ability to absorb *Black Swans*: equity capital, liquidity, and operating flexibility. The conclusion to emerge from this analysis is that the deciding factor in mediating the effects of revenue shocks on employment is liquidity. Cash reserves and cash margins make firms less fragile, but neither equity capital nor operating flexibility robustly buffer against *Black Swans*. The results continue to hold when we restrict the analysis to transient and cyclical revenue shocks, as well as when we use only a strictly exogenous revenue shock based on the airline industry.

Labour adjustment costs and investment to cash flow sensitivities

This sole-authored paper explores how labour adjustment cost may explain ICFS. Exploiting the staggered adoption of state-level US employment protection laws and utilizing 30 years of data, I find a negative relationship between labour adjustment costs and ICFS, reporting lower ICFS in firms operating with greater employment protection. As costs associated with the training, hiring, and dismissal of employees increase in response with planned investment, firms prioritize these adjustment costs over that of capital expenditures. Additionally, I construct a labour skills index leveraging Bureau of Labour Statistics survey data to evaluate the relationship between ICFS and skilled labour reliance. I find that lower ICFS are observed in firms depending on skilled labour to a greater extent and that this effect is largely absent in financially constrained firms. The results provide empirical support towards identifying the determinants of ICFS, while highlighting the need for caution in interpreting ICFS as a measure of financial constraints.

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Paper I

Asset tangibility and investment: explaining investment-to-cash flow sensitivities

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1. Introduction

The origins and determinants of investment-to-cash flow sensitivities (ICFS) have been a subject of ongoing debate in corporate finance for over four decades. While financial constraints have traditionally been viewed as the primary driver of ICFS, recent evidence suggests that asset tangibility plays a critical role. However, this shift remains largely underexplored across industries and time horizons. In their influential paper, Fazzari et al. (1988) argue that observed ICFS signify the existence of financial constraints, as firms facing a greater cost wedge of external financing rely heavily on internal funds for investment, and by extension, ICFS can be considered a reasonable measure of financial constraints. Subsequent research has challenged these propositions, with a deluge of literature dedicated to identifying the determinants and origins of ICFS while casting doubt on the financial constraints perspective. While the matter remains unsettled, recent evidence shows that ICFS have been declining over time, raising further questions about what drives these sensitivities.

The aim of this paper is to shed light on the disappearing ICFS phenomenon by investigating whether ICFS can be explained by firm asset tangibility, or capital intensity, at the industry level. Contemporary investigations hint at this relationship. Moshirian et al. (2017) find that only firms with high proportions of tangible assets have investments that vary with cash flow, particularly among global manufacturing firms. Their findings suggest that ICFS are higher in developing countries, where capital intensity is greater, than in developed economies, casting doubt on financial constraints as an explanation for ICFS. Similarly, Guan et al. (2019) report evidence that ICFS have declined much more sharply for manufacturing firms compared to U.S. and Canadian energy firms, which sustain very high levels of asset tangibility. According to their data, financial constraints cannot explain variations in ICFS, whereas asset tangibility offers a more plausible explanation for these findings.

The asset tangibility hypothesis posits that only firms with high levels of physical assets exhibit greater ICFS. These capital-intensive firms invest to a higher degree, as the high marginal productivity of physical assets leads to stronger ICFS. At the industry level, the asset tangibility hypothesis makes two straightforward predictions. First, firms in industries maintaining high levels of asset tangibility should exhibit greater ICFS. If ICFS are positively related to asset tangibility, investment preferences in industries that prioritize physical assets should translate into higher ICFS. The second, corollary implication is that industries transitioning away from tangible assets over time should exhibit lower ICFS as capital intensity declines. As investments in intangible assets such as trademarks, databases, patents, and human capital have become essential in today's business environment, physical assets represent a diminishing proportion of a firm's total assets. Numerous studies have documented the growing preference for intangible investments over physical assets (Corrado and Hulten 2010, Moshirian et al. 2017, Peters and Taylor 2017, Orhangazi 2019), highlighting the importance of understanding how asset composition influences investment behaviour. As the physical asset structure of firms shifts over time, one would expect to see a corresponding change in ICFS.

I report evidence that directly supports these predictions. Utilizing two of the Fama and French industry classification schemes (hereafter, FF10 and FF46)[1], I show that asset tangibility explains variations in ICFS across industries and over time. The industry-based approach offers several advantages. Most ICFS research focuses primarily on manufacturing firms, even though ICFS likely result from a complex interplay of firm, industry, and macro-level factors. Examining ICFS across industries enables sharper tests of cross-sectional and time-series patterns. Additionally, industry-level variation in asset tangibility provides an ideal setting to assess ICFS trends. If asset tangibility significantly influences ICFS, we should observe this effect at the industry level.

[1]The Fama and French original classification schemes consist of 12 and 48 industry groups, respectively. For the purpose of this study, two industry groups are eliminated from the sample: "Finance" and "Non-classifiable" under the Fama 12 classification, and "Banking" and "Almost nothing" in the Fama 48 scheme.

The empirical analysis begins by examining industry-level trends in asset tangibility and ICFS over time. I then present descriptive statistics on firm and industry characteristics over the sample period. Investment in physical assets follows a downward trend among all but the most asset-heavy industries. The data reveal a consistent decline in asset tangibility across most industries, except for a few capital-intensive sectors such as Utilities and Oil, Gas & Coal, which have maintained, or slightly increased, their tangible asset base. Industry mean asset tangibility has fallen sharply for Telephone and Television (42%), Healthcare, Medical Equipment & Drugs (47%), and Business Equipment (49%). In contrast, Utility and Oil, Gas, & Coal products industries have seen an 11% gain in their physical asset base, while other industries experience only marginal changes over time. Capital expenditures show similar patterns, reinforcing the link between declining asset tangibility and lower ICFS. From these initial observations, the asset tangibility hypothesis predicts a more pronounced decline in ICFS in industries that have shifted away from physical capital, with a lesser effect for industries whose asset tangibility has remained stable, a pattern confirmed by the data.

Baseline tests are performed by industry and across sub-periods to identify patterns of ICFS, estimating panel regressions on seven-year sub-periods from 1977 to 2018. Consistent with prior literature, ICFS have been declining among manufacturing firms. Notably, this trend extends beyond manufacturing to all FF10 industries, even after controlling for firm and time fixed effects.

I next conduct panel regressions on terciles of industries sorted by industry-level asset tangibility. This approach is similar to that of Moshirian et al. (2017) and Larkin et al. (2018) who form portfolio groups in examining country-level ICFS. If asset tangibility is an essential factor in explaining ICFS patterns, one would expect capital-intensive industry groups to demonstrate greater levels of ICFS in every sub-period. Furthermore, ICFS should decline in line with reductions in asset tangibility. The results confirm that the highest-asset-tangibility tercile consistently shows greater sensitivities compared to the lowest tercile in every period, from 1977–1983 (0.601 vs. 0.195) through 2012–2018 (0.374 vs. 0.086). This pattern remains across both FF10 and FF46 classifications and is robust after controlling for alternative financing sources and different Q measures.

The asset tangibility hypothesis also predicts a corresponding shift in ICFS for industries that have reduced their physical assets. To test this, I conduct a series of analyses on sub-samples of firms and industries to examine the evolving relationship among cash flow, investment, and asset tangibility. Industries are categorized based on changes in asset tangibility from the first to the last time period, facilitating a clearer assessment of its impact over time. The results show that ICFS remains consistently higher in industries where asset tangibility has increased, while industries exhibiting the greatest decline in asset tangibility show the largest drop in ICFS. These findings reinforce the role of asset tangibility as a key determinant of the downward trajectory of ICFS.

A series of robustness checks are performed to confirm the validity of the results. To account for potential measurement error in *Q* identified in previous studies (Erickson and Whited 2000, 2002, Bond et al. 2004, Cummins et al. 2006, Erickson et al. 2014, Peters and Taylor 2017), I re-estimate models using the error-adjusted *Q* measure from Peters and Taylor (2017). I additionally incorporate changes in debt, equity, and cash holdings to show that alternative sources of financing cannot explain the time-series and industry patterns of ICFS. Furthermore, regressions that include an interaction term between cash flow and asset tangibility reveal a positive, statistically significant relationship, lending further support to the asset tangibility hypothesis.

To address endogeneity concerns, I conduct an instrumental variable analysis using a two-stage least squares (2SLS) approach. Following Campello and Giambona (2013) and Lei et al. (2018), I use *Industry Labor*, the industry-year median ratio of employees to total assets, and *Industry_Resale*, the ratio of sale of physical assets to total PP&E and capital expenditures as instruments for asset tangibility. The IV-2SLS results confirm the robustness of the main findings.

It is notable that this paper does not directly assess financial constraints in relation to ICFS for two key reasons. First, despite extensive debate since the 1980's, recent research finds little new evidence linking financial constraints to ICFS. Instead, mounting evidence suggests that financial constraints fail to explain ICFS trends (Chen and Chen 2012, Farre-Mensa and Ljungqvist 2015, Andrén and Jankensgård 2016, 2018). If financial constraints cannot explain ICFS, it is worth investigating factors that can. Second, and more importantly, the financial constraints explanation faces a significant problem when incorporating asset tangibility: firms with high proportions of physical assets would arguably be less financially constrained due to the greater collateralization potential of their asset base (Almeida and Campello 2007, Falato et al. 2013, Peters and Taylor 2017). Hence, the financial constraints theory suggests we would observe lower ICFS for these firms. The evidence reported in this paper finds the polar opposite, with high asset tangibility firms demonstrating consistently higher ICFS compared to firms with low proportions of physical assets, making the financial constraints theory fit worse, not better, to the data. There is clearly more to the story than financial constraints, this paper investigates this.

This study provides compelling evidence that asset tangibility is a first-order determinant of ICFS. My findings build upon Moshirian et al. (2017) who study a cross-country sample of manufacturing firms and find that only firms with high asset tangibility demonstrate significant ICFS, and that ICFS are higher in developing countries. Guan et al. (2019) also find persistent ICFS in heavy-physical-asset firms. Extending these insights, I document the effect of asset tangibility on ICFS across a broader spectrum of firms, showing that ICFS patterns can be well explained by variations in asset tangibility across industries. Firms in industries with a stable physical asset base tend to exhibit higher ICFS, while those shifting toward intangible investments experience sharp declines. By leveraging FF10 and FF46 industry classifications, this study offers a more granular perspective on ICFS trends, addressing gaps in prior research that primarily focused on manufacturing firms.

The rest of this paper is organized as follows. Section 2 reviews the relevant literature, providing a foundation and motivation for the study. Section 3 presents the empirical models and describes the data. Section 4 provides descriptive statistics. Section 5 presents the empirical results and discusses robustness checks. Section 6 concludes.

2. Prior literature

In *Q* theory, investment behaviour should be fully explained by marginal *Q*. However, Fazzari et al. (1988) document significant ICFS on a fifteen-year sample of manufacturing firms after controlling for *Q*, attributing the results to that of financial constraints. The authors suggest that ICFS is a valid measure of financial constraints because the firms that appear to be constrained *a priori* show higher ICFS in their sample. The logic is as follows: as firms facing financial constraints incur a higher cost to secure external finance, we would expect to see greater ICFS in these firms because they rely more on internally generated capital for their investment needs. Over the last thirty years, however, this viewpoint has encountered extensive criticism (Kaplan and Zingales 1997, Alti 2001, Chen and Chen 2012). Interestingly, a consistent pattern has emerged from the literature - a substantial decline in observed ICFS over time. Fazzari et al. (1988) and Kaplan and Zingales (1997) report sensitivities between 0.20-0.70 from 1970-1984. Cleary (1999) finds sensitivities of 0.05-0.15 in a six-year sample from 1988-1994, while Baker et al. (2003) report similar values from 1980-1999. Contemporary studies report even lower sensitivities with Erickson and Whited (2002) and Almeida et al. (2010) estimating ICFS of only 0.01-0.19. More recently, Andrén and Jankensgård (2016) report sensitivities of around 0.05 on a large sample from 1988-2014.

Critique of Fazzari et al. (1988)'s financial constraint hypothesis abounds. A key point of contention is that financial constraints are unobservable to the researcher, thus empirical results tend to hinge on various measures used to proxy financial constraint status. Kaplan and Zingales (1997) respond to the claims of Fazzari et al. (1988) in their publication, "Do investment-cash flow sensitivities provide useful measures of financing constraints?", with a succinct response: "No". They manually examined the annual reports of the firms classified as constrained by Fazzari et al. (1988) and found that firms which appear less constrained exhibit greater ICFS. This evidence suggests the relationship between ICFS and financial constraints is inconsistent, because if we see large ICFS in both constrained and unconstrained firms, then ICFS clearly cannot uniquely measure financial constraints.

Subsequent research has further challenged the interpretation of ICFS as a proxy for financial constraints. Cleary (1999) classifies firms based on firm characteristics reporting results in line with Kaplan and Zingales (1997) - that more constrained firms have lower ICFS. Gomes (2001) demonstrates that ICFS can be positive even in the absence of financing frictions. Similarly, Alti (2001) finds that ICFS cannot be a valid measure of financial constraints because positive sensitivities are observed even in frictionless markets. In a notable contribution, Chen and Chen (2012) show that ICFS do not increase even during the 2007-2009 financial crisis, a period where firms would face undeniable hurdles to secure external finance. They continue, showing that sensitivities have dropped to negligible levels, suggesting that firm-generated cash flow has little to no influence on investment. More recent studies place further doubt on the financial constraints hypothesis. Farre-Mensa and Ljungqvist (2015) test various financial constraint measures and find little evidence that these measures effectively predict which firms behave as though they are constrained.

Contrary to the financial constraints hypothesis, another stream of literature argues that asset tangibility, not financial constraints, drives ICFS. Almeida and Campello (2007) suggest a "credit multiplier effect", building on the work of Kiyotaki and Moore (1997) to imply a non monotonic effect of tangibility on ICFS. When firms invest more in physical assets, they experience a greater increase in marginal debt capacity. In the event of a positive cash flow shock, high asset tangibility amplifies the effect of that shock on investment spending; firms increase investment more dramatically because of the larger marginal debt capacity. Chen and Chen (2012) similarly suggest that firms with tangible revenue streams have higher verifiability than those relying heavily on intangible assets, making internal funds more informative and thus more strongly linked to investment.

Recent studies suggest a simpler, more intuitive explanation of how asset tangibility affects ICFS. Moshirian et al. (2017) argue that ICFS cannot be a measure of financial constraints but are merely a reflection of firm capital intensity. Examining time-series patterns of ICFS and asset tangibility globally, they report that only high tangible capital firms have investments that vary with cash flow. Under the capital intensity argument, the explanatory power of tangibility does not rely primarily on financial constraints but on the information content of a firm's tangible asset base. Because capital-intensive firms hold a higher proportion of tangible capital in total productive capital, they invest more heavily in physical assets, which in turn tends to boost ICFS. Guan et al. (2019) provide support for the asset tangibility hypothesis with evidence from the manufacturing and energy sectors. They find that while U.S. and Canadian energy firms, known for high asset tangibility, maintain more stable ICFS over time, manufacturing firms experience a sharp decline. Since financial constraints cannot explain why ICFS remains high in energy firms but falls in manufacturing, the authors conclude that asset tangibility is the more plausible driver.

Taken together, the literature offers compelling motivation for the asset tangibility hypothesis, with the capital intensity argument finding the most empirical support. At the industry level, the asset tangibility hypothesis has two main implications. First, industries with higher asset tangibility should exhibit greater ICFS. If asset tangibility is a principal determinant of ICFS, this effect should persist across time and be evident in every sub-period. The greater marginal productivity of tangible assets prompts more robust investment responses to internal cash flow, yielding higher ICFS. Second, declining asset tangibility should coincide with declining ICFS. As industries shift toward intangible assets, their marginal productivity can decrease, resulting in weaker investment responses to cash flow and lower ICFS.

3. Empirical Specification

The analysis begins with tests to explore trends in asset tangibility and its relationship with ICFS. These initial tests serve as a foundation to better understand how asset tangibility and ICFS have evolved over time and how their changes align with each other. By estimating yearly ICFS across industries and plotting trends in industry-level asset tangibility, I aim to capture overall patterns that highlight the role of asset tangibility in explaining variations in ICFS over time. This preliminary analysis acts as a diagnostic step, establishing descriptive insights before I proceed to more formal econometric testing.

Following these initial insights, I proceed with a series of panel regressions to systematically evaluate the relationship between ICFS and asset tangibility. Consistent with prior literature, the baseline empirical model follows the framework of Fazzari et al. (1988):

$$\frac{I_{i,t}}{TA_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 \frac{CF_{i,t}}{TA_{i,t-1}} + \beta_2 Q_{i,t-1} + \epsilon_{i,t} \tag{1}$$

where I represents firm-level capital expenditures (CAPEX)[2], and CF is cash flow measured as income before extraordinary items plus depreciation (IB + DP) for firm i at

[2]Compustat items in parentheses

time t. Both variables are deflated by beginning-of-period total assets, TA_{t-1} (TA) to control for firm size. $Q_{i,t-1}$ represents beginning-of-period Tobin's Q, defined as the market value of assets divided by total assets. The market value of assets is total assets minus book value of equity (SEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price (PRCC_F*CSHOC). Firm and time fixed effects, α_i and α_t, are included to control for unobserved heterogeneity across firms and time. The key coefficient of interest, β_1 measures the investment-to-cash flow sensitivity (ICFS) while β_2 captures the investment sensitivity to Q.

Eq.(1) implies that firm investment depends on Q, which proxies investment opportunity, as well as internally generated cash flow, CF. Fazzari et al. (1988) postulate only firms facing financial constraints should have investments which vary with cash flow as otherwise they could access external finance through debt or equity issuance for investment needs.

While estimates from Eq.(1) may offer insights into the overall association between asset tangibility and ICFS, firm-specific and time factors may obscure the interpretation of observed regression results. To address this, while ensuring comparisons of results with previous studies, I extend the analysis by estimating Eq.(1) separately across seven-year sub-periods from 1977-2018. Estimating the model across sub-periods facilitates the use of time effects to control for unobserved heterogeneity, while still being able to observe patterns over time.

Inspired by the methodology of Moshirian et al. (2017) and Larkin et al. (2018), I further the investigation by categorizing industries into tercile groups based on industry-average asset tangibility levels, as well as into groups reflecting changes in asset tangibility over time. I then estimate Eq.(1) across these industry groups to gain a clearer analysis of whether ICFS systematically differs across asset-intensive industries, along with an examination of industries that have experienced the most significant shifts in asset tangibility.

4. Sample

The sample is constructed using annual US firm data from the Compustat database spanning the period 1977-2018. To analyse trends over time, I divide the dataset into seven-year sub-periods: 1977-1983, 1984-1990, 1991-1997, 1998-2004, 2005-2011, and 2012-2018. To ensure consistency with previous research and mitigate the effects of outliers, filters are applied in the same manner found in the literature (Almeida et al. 2004, Chen and Chen 2012, Andrén and Jankensgård 2016, Moshirian et al. 2017). Firms are required to have valid observations for all variables in Eq.1. They must also have total assets, sales, and market capitalization of at least $1 million inflation-adjusted dollars. Additionally, all variables are winsorized at the 1st and 99th percentiles to minimize the possible distortion effects of outliers. Consistent with Allayannis and Mozumdar (2004), Andrén and Jankensgård (2016), and Moshirian et al. (2017), only firm-year observations with positive cash flow are retained to avoid distortions caused by negative cash flow. This ensures that the decline in ICFS is not artificially driven by an increasing prevalence of negative-income observations.

To construct industry groups, I classify firms into industries in line with the Fama-French industrial classification system to identify patterns at the industry level. The advantage of using the Fama-French classification system compared to sorting firms by broad SIC codes is that it better captures industry structural changes as firms have moved into technology over time. With the aim of collating industries on the basis of similar risk characteristics, Fama and French's reclassification makes some key changes. For example, Alexander and Eberly (2018) document that Facebook and Microsoft (SIC code 73) were reclassified from SIC Services to Fama-French High Technology. Similarly, Apple (SIC 35), originally categorized under SIC Manufacturing, is more appropriately aligned with the High Technology classification under the Fama-French framework.

Descriptive statistics are presented in Table 1. The table reports sample means, medians, and standard deviations by industry and sub-period for the key variables used in this study: investment, asset tangibility, cash flow, and Tobin's *Q*. Untabulated correlations do not suggest multicollinearity concerns, with all values below 0.5. A few key observations emerge. Consistent with the increasing importance of intangible assets, the proportion of physical assets to total assets follows a declining trend in nearly all industries. Average asset tangibility has fallen sharply for Telephone and Television (0.567 - 0.330), Healthcare, Medical Equipment& Drugs (0.340 - 0.182), and Manufacturing (0.342 - 0.266). In contrast, Utility and Oil, Gas, & Coal products has seen a slight gain in their physical asset base (0.606 - 0.674). This suggests that while physical assets have become generally less important overtime, as intangible assets play a stronger role in today's business environment, a few capital intensive industries maintain their strong reliance on physical assets for production output. Investment in physical assets follows a similar pattern, with declining capital expenditures contributing to lower asset tangibility. These findings suggest a fundamental shift in asset composition and investment behaviour across industries and time, providing an ideal empirical setting to examine the role of asset tangibility in explaining ICFS dynamics.

Table 1: Descriptive statistics - Fama - French 10 Industry classification by sub-periods

		Investment			Asset tangibility			Cash flow			Q			Obs
Industry	Period	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	n
Business Equipment	1977-1983	0.110	0.085	0.088	0.265	0.247	0.124	0.140	0.133	0.072	1.524	1.269	0.863	2291
	1984-1990	0.090	0.067	0.078	0.254	0.236	0.131	0.125	0.113	0.074	1.739	1.447	0.956	3076
	1991-1997	0.078	0.057	0.073	0.219	0.192	0.135	0.137	0.123	0.083	1.972	1.568	1.274	3320
	1998-2004	0.057	0.039	0.060	0.185	0.145	0.139	0.121	0.103	0.084	2.303	1.775	1.546	3248
	2005-2011	0.043	0.027	0.050	0.142	0.099	0.132	0.116	0.101	0.076	2.024	1.682	1.172	2937
	2012-2018	0.040	0.025	0.046	0.135	0.092	0.131	0.106	0.093	0.070	2.100	1.725	1.237	2633
Chemicals and Allied Products	1977-1983	0.087	0.073	0.064	0.354	0.333	0.138	0.128	0.121	0.058	1.227	1.029	0.570	696
	1984-1990	0.079	0.066	0.056	0.361	0.349	0.155	0.120	0.117	0.060	1.560	1.330	0.764	655
	1991-1997	0.071	0.060	0.051	0.375	0.365	0.175	0.118	0.116	0.060	1.720	1.514	0.804	717
	1998-2004	0.050	0.040	0.042	0.350	0.337	0.175	0.098	0.094	0.057	1.619	1.350	0.952	698
	2005-2011	0.051	0.039	0.044	0.301	0.283	0.153	0.114	0.103	0.066	1.724	1.494	0.850	658
	2012-2018	0.049	0.038	0.042	0.302	0.268	0.167	0.110	0.103	0.057	1.887	1.702	0.895	588
Consumer Durables	1977-1983	0.074	0.059	0.057	0.288	0.275	0.117	0.117	0.110	0.060	1.042	0.943	0.401	864
	1984-1990	0.071	0.058	0.056	0.279	0.270	0.121	0.108	0.103	0.059	1.337	1.202	0.491	791
	1991-1997	0.071	0.056	0.060	0.281	0.269	0.130	0.114	0.102	0.066	1.505	1.305	0.699	871
	1998-2004	0.062	0.049	0.055	0.276	0.264	0.127	0.109	0.101	0.065	1.474	1.267	0.778	784
	2005-2011	0.050	0.041	0.042	0.233	0.225	0.116	0.104	0.091	0.068	1.554	1.315	0.804	582
	2012-2018	0.052	0.043	0.038	0.225	0.220	0.102	0.108	0.100	0.058	1.651	1.488	0.756	530
Consumer NonDurables	1977-1983	0.072	0.059	0.057	0.305	0.290	0.145	0.114	0.108	0.060	1.016	0.897	0.455	2231
	1984-1990	0.078	0.063	0.065	0.311	0.303	0.155	0.117	0.109	0.068	1.498	1.265	0.815	1623
	1991-1997	0.067	0.052	0.060	0.311	0.294	0.175	0.113	0.105	0.064	1.633	1.388	0.927	1740
	1998-2004	0.054	0.041	0.049	0.297	0.272	0.176	0.110	0.100	0.067	1.602	1.298	0.945	1715
	2005-2011	0.048	0.035	0.046	0.252	0.211	0.163	0.111	0.097	0.070	1.761	1.464	1.044	1212
	2012-2018	0.047	0.037	0.040	0.242	0.211	0.156	0.107	0.096	0.066	1.933	1.600	1.174	1066
Healthcare, Medical Equipment, and Drugs	1977-1983	0.099	0.075	0.080	0.340	0.306	0.169	0.129	0.122	0.065	1.731	1.396	1.116	803
	1984-1990	0.085	0.065	0.074	0.313	0.279	0.168	0.122	0.107	0.077	2.022	1.589	1.243	1134
	1991-1997	0.074	0.059	0.064	0.286	0.259	0.164	0.132	0.121	0.075	2.325	1.869	1.382	1607
	1998-2004	0.056	0.044	0.052	0.229	0.201	0.146	0.132	0.121	0.081	2.397	1.893	1.546	1708
	2005-2011	0.046	0.035	0.043	0.200	0.165	0.139	0.126	0.113	0.076	2.213	1.872	1.253	1506
	2012-2018	0.038	0.028	0.039	0.182	0.135	0.145	0.109	0.095	0.074	2.240	1.860	1.339	1133
Manufacturing	1977-1983	0.084	0.066	0.065	0.342	0.315	0.151	0.114	0.110	0.057	1.060	0.943	0.480	4425
	1984-1990	0.077	0.062	0.062	0.343	0.320	0.159	0.108	0.104	0.058	1.302	1.167	0.540	3525
	1991-1997	0.070	0.055	0.056	0.338	0.309	0.167	0.112	0.103	0.064	1.459	1.266	0.711	3613
	1998-2004	0.055	0.042	0.051	0.328	0.302	0.166	0.099	0.090	0.060	1.426	1.220	0.741	3314
	2005-2011	0.047	0.035	0.043	0.271	0.235	0.157	0.108	0.096	0.068	1.598	1.379	0.812	2475
	2012-2018	0.043	0.033	0.040	0.266	0.220	0.169	0.094	0.087	0.055	1.651	1.461	0.817	2144
Oil, Gas, and Coal Extraction and Products	1977-1983	0.213	0.187	0.129	0.606	0.627	0.173	0.148	0.139	0.079	1.653	1.310	1.083	1234
	1984-1990	0.121	0.092	0.100	0.636	0.677	0.191	0.108	0.104	0.064	1.251	1.107	0.623	1013
	1991-1997	0.172	0.130	0.127	0.651	0.678	0.194	0.130	0.120	0.075	1.415	1.274	0.623	1128
	1998-2004	0.171	0.137	0.124	0.676	0.715	0.203	0.144	0.130	0.083	1.491	1.360	0.656	1055
	2005-2011	0.190	0.157	0.129	0.646	0.681	0.212	0.163	0.153	0.086	1.695	1.516	0.813	1038
	2012-2018	0.151	0.113	0.121	0.674	0.722	0.207	0.121	0.108	0.078	1.434	1.202	0.894	912
Telephone and Television Transmission	1977-1983	0.150	0.128	0.105	0.567	0.587	0.270	0.132	0.125	0.056	1.264	1.046	0.584	422
	1984-1990	0.115	0.101	0.090	0.523	0.554	0.259	0.132	0.125	0.072	1.658	1.369	0.957	487
	1991-1997	0.105	0.092	0.084	0.448	0.428	0.237	0.129	0.124	0.074	1.912	1.645	0.972	678
	1998-2004	0.092	0.073	0.075	0.426	0.432	0.231	0.127	0.111	0.087	1.773	1.493	1.019	991
	2005-2011	0.083	0.073	0.060	0.399	0.385	0.214	0.135	0.119	0.082	1.602	1.408	0.732	988
	2012-2018	0.070	0.063	0.053	0.330	0.315	0.203	0.120	0.110	0.067	1.534	1.355	0.659	832
Utilities	1977-1983	0.112	0.102	0.058	0.808	0.847	0.107	0.083	0.078	0.025	0.920	0.882	0.169	1758
	1984-1990	0.082	0.073	0.050	0.772	0.803	0.115	0.081	0.082	0.023	1.035	1.024	0.177	1538
	1991-1997	0.071	0.063	0.043	0.738	0.756	0.113	0.077	0.076	0.024	1.142	1.127	0.154	1356
	1998-2004	0.070	0.061	0.042	0.661	0.672	0.155	0.074	0.071	0.033	1.218	1.180	0.279	932
	2005-2011	0.079	0.067	0.054	0.637	0.654	0.151	0.071	0.065	0.035	1.248	1.192	0.321	864
	2012-2018	0.077	0.072	0.041	0.659	0.706	0.177	0.065	0.061	0.028	1.255	1.213	0.242	714
Wholesale, Retail, and Some Services	1977-1983	0.095	0.072	0.083	0.339	0.306	0.195	0.106	0.099	0.058	1.048	0.923	0.425	2939
	1984-1990	0.099	0.070	0.090	0.346	0.310	0.212	0.104	0.095	0.064	1.452	1.233	0.709	2678
	1991-1997	0.090	0.061	0.091	0.329	0.282	0.222	0.106	0.094	0.065	1.601	1.299	0.907	2949
	1998-2004	0.079	0.055	0.076	0.330	0.269	0.234	0.105	0.092	0.068	1.560	1.240	0.985	2899
	2005-2011	0.060	0.046	0.057	0.304	0.246	0.234	0.106	0.097	0.063	1.650	1.392	0.895	2069
	2012-2018	0.060	0.043	0.057	0.290	0.231	0.214	0.107	0.094	0.066	1.910	1.506	1.143	1766

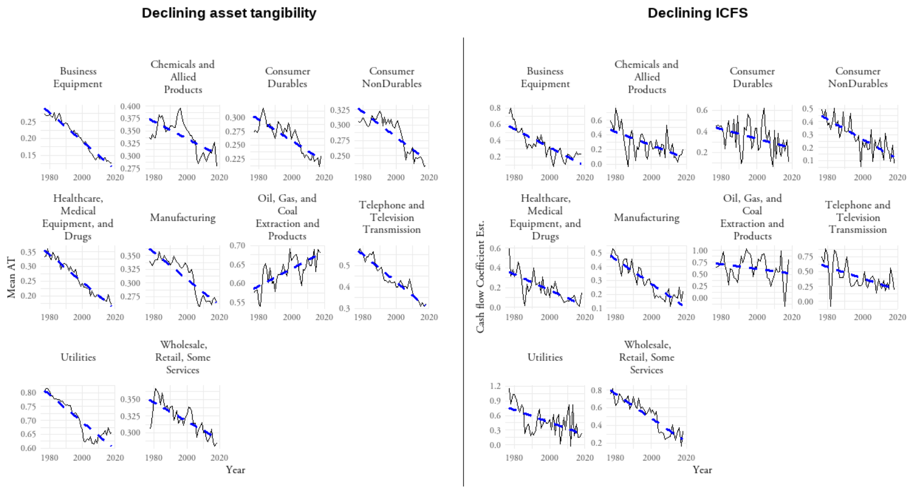
[1] Table reports the industry-level mean, median, and standard deviation values across the 7-year subperiods for the key variables used in the study. Investment is firm capital expenditure (CAPX) deflated by the beginning of period total assets; asset tangibility is the proportion of property, plant, and equipment (PP&E) to total assets; cash flow is income before extraordinary items plus depreciation scaled by beginning of period total assets; and Q is Tobin's Q proxied by firm market-to-book ratio.

5. Empirical results

5.1. Descriptive trends in ICFS

I begin with descriptive patterns and correlations of asset tangibility and ICFS over time. In all but the heavily asset-dependant Oil, Gas, and Coal Extraction industry, I document a falling trend in asset tangibility across the sample period. This is consistent with the general adoption of intangible assets across industries and over time. Echoing previous findings, I document a declining trend in ICFS among manufacturing firms from 1977 to 2019. Importantly, this declining trend is observed in all of the FF10 industries.

I estimate Eq.(1) without fixed effects on a yearly basis across the FF10 industries. This approach allows for an observation of the unadjusted relationship between cash flow and investment over time and across industries, providing a baseline perspective on ICFS trends. Figure 1 plots yearly mean asset tangibility and the ICFS estimates from annual regressions of Eq.(1), conducted cross-sectionally for each of the FF10 industries. The left panel shows the year-by-year change in asset tangibility, highlighting the shift from physical to intangible assets across industries. In parallel, the right panel charts the yearly estimates of the cash flow coefficient from Eq.(1), emphasizing a consistent downward trajectory in ICFS. This decline is particularly pronounced in manufacturing and technology-intensive sectors, underscoring the reduced dependency on tangible asset bases over time.



Note: Figure presents declining trends in average asset tangibility (left panel) and cash flow coefficient estimates (right panel)for the 10 Fama and French industries over time. Black line represents yearly estimates of the cash flow coefficient from Eq.(1) (without fixed effects) while the blue line shows linear trend over the sample.

Figure 1: Declining ICFS across industries

Correlations between the yearly ICFS and mean yearly asset tangibility are reported in Table 2. Six of the ten industries exhibit strong positive correlations above 0.5, with the highest correlations observed in Business Equipment (0.788) and Manufacturing (0.771). In contrast, the Oil, Gas, and Coal Extraction industry displays a slight negative correlation of -0.139, reflecting a modest increase in asset tangibility while still demonstrating a decline in ICFS over the sample period. Collectively, these results support the hypothesis that higher asset tangibility is associated with greater ICFS, while industries shifting toward intangible investments exhibit weaker sensitivities.

Table 2: Fama-French 10 Industry correlations between ICFS and AT

Industry	Correlation
Business Equipment	0.788
Chemicals and Allied Products	0.226
Consumer Durables	0.349
Consumer NonDurables	0.653
Healthcare, Medical Equipment, and Drugs	0.710
Manufacturing	0.771
Oil, Gas, and Coal Extraction and Products	-0.139
Telephone and Television Transmission	0.605
Utilities	0.475
Wholesale, Retail, Some Services	0.721

Note: Table presents correlations of yearly industry mean asset tangibility and the cash flow coefficient from Model 1 (without fixed effects) estimated by year across the Fama French 10 industries.

5.2. *Cash flow sensitivities - industry evidence*

I next test the relationship between ICFS and asset tangibility formally with fixed effects regressions along numerous avenues. Table 3 shows baseline regression results from Eq.1 across the FF10 industries. These findings reveal several notable patterns. First, in line with prior research, ICFS have consistently declined for manufacturing firms, falling from 0.358 to 0.096 over the sample period, with higher levels observed in earlier periods. Manufacturing firms also display a positive and significant Tobin's Q coefficient over time. Second, the results highlight a striking trend across the entire sample, ICFS have declined sharply across all industries.

Consistent with the asset tangibility hypothesis, industries that maintain higher proportions of physical assets exhibit significantly greater ICFS. For instance, the ICFS coefficient is 0.594 and statistically significant at the 1% level for high-tangibility Oil, Gas, and Coal Extraction firms during the 1977–1983 period, remaining relatively high at 0.218 in the 2012–2018 period. Conversely, ICFS for Telephone and Television firms decline from 0.307 in the first period to just 0.053 in the last period. These industry-level differences in ICFS challenge the financial constraints explanation while providing strong support for the asset tangibility hypothesis. Under the financial constraints hypothesis, higher ICFS levels should correspond to greater financing frictions. However, the evidence suggests that these results are unlikely to reflect binding financial constraints across entire industries, a far-fetched scenario. Firms with more physical assets available for collateral should face fewer financing constraints, which would traditionally be expected to result in lower ICFS. Instead, the opposite pattern is observed. More plausibly, these differences in sensitivities suggest that firms in high-asset-tangibility industries are more capital-intensive, leading them to invest more, which in turn results in higher ICFS.

Table 3: Baseline Investment regressions - Fama-French 10 industries by sub-periods

Industry	Period	Cash flow	T-stat	Q	T-stat	Adj. R-sq	n
Business Equipment	1977-1983	0.341	8.590	0.008	1.988	0.570	2291
	1984-1990	0.240	7.909	0.016	5.568	0.500	3076
	1991-1997	0.144	7.155	0.011	5.903	0.678	3320
	1998-2004	0.135	7.322	0.008	6.816	0.564	3248
	2005-2011	0.074	4.948	0.006	4.142	0.694	2937
	2012-2018	0.086	4.105	0.005	5.244	0.742	2633
Chemicals and Allied Products	1977-1983	0.462	4.556	0.032	2.895	0.564	696
	1984-1990	0.260	4.030	0.021	3.096	0.553	655
	1991-1997	0.155	2.057	0.021	2.579	0.366	717
	1998-2004	-0.026	-0.299	0.016	2.433	0.506	698
	2005-2011	0.048	1.322	0.009	2.282	0.717	658
	2012-2018	0.024	0.664	0.019	4.756	0.607	588
Consumer Durables	1977-1983	0.248	4.819	0.024	3.163	0.597	864
	1984-1990	0.324	6.198	-0.010	-1.342	0.462	791
	1991-1997	0.198	4.512	0.024	3.612	0.620	871
	1998-2004	0.221	3.650	0.008	1.685	0.649	784
	2005-2011	0.061	1.799	0.012	1.955	0.699	582
	2012-2018	0.086	2.908	0.008	1.318	0.626	530
Consumer NonDurables	1977-1983	0.266	5.658	0.017	3.321	0.552	2231
	1984-1990	0.321	5.968	0.007	1.305	0.482	1623
	1991-1997	0.190	4.702	0.017	3.344	0.552	1740
	1998-2004	0.119	4.381	0.015	3.849	0.526	1715
	2005-2011	0.122	3.772	0.010	4.327	0.573	1212
	2012-2018	0.129	3.438	0.007	2.816	0.625	1066
Healthcare, Medical Equipment, and Drugs	1977-1983	0.364	4.287	0.030	4.047	0.573	803
	1984-1990	0.153	2.835	0.020	4.333	0.460	1134
	1991-1997	0.150	4.845	0.012	4.622	0.496	1607
	1998-2004	0.084	2.991	0.008	4.089	0.509	1708
	2005-2011	-0.002	-0.085	0.009	4.591	0.494	1506
	2012-2018	0.049	1.876	0.006	3.115	0.468	1133
Manufacturing	1977-1983	0.358	10.512	0.016	2.433	0.465	4425
	1984-1990	0.272	9.237	0.022	4.706	0.400	3525
	1991-1997	0.165	7.756	0.012	3.586	0.509	3613
	1998-2004	0.131	5.548	0.013	4.575	0.556	3314
	2005-2011	0.072	3.435	0.014	4.749	0.598	2475
	2012-2018	0.096	4.323	0.012	4.257	0.607	2144
Oil, Gas, and Coal Extraction and Products	1977-1983	0.594	9.123	0.025	4.733	0.647	1234
	1984-1990	0.322	3.812	0.034	4.634	0.480	1013
	1991-1997	0.522	7.473	0.036	3.144	0.615	1128
	1998-2004	0.376	6.545	0.024	2.258	0.646	1055
	2005-2011	0.308	5.994	0.029	3.528	0.709	1038
	2012-2018	0.218	3.494	0.014	1.083	0.738	912
Telephone and Television Transmission	1977-1983	0.307	1.746	0.042	2.183	0.661	422
	1984-1990	0.232	2.712	0.019	2.472	0.774	487
	1991-1997	0.381	3.897	0.014	2.742	0.744	678
	1998-2004	0.066	1.377	0.016	3.648	0.624	991
	2005-2011	0.146	4.077	0.008	1.913	0.737	988
	2012-2018	0.053	2.629	0.002	0.290	0.767	832
Utilities	1977-1983	0.839	7.916	0.055	2.371	0.577	1758
	1984-1990	0.742	7.068	0.086	3.628	0.472	1538
	1991-1997	0.322	3.180	0.045	2.668	0.649	1356
	1998-2004	0.268	2.861	0.026	1.764	0.568	932
	2005-2011	0.217	2.140	0.057	4.193	0.736	864
	2012-2018	0.084	1.037	0.046	3.866	0.752	714
Wholesale, Retail, and Some Services	1977-1983	0.587	10.832	0.027	3.606	0.620	2939
	1984-1990	0.354	7.371	0.031	5.307	0.682	2678
	1991-1997	0.235	5.688	0.036	8.996	0.701	2949
	1998-2004	0.182	4.518	0.021	6.398	0.654	2899
	2005-2011	0.072	2.069	0.023	6.097	0.695	2069
	2012-2018	0.065	1.724	0.016	4.918	0.749	1766

Note: Table reports coefficients estimated from the regression of physical investment on cash flow and Tobin's *Q*. Data is taken from the Compustat universe, including firms with valid observations from Eq.(1). Firms with extreme sales or asset growth (>100%) are excluded to limit M&A effects. Firms with negative cash flow are removed. Sales and total assets are adjusted for inflation, requiring $1 million thresholds. Standard errors are clustered at the firm level.

5.3. *Asset tangibility and ICFS*

To further examine the role of asset tangibility in ICFS, industries are sorted into terciles based on level of asset tangibility. For each sub-period, I first calculate each industry's average asset tangibility then rank the industries from largest to smallest tangibility, finding the thresholds which split the distribution into three equal-sized groups. The top tercile contains the most capitally intense industries, while the bottom tercile consists of the industries with the lowest levels of asset tangibility. This sorting method captures time variation in asset tangibility at the industry level, as industries may shift between terciles when their asset composition changes over time. Table A1 illustrates the sorting mechanism. As the FF10 sample represents a quite broad spectrum of industries, little change is observed over the sample period where one industry moves to a higher or lower tercile. Conversely, the finer breakdown in industry classification in the FF46 scheme facilitates greater movement of industries in the terciles over time.

For each industry tercile in every sub-period, I estimate the baseline regression equation using year, firm, and industry fixed effects. Regression results are reported in Table 4,with Panel A using the FF10 classification and Panel B using the FF46 classification.

The findings are consistent with baseline results and support the asset tangibility hypothesis. Panel A shows that while ICFS has declined in all terciles under the FF10 classification, industries with low asset tangibility exhibit significantly lower ICFS (0.060) compared to firms in high-asset-tangibility industries (0.193) in the final period. Similar patterns emerge under the FF46 classification in Panel B, where ICFS remains higher for capital-intensive industries compared to industries with lower asset tangibility in each sub-period.

These differences in ICFS between terciles reflect variations in capital intensity. Firms in capital-intensive industries tend to invest more, leading to substantially higher ICFS. This effect is observed in every sub-period and is robust across both classification schemes, providing strong evidence that asset tangibility is a key determinant of ICFS.

Table 4: Industry terciles - level of asset tangibility

Tercile	Period	Cash flow	T-stat	Q	T-stat	Adj. Rsqr	n
Panel A: Fama 10							
High AT industries	1977-1983	0.608	11.346	0.035	7.811	0.708	3414
	1984-1990	0.394	6.519	0.032	5.631	0.573	3038
	1991-1997	0.470	9.019	0.027	4.331	0.718	3162
	1998-2004	0.227	6.296	0.024	5.870	0.695	2978
	2005-2011	0.285	8.012	0.025	4.595	0.779	2890
	2012-2018	0.193	4.695	0.012	1.571	0.764	2458
Avg AT industries	1977-1983	0.376	12.303	0.024	5.016	0.499	5924
	1984-1990	0.300	12.159	0.027	7.699	0.578	6858
	1991-1997	0.177	8.790	0.026	9.598	0.626	7279
	1998-2004	0.134	6.296	0.018	8.004	0.629	6911
	2005-2011	0.085	3.724	0.018	8.047	0.660	5202
	2012-2018	0.061	4.369	0.015	7.499	0.694	4498
Low AT industries	1977-1983	0.368	14.840	0.014	4.562	0.600	8325
	1984-1990	0.241	10.701	0.016	7.706	0.487	6624
	1991-1997	0.163	11.046	0.013	9.388	0.612	7538
	1998-2004	0.126	9.451	0.009	9.603	0.553	7455
	2005-2011	0.076	5.188	0.008	7.340	0.629	6237
	2012-2018	0.060	5.984	0.006	6.551	0.667	5362
Panel B: Fama 46							
High AT industries	1977-1983	0.565	12.732	0.039	10.384	0.642	6335
	1984-1990	0.418	10.174	0.036	8.666	0.590	5940
	1991-1997	0.344	10.659	0.035	8.388	0.666	6548
	1998-2004	0.222	7.795	0.022	7.448	0.640	6313
	2005-2011	0.200	8.054	0.027	7.400	0.701	5621
	2012-2018	0.150	4.967	0.019	4.218	0.701	5006
Avg AT industries	1977-1983	0.404	14.183	0.023	4.874	0.576	7433
	1984-1990	0.327	11.888	0.017	5.122	0.526	5215
	1991-1997	0.200	10.399	0.020	9.415	0.560	7060
	1998-2004	0.178	9.652	0.015	8.940	0.594	6419
	2005-2011	0.086	4.868	0.011	8.029	0.634	5629
	2012-2018	0.068	5.810	0.012	8.117	0.686	5083
Low AT industries	1977-1983	0.326	13.411	0.012	4.022	0.570	6980
	1984-1990	0.215	11.132	0.018	8.687	0.534	8558
	1991-1997	0.111	8.852	0.012	8.160	0.672	8309
	1998-2004	0.101	7.886	0.008	8.913	0.607	9010
	2005-2011	0.073	6.452	0.007	6.805	0.687	6879
	2012-2018	0.062	4.795	0.005	5.829	0.756	6060

Note: Table reports coefficients estimated from the regression of physical investment on cash flow and beginning period Q from Eq.(1) on industry terciles based on mean asst tangibility for each sub-period. Panel A utilizes the Fama-French 10 industry classification while Panel B uses the Fama-French 46 industry classification scheme.

5.4. Changes in asset tangibility

Thus far, the evidence points to a clear relationship between asset tangibility and ICFS. A key question in this study is whether the decline in observed ICFS can be explained by changes in asset tangibility. While this study focuses on asset tangibility as a primary determinant of ICFS, other structural and financial factors may also contribute to the observed trends. Notably, even firms with high asset tangibility have experienced a decline in ICFS, as shown in the previous section.

However, if asset tangibility is a key determinant of ICFS, we would expect industries with the greatest reduction in tangible assets to exhibit the largest decline in ICFS. Moshirian et al. (2017) provide global evidence of this effect, noting that manufacturing firms in developing countries, which rely more on physical assets, tend to exhibit higher ICFS. They attribute this pattern to shifts in asset tangibility, as developed nations have increasingly invested in intangible assets, leading to lower capital intensity and a corresponding decline in ICFS. To test this hypothesis, I categorize industries into three groups based on the percentage change in asset tangibility from the first (1977–1983) to the last (2012–2018) sub-period. This categorization allows for a direct comparison of ICFS trends across industries that have either maintained, moderately reduced, or substantially decreased their asset tangibility.

I isolate industries that have experienced only a marginal change or an increase in asset tangibility from those that have undergone a moderate or substantial decline. Table A2 presents the sorting results. Using both the FF10 and FF46 industry classifications, I construct two samples to enhance robustness. The cutoffs for classification are chosen to ensure equal-sized terciles in the FF10 classification and to differentiate industries in the FF46 classification based on their changes in asset tangibility over time. Compared to sorting by asset tangibility levels, sorting by changes in tangibility allows for greater within-group variation in capital-intensive industries, offering more precise testing of the relationship. I then estimate Eq.(1) on each industry group. If capital intensity is a determinant of ICFS, we should observe a lower ICFS, and a more pronounced decline, among industries that have experienced the greatest reduction in asset tangibility, relative to industries that have maintained their tangible asset levels.

The results, presented in Table 5, support this hypothesis. Panel A reports estimates using the FF10 classification, while Panel B presents results for the FF46 classification. Across both panels, the cash flow coefficient declines in all groups over time, confirming the broader downward trend in ICFS documented in the literature. However, the coefficient remains systematically higher for firms in industries that have experienced only marginal changes or increases in asset tangibility. In contrast, industries that have seen a substantial decline in tangible assets exhibit a significantly steeper drop in ICFS. In Panel B, the decline in ICFS is much more pronounced in the substantial decline group (from 0.363 to 0.067) compared to the increase group (from 0.504 to 0.229). These findings align with the conjecture of Moshirian et al. (2017) and suggest that as firms transition toward intangible assets, their investment behaviour becomes less sensitive to internally generated cash flow. This shift weakens ICFS over time, reinforcing the role of asset tangibility as a key determinant of ICFS dynamics.

Table 5: Industry groups by change in asset tangibility

Group	Period	Cash flow	T-stat	Q	T-stat	Adj. Rsqr	n
Panel A: Fama 10							
Marginal change	1977-1983	0.513	15.794	0.036	10.632	0.708	7100
	1984-1990	0.345	10.858	0.025	7.077	0.600	5969
	1991-1997	0.294	10.592	0.030	10.019	0.684	6534
	1998-2004	0.205	8.166	0.021	8.337	0.701	6367
	2005-2011	0.203	7.915	0.019	7.150	0.789	4977
	2012-2018	0.167	5.161	0.013	5.121	0.770	4332
Moderate decline	1977-1983	0.343	14.628	0.011	3.479	0.540	7580
	1984-1990	0.257	12.622	0.018	8.295	0.462	7392
	1991-1997	0.157	11.184	0.012	7.580	0.612	7804
	1998-2004	0.141	9.878	0.009	8.773	0.573	7346
	2005-2011	0.077	6.816	0.008	6.524	0.659	5994
	2012-2018	0.092	6.451	0.007	6.709	0.686	5307
Substantial decline	1977-1983	0.429	6.060	0.036	5.568	0.610	2983
	1984-1990	0.232	5.185	0.020	5.023	0.558	3159
	1991-1997	0.220	6.807	0.012	5.377	0.633	3641
	1998-2004	0.082	3.472	0.011	6.332	0.591	3631
	2005-2011	0.068	3.191	0.010	5.537	0.684	3358
	2012-2018	0.056	3.298	0.007	3.494	0.710	2679
Panel B: Fama 46							
Increase	1977-1983	0.504	7.573	0.029	5.921	0.647	1449
	1984-1990	0.314	4.366	0.033	4.924	0.488	1206
	1991-1997	0.441	7.220	0.044	4.276	0.622	1391
	1998-2004	0.279	4.914	0.032	3.350	0.641	1304
	2005-2011	0.259	5.632	0.025	3.754	0.708	1310
	2012-2018	0.229	4.092	0.014	1.253	0.725	1244
Marginal decline	1977-1983	0.430	15.857	0.022	5.128	0.560	11157
	1984-1990	0.383	14.554	0.027	8.737	0.574	9726
	1991-1997	0.218	11.274	0.027	10.869	0.626	10301
	1998-2004	0.196	10.003	0.015	8.753	0.597	9406
	2005-2011	0.119	6.858	0.017	8.597	0.585	7516
	2012-2018	0.071	4.352	0.015	8.916	0.627	6749
Substantial decline	1977-1983	0.363	14.074	0.020	6.557	0.639	8142
	1984-1990	0.202	10.756	0.016	8.233	0.574	8781
	1991-1997	0.136	10.240	0.012	9.568	0.672	10225
	1998-2004	0.105	8.298	0.010	10.759	0.625	11032
	2005-2011	0.070	6.720	0.008	7.994	0.719	9303
	2012-2018	0.067	6.062	0.005	6.459	0.775	8156

Note: Table reports coefficients estimated from the regression of physical investment on cash flow and beginning period Q from Eq.(1) on industry terciles based on the percentage change of mean tangibility from sub-period 1977-1983 to 2012-2018. Fama10 groups are sorted into three equal groups: marginal change, moderate decline, and substantial decline. The Fama46 industries are sorted as follow: Increase(positive change), marginal decline(below 30% change), and substantial decline (greater than 30% change in asset tangibility.

5.5. Robustness checks

The results presented so far provide strong evidence that asset tangibility is a key determinant of ICFS. To further validate these findings and rule out alternative explanations, I conduct a series of robustness checks. These tests address concerns related to alternative financing sources, measurement error in Tobinls Q, and potential endogeneity.

5.5.1. Other sources of finance and measurement error in Q

The availability and opportunity of external financing is theorized to affect both investment and ICFS. Examining ICFS on a global level, Larkin et al. (2018) argue that access to equity financing in developed countries is a key channel through which country-level financial development affects ICFS. This perspective aligns with the financial constraints hypothesis, which suggests that improved access to external financing should alleviate financial constraints, leading to lower ICFS. A potential concern is that the observed industry differences in ICFS, and the overall decline in sensitivities over time, may simply reflect increased reliance on external funding sources for investment. If this were the case, we would expect external finance variables to explain most of the variation in ICFS, overshadowing the effect of asset tangibility. Another concern is measurement error in Tobin's Q, which could bias ICFS estimates. Some studies argue that Q may be measured with significant error, leading to spurious correlations between investment and cash flow (Erickson and Whited 2000). To address this issue, Peters and Taylor (2017) propose an improved *Total Q* measure that accounts for intangibles and provides a more accurate proxy for investment opportunities. To test for these potential confounding effects, I extend the baseline regression to include *Total Q* as well as changes in debt, equity issuance, and cash holdings as additional explanatory variables. These variables capture the extent to which firms rely on external financing sources.

$$\frac{I_{i,t}}{TA_{i,t-1}} = \alpha_i + \alpha_t + \alpha_j + \beta_1 \frac{CF_{i,t}}{TA_{i,t-1}} + \beta_2 \frac{\Delta Debt_{i,t}}{TA_{i,t-1}} + \beta_3 \frac{\Delta Equity_{i,t}}{TA_{i,t-1}} + \beta_4 \frac{\Delta Cash_{i,t}}{TA_{i,t-1}} + \beta_5 Qpt_{t-1} + \epsilon_{i,t} \tag{2}$$

where $I_{i,t}$ is capital expenditures (CAPEX) and $CF_{i,t}$ is a measure of cash flow for firm i at time t. $\Delta Debt$, is the period-on-period change of the sum of total debt and current liabilities (DLC + DLTT). $\Delta Cash$ is the period-on-period change of cash and cash equivalents (CHE), while $\Delta Equity$ is the change of book equity (SEQ) minus the change in retained earnings (RE). As in Eq.(1), variables are deflated by beginning-of-period total assets, TA_{t-1} (TA). *Qpt* is the *Q* measure of Peters and Taylor (2017) catalogued in the Compustat database. Industry fixed effects, α_j, are added to control for unobserved heterogeneity at the industry level. I then repeat the tests in Section 5.3 with the control variables to add robustness to the initial results.

The robustness checks here are conducted in two steps, first estimating Eq.(2) as detailed above, and then estimating all models found in this investigation with the improved *Q* measure. Table 6 tabulates the findings across the industry terciles[3] sorted on asset tangibility. Changes in debt are positively associated with investment and statistically significant in several periods, indicating that firms with greater borrowing capacity are able to finance investments externally. This effect is more pronounced in high-asset-tangibility industries, consistent with the notion that firms with more collateralizable assets have higher debt capacity. Changes in cash holdings exhibit a negative relationship with investment, suggesting that firms may accumulate cash as a precautionary buffer rather than immediately deploying it for capital expenditures (Opler et al. 1999). While these external financing variables influence investment decisions to some extent, they do not alter the core ICFS patterns across asset tangibility terciles. The relationship between ICFS and asset tangibility remains robust after controlling for these factors. In addition, utilizing the improved *Q* measure cannot explain the patterns across the asset tangibility terciles. In untabulated results, I re-estimate all models with Peter and Taylor's (2017) corrected *Q* and find that the ICFS patterns remain consistent. These findings align with Ağca and Mozumdar (2017) who test numerous methods to tackle the error-in-variables problem, reporting ICFS cannot be attributed to measurement error in *Q* alone. Taken together, these robustness checks indicate that while external financing sources and *Q* measurement issues may play a role in explaining investment

[3]For the sake of brevity, results from the Fama French 46 industry are tabulated. Analogous results are observed utilizing both the Fama French 10 and 46 classifications in robustness tests.

behaviour, they do not account for the strong relationship between ICFS and asset tangibility.

Table 6: Investment regressions - other sources of finance

Tercile	Period	CF	T-stat	$\Delta debt$	T-stat	$\Delta equity$	T-stat	$\Delta cash$	T-stat	Qpt	T-stat	Adj Rsqr	n
High AT	1977-1983	0.564	11.784	0.010	2.149	0.072	2.561	-0.024	-1.289	0.038	10.164	0.647	6281
	1984-1990	0.424	10.457	0.008	1.558	-0.032	-1.119	-0.035	-3.094	0.036	8.820	0.597	5869
	1991-1997	0.345	10.822	0.022	2.310	0.002	0.083	-0.020	-2.342	0.034	8.081	0.669	6426
	1998-2004	0.224	7.824	0.004	3.589	0.031	0.692	-0.014	-1.846	0.021	7.054	0.639	6224
	2005-2011	0.202	8.172	0.040	1.055	-0.053	-1.141	-0.014	-1.778	0.025	6.799	0.703	5517
	2012-2018	0.138	4.739	0.020	1.168	0.041	0.441	-0.011	-1.047	0.020	4.871	0.699	4936
Avg AT	1977-1983	0.398	14.234	0.014	1.559	0.009	0.350	-0.034	-5.413	0.024	5.908	0.591	7350
	1984-1990	0.345	12.229	0.004	3.339	0.038	1.211	-0.007	-0.699	0.016	4.707	0.535	5157
	1991-1997	0.198	10.375	0.001	9.319	-0.021	-1.091	-0.002	-0.533	0.019	8.885	0.567	6924
	1998-2004	0.186	10.020	0.003	0.550	-0.011	-0.468	-0.019	-2.565	0.014	8.303	0.602	6247
	2005-2011	0.070	5.072	0.000	-2.657	0.035	1.814	-0.004	-0.385	0.010	7.612	0.640	5477
	2012-2018	0.091	6.187	0.002	1.506	-0.002	-0.049	-0.026	-2.890	0.010	7.202	0.706	4965
Low AT	1977-1983	0.320	12.851	0.003	5.143	0.042	2.037	-0.018	-3.006	0.011	3.672	0.585	6875
	1984-1990	0.218	11.611	0.017	4.497	0.002	0.115	-0.016	-3.319	0.016	8.058	0.553	8406
	1991-1997	0.115	9.016	0.009	3.839	0.003	0.275	-0.007	-1.724	0.011	7.226	0.676	8032
	1998-2004	0.105	7.952	0.000	0.640	0.004	0.209	0.002	0.553	0.008	8.589	0.616	8699
	2005-2011	0.080	6.891	0.000	0.844	-0.001	-0.011	-0.010	-2.078	0.007	6.268	0.698	6619
	2012-2018	0.063	4.783	0.027	1.802	0.027	0.741	-0.006	-1.423	0.005	5.926	0.745	5860

Note: Table reports estimate results from Eq.(2) across industry groups sorted by mean asset tangibility. $\Delta debt$ is period change of total debt, while $\Delta equity$ and $\Delta cash$ are period changes of total equity and cash holdings, respectively. Qpt is Peters and Taylor (2017)'s Total Q measure.

5.5.2. Investment-cash flow-tangible capital sensitivity

Moshirian et al. (2017) suggest that ICFS is, in essence, an *investment-cash flow-tangible capital sensitivity*, as firms with low tangible capital do not exhibit systematic sensitivity of investment to cash flow. The authors report a positive and significant interaction between cash flow and asset tangibility, indicating that firms with higher tangible capital exhibit stronger ICFS. Similar findings have been documented by Guan et al. (2019), who analyze manufacturing and energy firms from 1981 to 2005, and Almeida and Campello (2007) , who conduct comparable tests on a sample from 1985 to 2000. To investigate whether this effect holds at the industry level, I estimate a modified regression model that includes an interaction term between cash flow and asset tangibility. This approach provides a more direct test of whether industries with higher tangible capital exhibit stronger ICFS. The model is estimated across the same industry terciles as in Section 5.3:

$$\frac{I_{i,t}}{TA_{i,t-1}} = \alpha_i + \alpha_t + \alpha_j + \beta_1 \frac{CF_{i,t}}{TA_{i,t-1}} + \beta_2 AT_{i,t-1} + \beta_3 \left(\frac{CF_{i,t}}{TA_{i,t-1}} \times AT_{i,t-1} \right) + \beta_4 \frac{\Delta debt_{i,t}}{TA_{i,t-1}} + \beta_5 \frac{\Delta equity_{i,t}}{TA_{i,t-1}} + \beta_6 \frac{\Delta cash\ holdings_{i,t}}{TA_{i,t-1}} + \beta_7 Qpt_{i,t-1} + \epsilon_{i,t} \tag{3}$$

where Eq.(3) augments Eq.(2) with asset tangibility (AT) and its interaction term with cash flow(*CFxAT*), which serves to assess the effect of asset tangibility on ICFS. A positive and significant β_3 coefficient then represents an interaction effect, estimating the change of investment on cash flow given a one unit change in asset tangibility. Industry fixed effects α_j are added to control for unobserved heterogeneity at the industry level.

Before interpreting the results, it is important to reiterate the caution emphasized by Almeida and Campello (2007) in interpreting estimates from interaction models with continuous variables. In a linear specification, the estimated coefficients may not always lend themselves to straightforward interpretation. For example, to asses the partial effect of cash flow on investment at a particular level of asset tangibility, say z, it is necessary to compute $\beta_1 + (\beta_3 \times z)$. Following, the estimate β_1 in Eq.(3) represents ICFS when asset tangibility equals zero and conversely, β_2 is the investment - asset tangibility sensitivity when cash flow equals zero. In this manner, the conclusions offered by Moshirian et al.

(2017) and Guan et al. (2019) regarding the coefficient β_1 are somewhat unclear as it says little about the effect of cash flow on investment with the inclusion of the cross product term β_3, with the effect being outside of the distribution (asset tangibility = 0).[4]

Despite these nuances of interpretation, the results are clear. Table 7 reports a positive and significant coefficient on the cross-product term of cash flow and asset tangibility (CFxAT) across the industry terciles and all periods. These findings provide additional evidence that asset tangibility is a fundamental determinant of ICFS dynamics.

Table 7: Investment-cash flow-tangible capital sensitivities

Tercile	Period	CF	T-stat	AT	T-stat	CFxAT	T-stat	$\Delta debt$	T-stat	$\Delta equity$	T-stat	$\Delta cash$	T-stat	*Qpt*	T-stat	Adj Rsqr	n
High AT	1977-1983	0.026	0.252	-0.196	-5.439	0.942	5.374	0.011	2.265	0.067	2.301	-0.029	-1.486	0.038	10.279	0.652	6281
	1984-1990	0.105	1.429	-0.134	-5.483	0.610	4.462	0.009	1.587	-0.041	-1.406	-0.036	-3.016	0.036	8.859	0.601	5869
	1991-1997	-0.059	-0.927	-0.091	-3.408	0.718	5.906	0.023	2.466	0.000	0.017	-0.021	-2.478	0.035	8.718	0.673	6426
	1998-2004	-0.151	-2.840	-0.145	-6.848	0.663	6.609	0.005	4.056	0.022	0.506	-0.016	-2.061	0.022	7.484	0.646	6224
	2005-2011	-0.152	-3.620	-0.123	-6.095	0.668	7.449	0.029	0.648	-0.050	-1.009	-0.017	-2.062	0.026	7.346	0.711	5517
	2012-2018	-0.119	-2.683	-0.083	-4.066	0.487	4.547	0.023	1.416	0.046	0.447	-0.013	-1.297	0.021	5.077	0.704	4936
Avg AT	1977-1983	0.087	1.590	-0.176	-7.081	0.830	5.370	0.014	1.561	0.009	0.357	-0.034	-5.314	0.025	6.073	0.597	7350
	1984-1990	0.074	1.153	-0.160	-5.359	0.753	3.984	0.003	2.372	0.036	1.150	-0.007	-0.739	0.016	4.771	0.539	5157
	1991-1997	0.038	0.889	-0.146	-5.655	0.511	3.960	0.001	9.503	-0.022	-1.151	-0.002	-0.461	0.019	9.054	0.571	6924
	1998-2004	-0.021	-0.569	-0.139	-5.508	0.658	5.573	0.004	0.700	-0.007	-0.303	-0.021	-2.820	0.015	8.987	0.610	6247
	2005-2011	-0.002	-0.066	-0.080	-3.492	0.256	2.516	0.000	-2.729	0.035	1.761	-0.004	-0.424	0.010	7.706	0.641	5477
	2012-2018	-0.023	-0.956	-0.088	-3.983	0.424	4.146	0.002	1.468	-0.010	-0.257	-0.026	-2.743	0.011	7.840	0.710	4965
Low AT	1977-1983	0.095	2.046	-0.205	-6.935	0.856	4.714	0.003	4.733	0.037	1.773	-0.017	-2.892	0.011	3.647	0.590	6875
	1984-1990	0.022	0.618	-0.186	-6.018	0.737	5.412	0.017	4.942	0.003	0.175	-0.016	-3.384	0.017	8.345	0.559	8406
	1991-1997	0.028	1.019	-0.096	-4.162	0.377	2.918	0.009	3.793	0.005	0.473	-0.007	-1.799	0.011	7.447	0.678	8032
	1998-2004	-0.032	-1.660	-0.137	-5.848	0.666	5.896	0.000	0.767	0.003	0.171	0.001	0.367	0.009	9.175	0.627	8699
	2005-2011	-0.042	-2.309	-0.141	-5.471	0.773	5.302	0.000	0.927	0.025	0.493	-0.011	-2.120	0.007	6.937	0.710	6619
	2012-2018	-0.024	-1.327	-0.097	-2.843	0.632	3.802	0.027	1.746	0.036	0.816	-0.009	-1.960	0.005	6.110	0.752	5860

Note: Table reports estimate results from Eq.(3) across industry groups sorted by mean asset tangibility. *CFxAT* is the cross-product term of *CF*, cash flow, and *AT*, asset tangibility. $\Delta debt$ is period change of total debt, while $\Delta equity$ and $\Delta cash$ are period changes of total equity and cash holdings, respectively. *Qpt* is Peters and Taylor (2017)'s Total Q measure. Standard errors clustered at firm level.

[4]For a detailed explanation on the interpretation of interaction effects of continuous variables see Jaccard et al. (1990)

5.6. Instrumental variables

I next conduct an instrumental variable analysis to address endogeneity concerns. A potential concern is that the relationship between asset tangibility and ICFS may be endogenous. Firms with certain unobservable characteristics may simultaneously influence both their level of tangible assets and their sensitivity of investment to cash flow. To address this, I re-estimate Eq.(3) with the IV-2SLS approach. I follow Campello and Giambona (2013) and Lei et al. (2018) in selecting two instruments for asset tangibility, *Industry Labor* and *Industry Resale*.

The first instrument, *Industry Labor*, is defined as the industry-year median ratio of the number of employees to total assets. Since industries with higher labour intensity often rely less on tangible assets, *Industry Labor* provides a relevant measure of asset tangibility within a given sector. The second instrument, *Industry Resale*, serves as a proxy for the liquidity of the market for second-hand machinery and equipment within a firm's industry. The idea is that industries where physical capital is more easily resold are more likely to maintain higher asset tangibility levels. *Industry Resale* is constructed as the ratio of the median firm-level sales of property, plant, and equipment (SPPE) to the sum of total PP&E (PPEGT) and capital expenditures (CAPX). A higher ratio indicates a more active second-hand market with strong supply and demand conditions. In a highly liquid secondary market, firms can acquire used equipment at lower costs and integrate it into their production processes while also reducing the financial burden of holding tangible assets on their balance sheets. As a result, asset tangibility is expected to be influenced by the liquidity of machinery and equipment within an industry.

While no instrument may be perfect, the validity of the instrumental variables are closely considered. For a variable to serve as a valid instrument, it must be correlated with the endogenous regressor, the relevance requirement, and uncorrelated with the error term, the exclusion restriction. Column 1 in Table 8 reports significant signs on the two instruments in the first-stage regressions, confirming they are both correlated with asset tangibility and satisfying the relevance requirement. In untabulated results, I conduct the Sargan test for overidentification, which tests whether the instruments are correlated with the second-stage residuals. The results indicate that the instruments do not exhibit significant correlation with the error term, providing no statistical evidence against the exclusion restriction. The second-stage IV-2SLS estimates in Column 2 remain consistent with the baseline findings in Column 3, showing a positive and significant cross-product term of cash flow and asset tangibility. These results reinforce the hypothesis that industries with higher asset tangibility exhibit greater ICFS.

In summary, after addressing potential endogeneity, my previous findings remain intact, confirming that asset tangibility strengthens the sensitivity of investment to cash flow.

Table 8: Instrumental variables regression

	First Stage 2SLS	Second Stage 2SLS	OLS
IndustryLabor	-1.842^{***}		
	(0.328)		
IndustryResale	-1.249^{***}		
	(0.328)		
CashFlow	0.103^{***}	-0.336^{**}	-0.038^{***}
	(0.010)	(0.108)	(0.009)
$\Delta debt$	0.000	0.001^{*}	0.001^{*}
	(0.000)	(0.000)	(0.001)
$\Delta equity$	0.008	0.005	0.006
	(0.009)	(0.007)	(0.006)
$\Delta cash$	0.020^{***}	-0.013^{***}	-0.016^{***}
	(0.002)	(0.001)	(0.002)
Q	-0.011^{***}	0.013^{***}	0.014^{***}
	(0.001)	(0.001)	(0.001)
AssetTangibility		-0.346^{**}	-0.044^{***}
		(0.109)	(0.005)
CashFlow $\times$ *AssetTangibility*		1.696^{***}	0.784^{***}
		(0.332)	(0.028)
Firm Effects	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes
Num. obs.	115864	115864	115864
R^2 (within)	0.387	0.082	0.201

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Note: Table presents results from Eq. 3 using the instrumental variable 2SLS method, and standard OLS. Industry Resale is the median ratio of firm-level PP&E sales (SPPE) to total PP&E (PPEGT) and capital expenditures (CAPX), while Industry Labor is the median ratio of employees to total assets. Column 1 shows the first-stage, and Column 2 shows the second-stage results of the 2SLS regression. Column 3 shows the results of the standard OLS model. All continuous variables are winsorized at the 1% level, with firm-clustered standard errors in parentheses.

6. Conclusion

The decline in ICFS observed in recent decades has raised new questions about its underlying drivers. While prior research has largely focused on financial constraints as the primary explanation, few studies have comprehensively examined industry-level differences in ICFS. This study investigates ICFS patterns over time and across industries, providing strong evidence that asset tangibility is a key determinant of ICFS.

First, I document an industry-wide decline in ICFS over time. While much of the prior literature has focused on U.S. manufacturing firms, this study expands the scope to a broader set of industries. Previous research has primarily excluded financial and utility firms (Schleicher et al. 2010, André et al. 2014, Lewellen and Lewellen 2016), but few studies have systematically examined how ICFS varies across industries. By extending the analysis to a more diverse set of industries, this study complements prior findings and provides a more comprehensive view of the relationship between investment, cash flow, and tangible assets.

Next, I explore the asset tangibility hypothesis as a determinant of ICFS. This hypothesis posits that the proportion of tangible assets in a firm's total asset base influences investment behaviour, leading firms with high asset tangibility to exhibit greater sensitivity of investment to cash flow. The results consistently support this hypothesis. I find that industries with higher asset tangibility maintain stronger ICFS, whereas industries transitioning to a greater extent toward intangible assets experience steep declines in ICFS. As firms increasingly invest in intangible assets, the proportion of physical assets relative to total assets declines, contributing to weaker ICFS over time.

Finally, I demonstrate that the decline in ICFS cannot be fully explained by access to external financing or measurement error in Tobin's Q. The findings indicate that the explanatory power of asset tangibility is not driven by financial constraints. According to the financial constraints hypothesis, firms with greater access to collateral should experience lower ICFS due to reduced financing frictions. However, the results contradict this prediction, suggesting that differences in ICFS across industries are more likely driven by capital intensity rather than financing constraints.

The evidence presented in this paper provides robust support for asset tangibility as a first-order determinant of ICFS. The findings have important implications for the literature. First, they suggest future research in the investment-cash flow relationship account for capital intensity in their investigations. Second, they challenge the prevailing literature's continued reliance on the ICFS-financial constraints relationship, which has been shown to be inconsistent. This study not only underscores the importance of asset tangibility in shaping ICFS but also calls for further exploration of asset composition's role in influencing modern financing behaviour.

While this study focuses on asset tangibility as a primary determinant of ICFS, further research is needed to fully understand the declining ICFS puzzle. Future research should further investigate the role of intangible assets in shaping ICFS, exploring new measures to estimate intangibles. As the increasing reliance on intellectual property, software, and brand equity may have distinct implications for investment behaviour. Additionally, a deeper decomposition of asset tangibility, differentiating between machinery, real estate, and other fixed assets, could provide more granular insights into how specific asset types influence firm-level ICFS trends.

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Appendix

Table A1: Comparison of asset tangibility sorts - first and last periods

1977-1983			2012-2018		
Tercile	Industry	Mean AT	Tercile	Industry	Mean AT
High AT Industry	Business Supplies	0.431	High AT Industry	Agriculture	0.413
	Candy & Soda	0.462		Business Supplies	0.390
	Coal	0.524		Coal	0.552
	Communication	0.567		Communication	0.330
	Entertainment	0.552		Entertainment	0.501
	Healthcare	0.514		Non-Metallic and Industrial Metal Mining	0.580
	Non-Metallic and Industrial Metal Mining	0.537		Petroleum and Natural Gas	0.685
	Personal Services	0.477		Precious Metals	0.667
	Petroleum and Natural Gas	0.615		Real Estate	0.400
	Precious Metals	0.461		Restaurants, Hotels, Motels	0.504
	Real Estate	0.433		Shipbuilding, Railroad Equipment	0.333
	Restaurants, Hotels, Motels	0.627		Shipping Containers	0.345
	Shipping Containers	0.486		Steel Works Etc	0.372
	Transportation	0.605		Transportation	0.602
	Utilities	0.808		Utilities	0.658
Avg AT Industry	Agriculture	0.400	Avg AT Industry	Automobiles and Trucks	0.247
	Automobiles and Trucks	0.307		Beer & Liquor	0.315
	Beer & Liquor	0.397		Candy & Soda	0.268
	Business Services	0.313		Chemicals	0.325
	Chemicals	0.383		Construction Materials	0.324
	Construction Materials	0.375		Consumer Goods	0.188
	Fabricated Products	0.346		Electronic Equipment	0.201
	Food Products	0.370		Fabricated Products	0.234
	Pharmaceutical Products	0.301		Food Products	0.274
	Retail	0.336		Healthcare	0.258
	Rubber and Plastic Products	0.361		Machinery	0.188
	Shipbuilding, Railroad Equipment	0.311		Personal Services	0.278
	Steel Works Etc	0.406		Retail	0.310
	Textiles	0.340		Rubber and Plastic Products	0.324
	Trading	0.294		Textiles	0.295
Low AT Industry	Aircraft	0.258	Low AT Industry	Aircraft	0.153
	Apparel	0.175		Apparel	0.166
	Computers	0.263		Business Services	0.148
	Construction	0.279		Computers	0.105
	Consumer Goods	0.275		Construction	0.130
	Defense	0.287		Defense	0.163
	Electrical Equipment	0.266		Electrical Equipment	0.181
	Electronic Equipment	0.263		Insurance	0.023
	Insurance	0.194		Measuring and Control Equipment	0.117
	Machinery	0.269		Medical Equipment	0.143
	Measuring and Control Equipment	0.237		Pharmaceutical Products	0.165
	Medical Equipment	0.273		Printing and Publishing	0.165
	Printing and Publishing	0.256		Recreation	0.099
	Recreation	0.225		Tobacco Products	0.089
	Tobacco Products	0.275		Trading	0.106
	Wholesale	0.231		Wholesale	0.150

Note: Table shows Fama French industries sorted into terciles based on industry-average asset tangibility in first period of analysis (left column) and last period (right column).

Table A2: Industry groups by change in asset tangibility

Sample	Group	Industry	1977-1983	2012-2018	% change
Fama 10	Marginal change	Oil, Gas, and Coal Extraction and Products	0.606	0.674	0.112
		Chemicals and Allied Products	0.354	0.302	-0.145
		Wholesale, Retail, and Some Services (Laundries, Repair Shops)	0.339	0.290	-0.146
	Moderate decline	Utilities	0.808	0.658	-0.185
		Consumer NonDurables	0.305	0.244	-0.198
		Consumer Durables	0.288	0.225	-0.220
	Substantial decline	Manufacturing	0.342	0.265	-0.225
		Telephone and Television Transmission	0.567	0.330	-0.418
		Healthcare, Medical Equipment, and Drugs	0.340	0.182	-0.465
		Business Equipment	0.265	0.134	-0.495
Fama 46	Increase	Precious Metals	0.461	0.667	0.448
		Petroleum and Natural Gas	0.615	0.685	0.113
		Non-Metallic and Industrial Metal Mining	0.537	0.580	0.081
		Shipbuilding, Railroad Equipment	0.311	0.333	0.071
		Coal	0.524	0.552	0.053
		Agriculture	0.400	0.413	0.031
	Marginal decline	Transportation	0.605	0.602	-0.004
		Apparel	0.175	0.166	-0.053
		Real Estate	0.433	0.400	-0.076
		Retail	0.336	0.310	-0.078
		Steel Works Etc	0.406	0.372	-0.085
		Entertainment	0.552	0.501	-0.092
		Business Supplies	0.431	0.390	-0.094
		Rubber and Plastic Products	0.361	0.324	-0.103
		Textiles	0.340	0.295	-0.133
		Construction Materials	0.375	0.324	-0.135
		Chemicals	0.383	0.325	-0.150
		Utilities	0.808	0.658	-0.185
		Restaraunts, Hotels, Motels	0.627	0.504	-0.196
		Automobiles and Trucks	0.307	0.247	-0.197
		Beer & Liquor	0.397	0.315	-0.207
		Electronic Equipment	0.263	0.201	-0.235
		Food Products	0.370	0.274	-0.259
		Shipping Containers	0.486	0.345	-0.290
	Substantial decline	Machinery	0.269	0.188	-0.300
		Consumer Goods	0.275	0.188	-0.314
		Electrical Equipment	0.266	0.181	-0.318
		Fabricated Products	0.346	0.234	-0.323
		Wholesale	0.231	0.150	-0.349
		Printing and Publishing	0.256	0.165	-0.355
		Aircraft	0.258	0.153	-0.408
		Personal Services	0.477	0.278	-0.417
		Communication	0.567	0.330	-0.418
		Candy & Soda	0.462	0.268	-0.419
		Defense	0.287	0.163	-0.431
		Pharmaceutical Products	0.301	0.165	-0.451
		Medical Equipment	0.273	0.143	-0.476
		Healthcare	0.514	0.258	-0.498
		Measuring and Control Equipment	0.237	0.117	-0.508
		Business Services	0.313	0.148	-0.528
		Construction	0.279	0.130	-0.535
		Recreation	0.225	0.099	-0.558
		Computers	0.263	0.105	-0.600
		Trading	0.294	0.106	-0.638
		Tobacco Products	0.275	0.089	-0.678
		Insurance	0.194	0.023	-0.879

Note: This table demonstrates industry sorting into groups based on the percentage change of asset tangibility from sub-period 1977–1983 to 2012–2018. Fama 10 industries are sorted into three equal groups: marginal change, moderate decline, and substantial decline. The Fama 46 industries are sorted as follows: Increase (positive change), marginal decline (below 30% change), and substantial decline (greater than 30% change in asset tangibility).

Paper II

Do financial resources determine cost behaviour?

Håkan Jankensgård & Nick Christie

1. Introduction

A seminal study in the cost management literature concludes costs are less responsive to decreases in business activity compared to similar-sized increases (Andersen, Banker, and Janakiraman, 2003, henceforth ABJ). Such an asymmetrical response to changes in revenue – known as 'sticky costs' – has been shown by subsequent research to be pervasive across time and industries. Sticky costs are consistent with a model of cost behaviour in which, during periods of falling revenue, firms will anticipate revenue growth will resume, and in which firms that cut costs too aggressively stand to benefit less from such future revenue growth. That is, it is rational to keep some excess capacity when it can be assumed that revenue will, more likely than not, revert to its growth trajectory. Firm-years with revenue growth indeed outnumber those in which revenue decreases by a ratio of approximately three to one.

A model of cost behaviour in which firms can freely choose to defer capacity reductions – and operate with higher costs in anticipation of a rebound – implies an absence of binding constraints. In this study, we hypothesize that financial constraints can get in the way of such optimizing behaviour. Stated in simple terms, our hypothesis implies costs become less sticky the more financially constrained firms become. Firms that are constrained by a lack of financial resources need to prioritize survival and strategic investments, and as a consequence, begin cutting costs much sooner in response to falling revenue. Healthier firms, in contrast, do not risk survival by the wait-and-see approach and may therefore cut costs less aggressively. Ours is essentially a risk management argument: financially weak firms manage the risk of bankruptcy by adjusting their cost structure to a larger extent than their more well-capitalized peers. We also conjecture, in line with Jensen's agency costs of free cash flow-hypothesis (Jensen, 1986) that excessive financial slack may be conducive to poor cost discipline and higher cost stickiness as firms shielded by ample financial resources neglect to adapt to changing circumstances.

The relation between financial resources and cost behaviour is examined using a sample of U.S. manufacturing firms between 1984 and 2018. We follow the literature in using selling, general, and administrative costs (SG&A) as our main dependent variable. The same baseline regressions as in ABJ (2003) are implemented, allowing us to confirm a statistically and economically significant level of cost stickiness in our sample. There is a difference of -0.084 in the elasticity of SG&A with respect to the logarithmic change in sales in firm-years in which revenue decreases (hereafter this difference is referred to as 'cost stickiness'). We then proceed to sort firms into groups according to *a priori* measures of financial constraints, drawing on an extensive literature relating financial constraints to investment behaviour. As we shall see, the data strongly support the hypothesis that lack of financial resources constrain sticky cost behaviour. The hypothesis that agency costs of financial slack leads to higher stickiness by way of poorer cost discipline, however, is not supported by the data. In fact, while we are able to verify that excessive financial slack does lead to higher levels of stickiness, these outcomes coincide with superior cost efficiency.

Our first analysis maps out cost stickiness as a function of three widely used measures of financial status: leverage, the Kaplan-Zingales (KZ) index, and Altman's Z-score. A similar pattern emerges for all three measures. In accordance with the hypothesis, the most constrained quartile consistently displays the least cost stickiness. Sorting the sample into quartiles of leverage, the least leveraged quartile has a cost stickiness of -0.204. For firms in the high-leverage quartile, in contrast, the corresponding estimate is 0.021. The intermediate quartiles have relatively similar stickiness estimates (of about -0.10). That is, whereas other firms exhibit a cost behaviour consistent with the sticky cost-model, high-leverage firms do not. In the KZ and Z-score sorts we also find that cost stickiness all but disappears in the financially weakest quartile (-0.027 and 0.014, respectively) but remains negative and large among the firms furthest removed from financial distress (-0.161 and -0.243)

A possible objection to these results is that the sorting criteria we use captures not only financial resources but also correlates with other firm characteristics which have a strong degree of influence on cost behaviour. Indeed, this sort of concern has long plagued the literature investigating the role of financial constraints in shaping investment behaviour (see, for example, Kaplan and Zingales, 1997). To address this possibility, and to better isolate the effect of leverage, we carry out leverage sorts after first sorting firms into quartiles according to firm size (using total assets as our measure of size). The resulting 4x4 matrix is revealing. Cost stickiness tends to be below -0.20 in large firms characterized by low leverage, and even reaches as low as -0.309 in the lowest leverage quartile. These results clearly suggest large firms with lots of financial slack enjoy the most latitude to act in accordance with the sticky cost-model. Smaller firms with a significant amount of debt, in contrast, do not have this luxury and need to adapt their cost structure much more quickly to drops in demand. For these firms, cost stickiness again goes towards zero.

We next examine the hypothesis that above-baseline levels of stickiness are driven by poor cost discipline. The idea, as noted above, is that firms get lazy when they accumulate financial resources, which shields them from the discipline imposed by capital markets. To this end, we map out, according to the same size-leverage matrix, the median values of measures of cost efficiency and Q. This analysis yields a pattern that points the other way, however, namely to high-stickiness firms having *better* cost discipline and overall efficiency. From this we draw the important conclusion that levels of cost stickiness which far exceed the baseline should not automatically be taken to suggest sub-optimal cost behaviour, even when ample financial slack is present. One explanation for lower cost efficiency in the category of firms characterized by this "non-sticky" behaviour is that catching up in years of revenue growth is inefficient and costly, and that the accumulation of adjustment costs pushes the overall cost level up (see Biddle, 2014. p. 205).

While the findings with respect to cost efficiency allow us to refute the agency costs of financial slack-hypothesis, it does introduce an omitted variable problem in our analysis of the relation between financial resources and sticky costs. Both financial resources and cost efficiency seem capable of explaining patterns in cost stickiness. The fundamental reason for this endogeneity is likely that capital structure over time adapts to cost efficiency in the sense that less profitable firms need to tap into borrowing more often to keep themselves going, leading to higher leverage. More efficient and profitable firms, in contrast, accumulate equity in the form of retained earnings. The problem afflicting inferences based on comparisons of subgroups with different cost efficiency is that these groups differ in terms of their ex-ante probability of a decrease in revenue, which we also show. This probability of a decrease is an important input for managers when they resolve the trade-off between keeping and adjusting the cost structure. Our strategy is therefore to apply filters that ensure the sub-samples have equal decrease-probabilities, defined as the fraction of firm-years in which there is a decrease in revenue.

To equalize decrease-probabilities across sub-samples, we re-estimate the model after homogenizing the sample by removing firms for which the sum of SG&A and cost of goods sold exceed revenue, which is our proxy for economic distress (similar to e.g. Allayannis and Mozumdar, 2004). We also limit the sample by excluding the 1st and 4th quartiles in terms of cost efficiency. We are able to confirm that the relevant sub-groups after these filters have very similar decrease-probabilities that align with the sample average. Moreover, we also incorporate cash holdings into this analysis because firms can offset the constraining effect of debt by keeping cash reserves which allows flexibility to maneuver without reliance on capital markets. Comparing the sub-samples with high leverage-low cash (constrained firms) and low leverage-high cash (unconstrained firms), we find that it is, controlling for size and cost efficiency, the group lacking in financial resources that displays the highest level of cost stickiness (-0.125 vs -0.023).

To drill deeper into the role of financial constraints in shaping firms' cost behaviour we proceed to analyze its effects on two other aspects of firms' cost structure: purchases and number of employees. Purchases is a novel measure in the sticky cost-literature that, we argue, better captures variable costs than the one hitherto used in the literature (cost of goods sold). Purchases is calculated as cost of goods sold adjusted for the change in inventory and is therefore a more cash effective measure than cost of goods sold itself, which is a periodized number. Whereas the literature has found little or no stickiness for cost of goods sold, we find a substantial anti-stickiness for purchases. That is, firms respond to a decrease in revenue by adjusting purchases down more in percentage terms. Again, financial resources strongly influence this tendency. Repeating our leverage-cash sorts, controlling for size and cost efficiency to equalize decrease-probabilities, we find that firms with few financial resources have higher anti-stickiness than their more well-capitalized counterparts. This is further evidence that financially weak firms manage their risk by aggressively adjusting their cost structure to fluctuations in product demand. The analysis based on the number of employees as a proxy for costs yields the same conclusion.

This study makes its primary contribution to the literature on cost behaviour. As we have already seen, sticky costs were first conceptualized and empirically investigated in the cost management literature by ABJ (2003). In their paper, the authors show that various factors influence the magnitude of the asymmetry observed in the baseline regressions, such as the length of the estimation period and whether decreases occur in successive periods. Several subsequent papers have further explored factors that influence the extent of cost stickiness. These studies have shown sticky costs to be a function of factors such as capacity utilization (Balakrishnan et al., 2004), legal regimes with respect to unionization (Banker and Chen, 2006), and corporate governance (Xue and Hong, 2016), to name but a few. The paper closest to ours is Li and Zheng (2017), who report that the interaction between cost stickiness and product market dynamics is influenced by firms' financial strength. Also related are Cheng, Jiang, and Zeng (2018), who find that the degree of cost stickiness varies with the degree of regional financial development in China. Also exploring the connection between financial factors and sticky costs, Costa and Habit (2020) find an association between trade finance and cost stickiness. We add to this literature by providing a comprehensive investigation into the role of financial resources in shaping cost behaviour, both in terms of constraining sticky cost behaviour as well as evidence of relevance to the agency cost of financial slack-hypothesis. We are also the first to analyze the cost stickiness of purchases as opposed to the traditional but less precise proxy for variable costs, namely cost of goods sold.

The results presented in this study also contribute to the literature investigating the flexibility costs of debt, which is to say the negative effect on firms' ability to flexibly adjust to changes in their environment arising from a need to prioritize debt servicing (Friedrich and Zator, 2020). Friedrich and Zator (2020) find significant differences in the response to an exogenous shock to demand between firms burdened by high levels of debt and those less financially constrained. Those with less debt were able to launch strategic initiatives to counteract the demand shortfall, such as initiating exports to new markets, introducing new products and innovating more. Further illustrating the connection between real outcomes and binding financial constraints, Giroud and Mueller (2016) show that job losses were more accentuated in high-leverage firms during the financial crisis in the late 2000's. Another strand has also found that financial resources influence product market behaviour (e.g. Fresard, 2010). Almeida et al. (2011) instead investigate investment behaviour and find an excess reduction in capital expenditure among firms with a more acute need to service debt following the crisis in the late 2000's. We add to the literature on the flexibility costs of debt by providing broad-sample evidence of a persistent tendency for financially constrained firms to shed costs and employees disproportionately more in response to revenue shocks, as well as evidence suggesting that the accumulation of adjustment costs diminish these firms' overall cost efficiency. Our results support the view that excessive adjustments to cost structure is an important component of financial distress with implications for risk management and capital structure decisions.

The paper proceeds as follows. Section 2 reviews the literature and outlines the hypotheses to be tested. Section 3 contains a description of the sample, variables, and empirical model. Section 4 presents the results from the empirical tests. Section 5 concludes the paper.

2. Literature review and hypothesis development

The model of sticky costs should be understood relative to the basic model in the cost management-literature, which is that costs can be divided into fixed and variable components, where the latter rise and fall in direct proportion to business activity (Noreen, 1991). This traditional view in cost accounting thus supposes that the level of change in costs is independent of the direction of the change in business activity.

While the phenomenon of asymmetric cost responses reach back to Germany in the 1920's (see Brasch, 1927), ABJ (2003) were the first in this literature to develop an intuitive explanation of this cost behaviour. According to ABJ (2003), the way costs respond to changes in activity reflect a conscious managerial decision rather than a mechanical rule. When demand is increasing, managers typically commit the necessary resources to support this expansion. When faced with a decrease in demand, however, they must assess whether this drop is temporary or not before deciding to remove previously committed resources. They must also assess the magnitude of adjustment costs in the form of things like severance pay (when workers are dismissed) and training (when they are later hired to support renewed growth). Stickiness of SG&A costs, the authors state, "occurs if managers decide to retain un-utilized resources rather than incur adjustment costs when volume declines." In their empirical study, ABJ (2003) find, consistent with the sticky cost-model, that SG&A costs respond differently to decreases in activity. Whereas SG&A respond by a 0.55% increase when revenue goes up by 1%, the corresponding number for a 1%-decrease is 0.35%.

The literature that has ensued following the ABJ (2003) paper has investigated various circumstances affecting the degree to which firms conform to the sticky cost-model. Balakrishnan et al (2004) study the impact of capacity utilization. Using data from U.S. therapy clinics, they find that there is less cost stickiness when there is already excess capacity, suggesting that clinics respond more promptly to decreases in activity in these cases. Here, sticky cost behaviour comes about not only because managers choose to retain un-utilized capacity when activity falls, but also because they counteract falling demand by lowering prices. When demand increases, in contrast, they add capacity but do not raise prices to the same extent. Banker et al (2014) argue and present supporting evidence that greater demand uncertainty induces managers to commit to more fixed costs to avoid "congestion costs" that occur for high realizations of demand. Banker and Chen (2006) show that cost stickiness is a function of differences in the rigidity of labor laws, which induce country-specific adjustment costs as firms seek to adapt the size of their labor force to varying demand. Kama and Weiss (2010) show that managers who face incentives to meet earning targets are more likely to accelerate cuts to slack resources in response to sales drops, suggesting deliberate resource adjustment that diminish cost stickiness. Kuang et al. (2015) show that managerial optimism is a determinant of cost stickiness. Overconfident managers, who presumably make a more optimistic assessment of the scope for future revenue increases, are associated with a higher degree of cost stickiness. Xue and Hong (2016) show that increased corporate governance restricts management opportunism, thereby reducing earnings management incentives which diminish cost stickiness. Taken together, the literature shows that cost stickiness cannot be disentangled from the motivation of managers.

No study in the literature of which we are aware, however, has undertaken a comprehensive investigation of the role of financial resources in shaping sticky cost behaviour. While studies by Li and Zheng (2017), Cheng, Jiang, and Zeng (2018), Costa and Habit (2020) all add financial variables to their investigation of sticky costs, none of these papers differentiate between the impact of binding financial constraints, on the one hand, and excessive financial slack, on the other. As we outline below, both financial constraints and financial slack have implications for cost stickiness.

We posit that binding financial constraints are an important determinant of operating flexibility such as sticky cost behaviour. Our argument is a straightforward one: accepting additional expenses to maintain un-utilized capacity may only be feasible or a good idea if the firm has enough financial resources to support the ongoing cash outlays, and, crucially, to withstand even further decreases in revenue. There is a clear risk management dimension to this argument. When faced with a non-trivial probability of distress and even bankruptcy, firms are more likely to prioritize survival and engage in more aggressive cost cutting. The excess slashing of costs is, in this view, a substitute for other forms of risk management. Because of the high costs of this reactive type of interference with committed resources, which incurs various forms of adjustment costs, firms are only likely to undertake this endeavor if they face severe enough financial constraints. The argument is also relevant even when bankruptcy is not an acutely felt prospect, because financially constrained firms face a similar choice between maintaining value-creating investments and un-utilized production capacity. That is, capital expenditure programs and maintaining the flexibility to respond to future increases in demand may, in these cases, be competing uses of scarce funds (Kahl, Lunn, and Nilsson, 2019). These considerations lead us to the first hypothesis of this paper:

H1: Financially constrained firms exhibit a lower degree of cost stickiness because of a stronger need to preserve liquidity to reduce the risk of bankruptcy and underinvestment

The hypothesis only speaks of the direction of the change in observed cost stickiness as a function of increasing financial constraints. It is difficult to hypothesize about whether cost stickiness should go towards zero or remain a negative, albeit lower, number separate from zero. This is essentially an empirical question. A definitive possibility is also that cost stickiness turns positive, which is evidence of so-called anti-sticky costs. These are cases in which the cost cuts are proportionally larger than the decrease in activity that precipitated them.

While a lack of financial resources may be problematic as it prompts firms to cut costs too aggressively in case of revenue shocks, there can also be too much of a good thing. A well-known problem in the corporate finance literature is that managers prefer to accumulate financial slack and spend it in ways that increase their personal utility but are wasteful from the shareholders' perspective. This is the agency costs of free cash flow-problem articulated by Michael Jensen, who also argue that debt can be used as a disciplining device to counter such tendencies (Jensen, 1986). When managers must worry about meeting ongoing debt obligations, they cannot spend as freely on project that generate poor returns because it might ultimately lead to the firm's demise. The same argument easily carries over to existing financial slack in the balance sheet, which is essentially the consequence of free cash flows accumulated in the past. When the firm has significant financial resources at hand, such as cash and un-used debt capacity, it is less reliant on capital markets who therefore cannot impose discipline on its managers. This line of argument leads to our second hypothesis:

H2: Due to agency problems of financial slack, firms with ample financial resources have higher-than-average levels of cost stickiness

3. Data, variables, and descriptive statistics

3.1. Empirical model and variables definitions

Following ABJ (2003), the following empirical model is estimated to gauge the response of costs to contemporaneous changes in sales revenue:

$$Y_{i,t} = \beta_0 + \beta_1 Revenue\_Rate_{i,t} + \beta_2 DecreaseDummy_{i,t} \times Revenue\_Rate_{i,t} + \epsilon_{i,t} \quad (1)$$

where $Y_{i,t}$ corresponds to one of the three dependent variables in our tests: *SG&A_Rate*, *Purch_Rate*, and *Employee_Rate*. *SG&A_Rate* is the logarithm of the ratio of SG&A to one-period lagged SG&A ($XSGA/XSGA_{t-1}$)[1]. Similarly, *Purch_Rate* and *Employee_Rate* are the logarithm changes of *Purchases* and number of employees (EMP), respectively. *Revenue_Rate* is defined as the logarithm of the ratio of sales revenue ($SALE/SALE_{t-1}$), while *DecreaseDummy* is a dummy variable that takes on the value of 1 when sales revenue decreases between periods $t-1$ and t, and 0 if not.

Revenue, SG&A and COGS are defined as annual sales (SALE), selling, general, and administrative expenses (XSGA) and cost of goods sold (COGS), respectively. We compute *Purchases* as COGS adjusted for the change in inventory ($COGS - INVT_{t-1} + INVT$). Assets is total assets (AT). Leverage is defined as total liabilities divided by total assets (LT/AT). Cash is defined as cash and cash equivalents divided by total assets (CHE/AT). Zscore is the Altman Z-score calculated as in Altman (1968)[2] while the KZ score is calculated following Lamont et al. (2001)[3] All ratios are winsorized at the 2nd and 98th percentiles to minimize the possible distorting effects of outliers.

Model 1 serves as the basis of our cost stickiness assessment. As noted by ABJ (2003), the ratio and log specification improves compatibility of variables across firms and controls for potential heteroskedasticity. To facilitate comparability with previous literature we pursue this model specification although we confirm qualitatively similar results

[1]Compustat items in parentheses

[2]Following Altman (1968), the Z-score for manufacturing firms is calculated as: $Z\_score = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5$. where X1 equals the ratio of working capital/total assets measuring liquid assets in relation to firm size. X2 is retained earnings/total assets which is a measure of profitability, and X3 is EBIT/total assets measuring operating efficiency. X4 is market value of equity divided by book value of liabilities and adds a market dimension, and X5 is sales/total assets reflecting asset turnover.

[3]Lamont, Polk, and Saa-Requejo (2001) calculate the KZscore with Compustat items as follows: $-1.002(IB + DP)/PPENT_{t-1} + 0.283(AT + PRCC\_FxCSHO - CEQ - TXBL)/PPENT) + 3.139(DLTT + DLC)/(DLTT + DLC + SEQ) - 39.368(DVC + DVP)/PPENT_{t-1}$.

when estimating with strict linear specifications, as well as in a panel setting including firm and year fixed effects with clustered standard errors. An added benefit of the log specification allows for an intuitive interpretation of the estimated coefficients in percentage form. As *DecreaseDummy* is zero when revenue increases, β_1 measures the percentage increase in costs for a 1% increase in revenue. In periods of a revenue decrease, *DecreaseDummy* takes on a value of 1 and the sum of β_1 and β_2 measures the percentage decrease in costs for a 1% decrease in revenue. Hence, the coefficient β_2 serves to gauge the asymmetrical change in costs with an increase or decrease in revenue and captures the extent of cost stickiness. In a traditional model of cost behaviour, increasing and decreasing changes in costs relative to revenue will be equal and therefore $\beta_2 = 0$. In the presence of sticky costs, however, β_2 will be negative. Following ABJ(2003), we do not include the dummy on its own as it is only relevant insofar as it modifies the slope of the relationship between revenue and the dependent variable.

3.2. Data

The sample is constructed using data on US manufacturing firms (SIC 1999-4000) found in the Compustat annual database for the years 1984 to 2018. Following ABJ (2003), we delete observations with missing values for the current and lagged values of revenue and SG&A, as well as observations where S&A is larger than revenue.

3.3. Descriptive statistics

Descriptive statistics for the variables used in this study are reported in Table 1, whereas Table 2 reports the associated correlation coefficients. In Table 1 we find a SG&A-to-Revenue ratio of 29%, which compares with 26% in ABJ (2003). Among the correlations in Table 2 we note that there is, as expected, a positive association between size and leverage, although not a very strong one (0.10). Also noteworthy is the sizable negative correlation between leverage and cash holdings (-0.43). On average, highly leveraged firms also have less cash.

Table 1: Descriptive statistics

Statistic	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max	N
Revenue_Rate	0.09	0.25	−0.52	−0.03	0.07	0.20	0.89	76,962
SG&A_Rate	0.09	0.22	−0.47	−0.02	0.07	0.18	0.75	76,962
Purch_Rate	0.08	0.29	−0.69	−0.06	0.07	0.20	0.91	72,521
Employee_Rate	0.03	0.21	−0.55	−0.06	0.02	0.11	0.69	71,668
Leverage	0.52	0.29	0.09	0.31	0.50	0.67	1.50	76,840
Cash	0.15	0.16	0.001	0.02	0.08	0.22	0.66	76,906
Totalassets	2,180.34	6,161.96	1.89	31.85	165.06	951.13	34,636.00	76,947
Cost_efficiency	0.91	0.15	0.08	0.84	0.90	0.95	1.99	76,962
SG&A/Sales	0.29	0.19	0.001	0.15	0.25	0.38	1.00	76,962

Note: Table presents descriptive statistics for testing sample. *Revenue_Rate* is the log change in sales revenue. Similarly, *SG&A_Rate*, *Purch_Rate*, and *Employee_Rate* are the log changes in *SG&A* (XSGA), *Purchases* (defined as $COGS - INVT\_t - 1 + INVT$), and number of employees (EMP), respectively. *Leverage* is total liabilities to total assets (LT/AT). Cash is defined as cash and cash equivalents standardised by beginning of period total assets(CHE/AT). Cost effeciency is calculated as the sum of Cost of goods sold and *SG&A* to sales revenue ((COGS + XSGA/SALE)), while *SG&A/Sales* is (XSGA/SALE). Sample consists of all US Manufactuing firms from the period 1984-2018

Table 2: Correlations

Statistic	*Revenue_Rate*	*SG&A_Rate*	*Purch_Rate*	*Employee_Rate*	*Leverage*	*Cash*	*Totalassets*
Revenue_Rate	1						
SG&A_Rate	0.66	1					
Purch_Rate	0.84	0.57	1				
Employee_Rate	0.58	0.55	0.59	1			
Leverage	-0.12	-0.16	-0.1	-0.15	1		
Cash	0.07	0.06	0.03	0.07	-0.43	1	
Totalassets	-0.03	-0.03	-0.03	-0.01	0.1	-0.08	1

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

4. Empirical results

4.1. Baseline regression

Table 3 reports the results from a model that regresses the logarithmic change in SG&A on the corresponding change in revenue. Following ABJ (2003), the model also includes an interaction term between the logarithmic change in revenue and a dummy variable that takes the value one if the change in revenue is negative. It is this interaction term that we refer to as 'cost stickiness', as it captures the asymmetric response of SG&A

to changes in revenue depending on whether revenue increases or decreases. The baseline regression in Table 3 indicates a cost stickiness in the full sample of -0.084. This is a lower number compared to ABJ (2003), who report a coefficient on the interaction term of -0.191. This difference could be due to the fact that we use much more recent data (their sample ends in 1998), and that we winsorize the variables rather than drop extreme outliers, as they do.

Table 3: Baseline regression

	Dependent variable:
	SG&A
Revenue_Rate	0.619^{***}
Revenue_Rate × *DecreaseDummy*	-0.084^{***}
Constant	0.024^{***}
Observations	76,962
R^2	0.457
Adjusted R^2	0.457
Note:	*p<0.1; **p<0.05; ***p<0.01

Table presents pooled OLS estimates from the following equation: $SG\&A\_Rate_{i,t} = \beta_0 + \beta_1 Revenue\_Rate_{i,t} + \beta_2 DecreaseDummy_{i,t} \times Revenue\_Rate_{i,t} + \epsilon_{i,t}$. Where $SG\&A\_Rate_{i,t}$ and $Revenue\_Rate_{i,t}$ are the logarithms of the change in *SG&A* and *Revenue*, respectively, for firm i in period t. $DecreaseDummy_{i,t}$ is a dummy variable equal to 1 if the the revenue of firm i for period t is less than that in the preceding period, and 0 otherwise. Sample consists of all U.S. manufacturing firms in the Compustat file from 1984-2018.

4.2. Sticky SG&A and financial constraints

In this section, we introduce our financial constraints measures – leverage, KZ-score and Z-score – to investigate their importance to cost behaviour. The latter score was originally developed as bankruptcy prediction model but has also become widely used in empirical research to classify firms according to their general financial status. Among the various financial constraints measures found in the investment literature, the KZ-score is the most widely utilized measure for estimating financial constraint status. As regards leverage, a deep theoretical literature in corporate finance shows that contracting problems, due to distorted incentives, get progressively worse the more highly leveraged a firm is. For example, in the debt overhang-model of Myers (1977), firms burdened by too much debt are unable to issue equity because it would represent a direct wealth transfer to existing debtholders, whose claim on the firm would be made safer. Other things being equal, therefore, a firm's financial constraint status can be assumed to be an increasing function of its leverage.

Table 4 shows the results from regressions in which the basic model is re-estimated for different quartiles of each measure. They tell a very consistent story. As financial constraints intensify cost stickiness decreases and all but disappears. For the Leverage and Z-score groups, cost stickiness in fact turns positive in the most constrained quartile, though the numbers are very close to zero. This finding implies that, for constrained firms, there exists no difference in the response of SG&A to positive and negative changes in revenue. For the other quartiles in the leverage sort, cost stickiness lies between -0.121 and -0.204, consistent with substantial cost stickiness in the absence of binding financial constraints.

Table 4: Cost stickiness and financial constraints

Group	Quartile	Constant	tstat	B1	tstat	B2	tstat	adj Rsqr	n	B1 + B2
Leverage	1st Quartile	0.036	20.173	0.604	99.272	-0.204	-13.694	0.441	19210	0.401
	2nd Quartile	0.029	19.108	0.617	101.852	-0.100	-6.890	0.469	19210	0.517
	3rd Quartile	0.019	12.641	0.662	104.101	-0.121	-8.149	0.476	19210	0.540
	4th Quartile	0.010	5.176	0.594	83.593	0.021	1.437	0.439	19210	0.615
KZ_score	1st Quartile	0.018	14.582	0.700	112.364	-0.161	-11.173	0.528	17028	0.539
	2nd Quartile	0.020	12.733	0.651	87.395	-0.120	-7.631	0.447	17028	0.531
	3rd Quartile	0.019	10.307	0.660	91.412	-0.159	-9.901	0.459	17028	0.501
	4th Quartile	0.035	14.144	0.560	79.409	-0.027	-1.621	0.430	17028	0.533
Z_score	1st Quartile	0.042	24.834	0.621	113.432	-0.243	-14.016	0.483	17568	0.379
	2nd Quartile	0.023	16.925	0.660	107.200	-0.178	-11.517	0.489	17567	0.483
	3rd Quartile	0.014	9.222	0.719	107.712	-0.213	-14.145	0.508	17567	0.505
	4th Quartile	0.009	3.790	0.517	61.800	0.014	0.875	0.354	17568	0.532

[1] **Note:** Table reports coeffcients from the following model: $SG\&A\_Rate_{i,t} = \beta_0 + \beta_1 Revenue\_Rate_{i,t} + \beta_2 DecreaseDummy_{i,t} \times Revenue\_Rate_{i,t} + \epsilon_{i,t}$. Where $SG\&A\_Rate_{i,t}$ and $Revenue\_Rate_{i,t}$ are the logarithms of the change in *SG&A* and *Revenue*, respectively, for firm *i* in period *t*. Quartile groups are formed by first ranking firm-year obs by the respective financial constraints proxy score, then finding the cut-off points that separate the sample into four equal-sized groups. *Leverage* is calculated as total liabilities to total assets. Zscore and KZscore are calculated following Altman (1968) and Lamont et al. (2001). Observations belonging to Quartile 1 of each group are considered less constrained while firms in Quartile 4 are considered more constrained. Sample consists of all Manufactuing firms from the period 1984-2018

4.3. Sticky SG&A as a function of leverage and size

One concern with the results presented in the previous section is that they suffer from an omitted variable bias. Leverage is an endogenous policy-variable that has an alternative interpretation, namely that it captures superior access to financial markets because truly constrained firms cannot even obtain any large degree of debt financing in the first place (e.g. Adam, 2009). Leverage is in fact known to vary systematically with firm size, as do composite measures of firm health like the Z-score, raising the possibility that the findings in 4.2 merely reflect a size effect. Large firms are typically assumed to have better access to capital markets (Kadapakkam et al., 1998), and may have incentives and abilities with respect to cost management that systematically affect cost stickiness but are unrelated to financial constraints. To address this concern, and control for size, we first split the sample into quartile according to total assets and then repeat our initial leverage-split for each of these four size-cohorts. The resulting 4x4 matrix is shown in Figure 1. It contains only the coefficient on the interaction term, which is our estimate of cost stickiness.

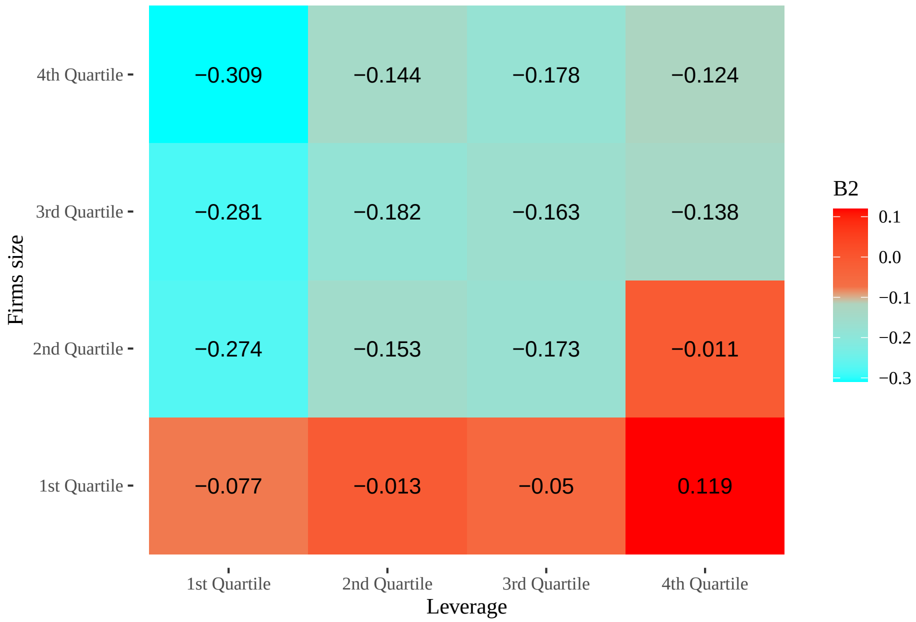

Figure 1: Quartile sorts.

Note: Figure shows estimates of β_2 from the following equation on quartiles of levearage and size: $SG\&A\_Rate_{i,t} = \beta_0 + \beta_1 Revenue\_Rate_{i,t} + \beta_2 DecreaseDummy_{i,t} \times Revenue\_Rate_{i,t} + \epsilon_{i,t}$. Leverage is calculated as total debt to assets (LT/AT) while size is total assets of firm(AT). Quartile groups are formed by first ranking firm-year observations by associated variable then calculating cut-off values which divides the sample into four equal-sized groups. Observations are then mapped to both quartile groups to compile the matrix for testing, e.g. the β_2 estimate in the top-left corner is resultant from the sub-sample of observations belonging to the 1st quartile of leverage and 4th quartile of size. Sample consists of all manufacturing firms from the period 1984-2018.

Figure 1 is revealing. It strongly suggests that financial constraints are at work. The combinations involving large firms with low leverage display substantial cost stickiness, reaching as low as -0.309. As firms get progressively smaller, but are more burdened with debt, cost stickiness tends towards zero. For the quartile containing the smallest firms but also the highest level of leverage, significant *anti*-stickiness can be observed (0.119).

As before, a reasonable interpretation is that firms characterized by few financial resources have very little flexibility to optimize their cost behaviour and need to act more quickly to reduce excess capacity. The finding that very large firms with trivial amounts of debt show such high cost stickiness is interesting in relation to Hypothesis 2 as it suggests these firms enjoy potentially too much flexibility, to the point where they lack cost discipline and prefer to maintain costs even when they would rationally reduce capacity when faced with falling demand. To learn more about whether the observed high levels of stickiness in firms with financial slack are reflective of poor cost discipline, we proceed to overlay Figure 1 with a measure of cost efficiency, which relates the sum of SG&A and COGS to revenue. Figure 2 reports the median values of cost efficiency for the firms in each of the 16 sub-samples in Figure 1. What stands out is a pattern that contradicts Hypothesis 2. As we move towards the upper left corner, which contains firms that score high on stickiness and financial slack, cost efficiency gradually improves. The firms with the least financial slack (and the least cost stickiness, as per Figure 1) in fact has a cost efficiency ratio exceeding 1, suggesting that they fail to break even in terms of their operating margin.

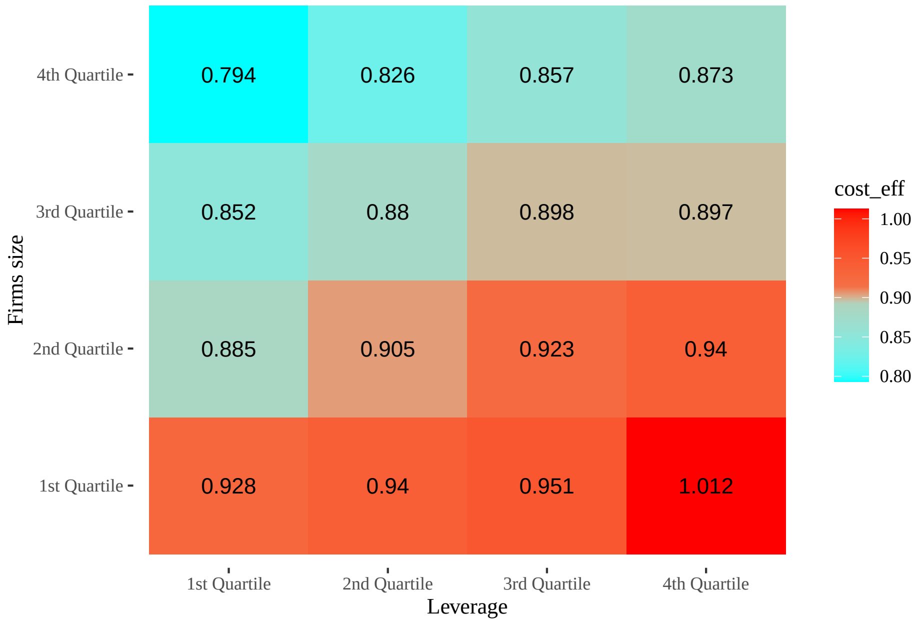

Figure 2: Quartile sorts - Cost effenciency.

Note: Figure shows median *Cost_effenciency* estimates on quartile groups of leverage and size. *Cost_effenciency* is defined as Compustat items (COGS + XSGA)/ SALE. Quartile groups are formed by first ranking firm-year observations by associated variable then calculating cut-off values which divides the sample into four equal-sized groups. Observations are then mapped to both quartile groups to compile the matrix for testing, e.g. the median *Costeffenciency* estimate in the top-left corner is resultant from the sub-sample of observations belonging to the 1st quartile of leverage and 4th quartile of size. Sample consists of all manufacturing firms from the period 1984-2018.

To continue this investigation, we also estimate median values for Peters and Taylor's Q measure (Peters and Taylor, 2017) and repeat the sorts in Figure 1. Depressed Q-values are indicative of low firm value and generally lower economic efficiency. The results are reported in Figure 3 and point to the same conclusion as Figure 1. Firms with more financial slack/cost stickiness (upper left corner) have the highest Q-values. As we move towards more constrained firms in the lower right corner, Q-values drop towards 0.3, indicating lower economic efficiency.

Figure 3: Quartile sorts - Total Q.

Note: Figure shows median *Total_Q* estimates on quartile groups of leverage and size. *Total_Q* estimates are obtained from the WRDS data providor, originating from the estimates of Peters and Taylor (2017) and available for the Compustat US fundamental files. Quartile groups are formed by first ranking firm-year observations by associated variable then calculating cut-off values which divides the sample into four equal-sized groups. Observations are then mapped to both quartile groups to compile the matrix for testing, e.g. the median $Total_q$ estimate in the top-left corner is resultant from the sub-sample of observations belonging to the 1st quartile of leverage and 4th quartile of size. Sample consists of all manufacturing firms from the period 1984-2018.

4.4. Sticky SG&A as a function of leverage and cash

The evidence presented in the previous section allows us to refute hypothesis 2 and instead infer that firms with more sticky behaviour generally are more cost efficient. One natural way to interpret this finding is that financially weak firms accumulate adjustment costs as a result of their non-sticky cost behaviour, which has a detrimental effect on cost efficiency. While shining a light on this important question, the refutation of hypothesis 2 introduces an endogeneity problem with respect to the relation between financial resources and cost stickiness, because the pattern in cost efficiency seems equally capable of explaining differences in stickiness. The mechanism of relevance here is that less cost-efficient firms rely more on debt to keep them going, which increases their leverage. More efficient firms, in contrast, are able generate more profits and build equity, which pushes leverage down.[4]

What these differences in cost efficiency imply is that the sub-categories in our size-leverage sorts do not face similar probabilities of experiencing a decrease in revenue. We are able to confirm that this probability is systematically higher in less efficient firms (not tabulated but available on request). This is a serious concern, because in the stick cost-model this probability is a crucial input when managers resolve the trade-off between keeping and cutting costs. To improve our ability to make inferences with respect to financial resources, we would therefore like to equalize decrease probabilities across the sub-samples. We do this by applying two filters.

In the first, we exclude firms for which the cost efficiency ratio exceeds 1. These are firms that have negative or a very slim gross margin, which is indicative of economic (as opposed to financial) distress. In the second, we remove firms in the 1st and 4th quartiles with respect to cost efficiency, leaving only firms that have comparable cost efficiency in the sample. We do this after first dividing the sample into large and small firms based on the median of total assets, thus controlling for size.

In this analysis, we also consider another circumstance that could obfuscate the interpretation of the leverage-sorts. Firms may hold significant amounts of cash, which partly or wholly offsets the increased risk that comes with debt financing. While the overall correlation between leverage and cash holdings is negative in our sample, there is still the possibility that leveraged firms seek to hold cash positions in order to ensure enough financial flexibility to engage in optimizing cost behaviour. We therefore do sorts on cash and leverage. The results are reported in Table 5. To save space, we only report the two most interesting combinations, i.e. high leverage-low cash (constrained firms) and low leverage-high cash (unconstrained firms) in Panel A, and the results for the regressions in which the 1st and 4th quartiles in terms of cost efficiency has been removed in Panel B. It is important to note that these subgroups have similar decrease-probabilities (23% and 26%, respectively), which mitigates the concern that perceived

[4]Technically, another mechanism is that weaker firms impair their assets to a larger extent. The resulting impairment losses deplete equity, thus increasing observed leverage.

differences in the probability of revenue growth resuming is driving the results.

Table 5 supports the view that financial resources are a first-order determinant of cost behaviour. For both size groups, constrained firms exhibit more stickiness. The difference is about the same in both size-categories in Panel A (-0.250 vs -0.152 for large firms compared to -0.125 vs -0.023 for small firms). Panel B shows that equalizing decrease-probabilities does matter. In this case, an economically significant difference remains for large firms, although smaller than before (-0.194 vs -0.125). For small firms the difference is about the same though the absolute values change (-0.060 vs 0.056). When cost efficiency exceeding one is required, conclusions are unaffected (un-tabulated).

4.5. Sticky purchases and financial constraints

The study by Andersen et al (2003) focuses on SG&A costs as an empirical proxy for resource provision. Several papers in the literature have broadened the investigation to cover also cost of goods sold, which is generally considered as a more variable cost than SG&A (e.g. Subramaniam and Weidenmeir, 2003). This literature has typically found substantially less cost stickiness when the logarithmic change in cost of goods sold is used as dependent variable (e.g. Chen, Harford, and Kamara, 2019).

We argue that purchases, defined as cost of goods sold adjusted for the change in inventory, is a more useful empirical measure of variable costs. It is more closely tracking the firm's actual cash outlays than is the periodized cost of goods sold, which adds beginning-of-year inventory but subtracts end-of-year inventory in keeping with the principle of matching revenue with the associated costs. In essence, periodizing means that investments in inventory will materialize as cost of goods sold only at some later point in the future when those goods are finally generating sales. Cash effective purchases is more relevant to consider because it more accurately reflects a variable which managers control and it reflects the risk dimension better. When revenue decreases and managers in financially constrained firms hit the brakes, what is scaled back are actual purchases regardless of how those are later periodized.

In Model 1 in Table 6, we re-estimate the baseline model with purchases as dependent variable. In contrast to the generally limited asymmetry found in cost of goods sold for revenue decreases, we find a large asymmetric response for purchases. What is more,

Table 5: SG&A as Dependent Variable

	PANEL A: All Quartiles of Cost Efficiency				
	Full Sample	Low Leverage High Cash	High Leverage Low Cash	Low Leverage High Cash	High Leverage Low Cash
		Large Firms		Small Firms	
Dep. var = *SG&A_Rate*	(1)	(2)	(3)	(4)	(5)
Revenue_Rate	0.619***	0.657***	0.791***	0.575***	0.602***
Revenue_Rate × *DecreaseDummy*	−0.084***	−0.250***	−0.152***	−0.125***	−0.023
Constant	0.024***	0.029***	0.009***	0.038***	0.015***
Observations	76,962	10,813	15,218	15,706	11,305
R^2	0.457	0.533	0.571	0.423	0.431
Adjusted R^2	0.457	0.533	0.571	0.423	0.431

Note: *p<0.1; **p<0.05; ***p<0.01

	PANEL B: Center Quartiles of Cost Efficiency				
	Full Sample	Low Leverage High Cash	High Leverage Low Cash	Low Leverage High Cash	High Leverage Low Cash
		Large Firms		Small Firms	
Dep. var = *SG&A_Rate*	(1)	(2)	(3)	(4)	(5)
Revenue_Rate	0.669***	0.669***	0.800***	0.622***	0.706***
Revenue_Rate × *DecreaseDummy*	−0.016	−0.194***	−0.125***	−0.060**	0.056*
Constant	0.017***	0.026***	0.007***	0.027***	0.004
Observations	38,480	4,671	7,501	8,048	5,214
R^2	0.515	0.524	0.590	0.479	0.546
Adjusted R^2	0.515	0.524	0.589	0.479	0.546

*p<0.1; **p<0.05; ***p<0.01

Note: Table presents pooled OLS estimates from the following equation on firms sorted by size and leverage:$SG\&A\_Rate_{i,t} = \beta_0 + \beta_1 Revenue\_Rate_{i,t} + \beta_2 DecreaseDummy_{i,t} \times Revenue\_Rate_{i,t} + \epsilon_{i,t}$ Where $SG\&A\_Rate_{i,t}$ and $Revenue\_Rate_{i,t}$ are the logarithms of the change in *SG&A* and *Revenue*, respectively, for firm *i* in period *t*. $DecreaseDummy_{i,t}$ is a dummy variable equal to 1 if the revenue of firm *i* for period *t* is less than that in the preceding period, and 0 otherwise. Size, cash, and leverage groups are constructed by splitting the sample distributions at the median, creating two equal-sized groups for each metric (High and Low). For brevity, only combinations of interest are tabulated (High vs. Low). Panel A consists of all U.S. manufacturing firms in the Compustat files from 1984-2018. Panel B restricts the sample to observations located in the center two quartiles of cost efficiency (observations in the first and fourth quartiles are removed).

Table 6: Purchases as Dependent Variable

	PANEL A: All Quartiles of Cost Efficiency				
	Full Sample	Low Leverage High Cash	High Leverage Low Cash	Low Leverage High Cash	High Leverage Low Cash
		Large Firms		Small Firms	
Dep. var = *Purch_Rate*	(1)	(2)	(3)	(4)	(5)
Revenue_Rate	0.925***	0.950***	0.973***	0.899***	0.921***
Revenue_Rate × *DecreaseDummy*	0.191***	0.157***	0.225***	0.156***	0.227***
Constant	0.010***	0.003	0.010***	0.010***	0.015***
Observations	72,521	10,636	14,445	14,414	10,454
R^2	0.708	0.713	0.804	0.661	0.721
Adjusted R^2	0.708	0.713	0.804	0.661	0.721

Note: *p<0.1; **p<0.05; ***p<0.01

	PANEL B: Center Quartiles of Cost Efficiency				
	Full Sample	Low Leverage High Cash	High Leverage Low Cash	Low Leverage High Cash	High Leverage Low Cash
		Large Firms		Small Firms	
Dep. var = *Purch_Rate*	(1)	(2)	(3)	(4)	(5)
Revenue_Rate	0.967***	0.990***	0.998***	0.944***	0.964***
Revenue_Rate × *DecreaseDummy*	0.207***	0.160***	0.208***	0.151***	0.263***
Constant	0.008***	0.004	0.009***	0.007***	0.010***
Observations	36,549	4,614	7,158	7,554	4,797
R^2	0.748	0.765	0.853	0.671	0.760
Adjusted R^2	0.748	0.765	0.853	0.671	0.760

*p<0.1; **p<0.05; ***p<0.01

Note: Table presents pooled OLS estimates from the following equation: $Purch\_Rate_{i,t} = \beta_0 + \beta_1 Revenue\_Rate_{i,t} + \beta_2 DecreaseDummy_{i,t} \times Revenue\_Rate_{i,t} + \epsilon_{i,t}$ Where $SG\&A\_Rate_{i,t}$ and $Revenue\_Rate_{i,t}$ are the logarithms of the change in *SG&A* and *Revenue*, respectively, for firm *i* in period *t*. $DecreaseDummy_{i,t}$ is a dummy variable equal to 1 if the revenue of firm *i* for period *t* is less than that in the preceding period, and 0 otherwise. Size and leverage groups are constructed by splitting the sample distributions at the median, creating two equal-sized groups for each metric (High and Low). For brevity, only combinations of interest are tabulated (High vs. Low). Panel A consists of all U.S. manufacturing firms in the Compustat files from 1984-2018. Panel B restricts the sample to observations located in the center two quartiles of cost efficiency (observations in the first and fourth quartiles are removed).

this impact is large and positive, which constitutes evidence of anti-sticky behaviour. Our estimates suggest that the anti-stickiness of purchases is around 0.191, which is a significantly larger number (in absolute terms) than the stickiness of SG&A costs. Apparently, firms respond resolutely when it comes to cutting purchases in response to decreases in revenue, to the point where they are doing so by a larger percentage than the corresponding decrease in activity. A plausible interpretation is that firms are keen to "protect" their operating margins from deteriorating when sales volumes go down, and therefore cut purchases proportionally more.

Models 2 through 5 in Table 6 introduce financial resources. We use the same empirical design as in Table 5, sorting firms initially according to size to create more homogeneous sub-samples, after which they are compared based on their combination of leverage and cash. The conclusion from these models echoes the one in the previous tables in that there is a clear asymmetry between the financially most constrained and unconstrained groups. As with SG&A, these findings can be given a risk management interpretation. Weaker firms need to keep risk in check and therefore promptly cut costs when revenue decreases, whereas more robust firms can engage in optimizing (sticky) cost behaviour.

4.6. Sticky employment and financial constraints

In this section we investigate another proxy for firm's cost level, namely the number of employees. Employment numbers have generated significant interest in previous research in relation to financial constraints, where the asymmetric behaviour is referred to as 'labor hoarding' rather than sticky costs. The empirical approach is generally to compare the downward adjustment of firms in recessions conditional on size and leverage. In a recent addition to this literature, Giroud and Mueller (2016) find that such hoarding of labor was restricted by high leverage following the onset of the financial crisis in the late 2000s. Similar conclusions are reached in Friedrich et al. (2020) who study how leverage mediates the effects of an exogenous and sector-specific drop in demand across various dimensions, including employment. We instead focus on asymmetric responses to revenue shocks not restricted to recessions. Our results point to similar conclusions, as can be seen in Table 7. Now the dependent variable is the logarithmic change in employees rather than SG&A. Interestingly, the full sample results indicate essentially no cost stickiness in the number of employees (0.015). When partitioned according to financial resources, however, we find sticky behaviour only for the resource-rich sub-samples. Small firms with few financial resources, in contrast, display significant anti-sticky behaviour, in accordance that they have the most acute need to manage bankruptcy risk by adjusting their cost structure.

Table 7: Employees as Dependent Variable

	PANEL A: All Quartiles of Cost Efficiency				
	Full Sample	Low Leverage High Cash	High Leverage Low Cash	Low Leverage High Cash	High Leverage Low Cash
		Large Firms		Small Firms	
Dep. var = *Employee_Rate*	(1)	(2)	(3)	(4)	(5)
Revenue_Rate	0.495***	0.542***	0.562***	0.473***	0.471***
Revenue_Rate × *DecreaseDummy*	0.058***	−0.122***	0.051**	−0.004	0.167***
Constant	−0.006***	0.004*	−0.010***	0.001	−0.020***
Observations	71,668	10,423	14,324	14,398	10,281
R^2	0.343	0.399	0.346	0.336	0.331
Adjusted R^2	0.343	0.399	0.346	0.336	0.331

Note: *p<0.1; **p<0.05; ***p<0.01

	PANEL B: Center Quartiles of Cost Efficiency				
	Full Sample	Low Leverage High Cash	High Leverage Low Cash	Low Leverage High Cash	High Leverage Low Cash
		Large Firms		Small Firms	
Dep. var = *Employee_Rate*	(1)	(2)	(3)	(4)	(5)
Revenue_Rate	0.538***	0.557***	0.593***	0.510***	0.529***
Revenue_Rate × *DecreaseDummy*	0.015	−0.147***	0.020	−0.061**	0.138***
Constant	−0.008***	−0.005*	−0.013***	−0.004	−0.008**
Observations	36,315	4,529	7,148	7,477	4,809
R^2	0.344	0.360	0.360	0.318	0.347
Adjusted R^2	0.344	0.359	0.360	0.318	0.346

*p<0.1; **p<0.05; ***p<0.01

Note: Table presents pooled OLS estimates from the following equation: $Employee\_Rate_{i,t} = \beta_0 + \beta_1 Revenue\_Rate_{i,t} + \beta_2 DecreaseDummy_{i,t} \times Revenue\_Rate_{i,t} + \epsilon_{i,t}$. Where $SG\&A\_Rate_{i,t}$ and $Revenue\_Rate_{i,t}$ are the logarithms of the change in *SG&A* and *Revenue*, respectively, for firm i in period t. $DecreaseDummy_{i,t}$ is a dummy variable equal to 1 if the revenue of firm i for period t is less than that in the preceding period, and 0 otherwise. Size and leverage groups are constructed by splitting the sample distributions at the median, creating two equal-sized groups for each metric (High and Low). For brevity, only combinations of interest are tabulated (High vs. Low). Panel A consists of all U.S. manufacturing firms in the Compustat files from 1984-2018. Panel B restricts the sample to observations located in the center two quartiles of cost efficiency (observations in the first and fourth quartiles are removed).

5. Conclusions

The results presented in this study uniformly point to the conclusion that financial resources determine cost behaviour in an economically meaningful way. Across a range of tests, and different indicators of both costs and financial resources, we consistently find that cost stickiness increases in the level of financial resources. Our interpretation of these findings is that firms can only optimize their cost behaviour if they have the financial freedom to do so. Financially weak firms, in contrast, likely must prioritize the preservation of liquidity to stave off the risk of bankruptcy and not having sufficient funds for their strategic investments.

Our results add to the growing evidence that binding financial constraints affect real outcomes. Previous research has shown this to be relevant for employment, product market behaviour, and investment behaviour. The evidence presented in these pages provide broad-sample evidence supporting the hypothesis that financial resources also influence cost behaviour and that optimizing behaviour is conditional on their availability.

Presumably, the excessive reduction of costs and capacity in the face of financial constraints is a costly and broadly undesired necessity for managing risk when other options have already been exhausted. That is, the results imply that there are material and negative consequences from rushing in with cost-saving programs in the face of activity decreases. Sub-optimal cost management should therefore be added to the list of costs related to financial distress, which is one of the key determinants of capital structure and risk management policies. Interesting research could be done in which the negative effects of not being able to conform to optimizing sticky cost behaviour are investigated,for example in terms of future competitiveness or market share growth.

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Paper III

The Black Swan problem: the role of capital, liquidity and operating flexibility

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1. Introduction

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

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

The dilemma – the Black Swan-problem – faced by firms is that these general risk management strategies reduce the return on equity in the vast majority of scenarios in which no tail risk materializes. In fact, firms are frequently lambasted for maintaining large and "unproductive" cash balances and for having "inefficient" balance sheets (implying under-utilization of debt). Given that strategies for increasing corporate resilience are costly, it is important to know how effective they are in coping with tail risk. Which of the various forms of buffers are, according to the data, better at absorbing shocks to performance? What really mattes when it comes to lowering fragility in a worst-case scenario? The question is essentially one of "risk capital", i.e. how to provide for resources that allow the firm to survive and continue to execute its strategy in a worst-case scenario (Alviniussen and Jankensgård 2009), as well as how to do so *efficiently*. In shaping a response to the Black Swan-problem, it is also helpful to have data on the frequency at which such events can be assumed to occur and their distribution across industries.

In this paper, we address the question of firms' resilience to tail risk by examining how shocks to the corporate top line (revenue) impacts size of the workforce. We define a Revenue Black Swan as an unexpected year-on-year drop in revenue between 30-90% (in the interest of brevity we henceforth refer to this simply as a "Black Swan") and construe firm fragility in terms of a comparably large sensitivity of employment numbers to such revenue shocks. Specifically, we analyse whether risk capital buffers moderate the impact of these shocks on the number of employees. To ensure the observed shocks are not driven by corporate events such as disposals of assets, we only count firm year observations where asset sales do not exceed 5% of total assets. In choosing the number of employees as our dependent variable for gauging economic impact, we align with a large literature that uses employment data in relation to financial factors (Sharpe 1994, Chodorow-Reich 2014, Falato and Liang 2016, García-Posada Gómez 2019, Benmelech et al. 2019, Bäurle et al. 2021). To carry out this investigation, we gather Compustat data for US firms stretching back to 1955, incorporating all industries except financial and utility.

We report a number of stylized facts on revenue shocks over 65 years. Consistent with the popular view that uncertainty has been growing over time, the incidence of Black Swans is considerably higher in the latter part of the sample period. Up to the mid 1970's, the average rate of Black Swans was 1.2%, whereas in the 2000's it is 6.1%. Further underscoring this trend, four out of the five highest Swan-years are observed after 2000. This rise occurs *despite* an increase over time in the average size of publicly listed firms in the US (small firms are disproportionately affected by Black Swans). While to some extent the rising incidence of Black Swans reflects a change in the sample composition towards more technology-intense firms, we observe an increase in all industries investigated. Black Swans are, to a fair degree, transitory events in the sense that the afflicted firm sees a rebound in its fortunes in the following year (40%). Only a very small percentage of firms hit by a Black Swan enters bankruptcy (1%) or is liquidated (0.7%).

Our multivariate analysis, incorporating over 160,000 firm-year observations, suggests that liquidity is most effective in insulating firms from the effects of tail risk events. We run firm fixed-effect regressions of the log number of employees on our proxies for risk capital buffers (equity ratio, cash reserves, cash margin, and operating flexibility) and include a dummy variable that flags whether a Black Swan has occurred in a particular year. To reduce concerns about endogeneity, and to ensure these events are unexpected, we add the requirement of two prior years of positive revenue growth. The results indicate that end-of-year employment is on average 17% lower in firm-years in which a Black Swan occurs compared to non-Black Swan years. The buffer variables – equity ratio, cash reserves, cash margin, and operating flexibility – are then interacted with the Black Swan-dummy to get an indication of the extent to which they act as "shock-absorbers". Cash reserves is, by a wide margin, the variable that most robustly reduces the sensitivity of employment to revenue shocks. Being in the top third in terms of cash reserves decreases fragility by 32%. This conclusion holds when we change the setting to investigate cyclical Black Swans, i.e. years in which the Swan-rate spikes due to economy-wide recessions, as well as transient Black Swans, i.e. those shocks that are followed by a rebound and therefore temporary in nature. Cash margins are also associated with lower fragility, albeit not to the same extent as cash reserves. Our results are in accordance with Gamba and Triantis (2014), who show that liquidity "serves a critical and distinct role in risk management." In their model, which investigates various frictions that affect corporate policy, liquidity emerges as the most effective mechanism for risk management. They argue that their findings provide a theoretical justification for the high levels of cash that have been reported in the non-financial sector (e.g. Bates et al. 2009). Our results support this conclusion.

A potential concern is that the revenue shocks employed in our study partially reflects the impact of a permanent decline in business fortunes, which may be systematically related to levels of risk capital. As mentioned, we lag the risk capital variables two years to mitigate this problem and include only revenue shocks that can be viewed as unexpected. Importantly, our results hold when we directly control for endogeneity by conducting an analysis of the airline industry, which is notoriously vulnerable to global shocks, many of which are clearly unexpected and exogenous to firm revenue streams (e.g. shocks related to sudden health risks or terrorism). This analysis of the sensitivity of employment to Black Swans in the airline sector confirms the superior role of liquidity in reducing firm fragility.

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

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

Our results also contribute to the literature on the impact of financial resources on private sector employment. One conclusion to emerge from this literature is that firms tend to engage in "labour hoarding", which is to say preserving the workforce following a negative shock to performance. The reasons for such hoarding is generally that firms may anticipate a rebound in growth and want to avoid adjustment costs in the form of severance pay and training (Anderson et al. 2003). As noted, our findings run contrary to one of the other main conclusions to emerge from this research, namely that leverage constrains labour hoarding when there is an exogenous shock to performance (Chodorow-Reich 2014, Giroud and Mueller 2016, Bäurle et al. 2021). Potential reasons for the different conclusions are that these studies focus on relatively narrow sectors of the economy, and that they do not control for cash reserves and cash margins in their empirical tests. Using a broad sample spanning 50 years, and using a firm-fixed effects framework that also controls for cash reserves and cash margins, the proportion of equity financing does not appear to be a decisive factor in mediating the effect of revenue shocks on employment.

2. Hypotheses

In this section, we outline several empirical predictions based on the literature. Our main interest lies in risk capital and the four associated buffer variables discussed in the introduction: equity capital, cash reserves, cash margins, and operating flexibility.

In studying the sensitivity of investment to changes in cash flow, Fazzari et al. (1988) claim that financial constraints cannot be directly observed, but may be possible to infer from differences in observed investment-cash flow sensitivities. Likewise, firm fragility is not directly observable, but may be inferred from differences in the observed employment-revenue sensitivities. There are significant costs involved in terms of severance pay and training (in case of later rehiring), suggesting that firms have strong incentives to avoid cuts that are damaging to its long term prospects. As a result, they tend to engage in a practice referred to as "labour hoarding" (Anderson et al. 2003). Following this argument, in the presence of revenue shocks, excessive cuts in the number of employees suggest that the firm is acting defensively out of a weak position.

As discussed in the introduction, one way to absorb losses and reduce the impact of shocks to performance is to keep a buffer of highly liquid assets such as cash. Such readily available cash reserves provide a means to meet ongoing cash commitments without having to make costly adjustments. The literature analysing firm's cash policy cites the "pre-cautionary savings" motive for liquidity as one of the key benefits of cash holdings (Opler et al. 1999) and that this benefit is greater when firms are in a weak state (Pinkowitz and Williamson 2003). This argument lines up with the theoretical model of Gamba and Triantis (2014), showing that liquidity serves as a key risk management device against rising risk levels in the economy. Operating assets do not function as a buffer in this sense because they are generally illiquid and may need, in the case of a large and unexpected shock, to be sold at a discount to fair value in a so-called asset fire sale (Shleifer and Vishny 1992). That is, liquidating operating assets in response to a shock to performance should be viewed as a negative consequence of variability and not a convenient way to handle performance shortfalls.

H1: *The impact of Black Swans on the number of employees decreases with cash reserves.*

In a similar way to cash, a positive cash margin, construed in terms of the amount of cash generated per unit of revenue, provides a way to absorb revenue shocks[1]. For obvious reasons, the wider the firm's margins, the more of a drop in revenue it can handle without running into difficulties in serving cash obligations that could imply costly adjustments to operations. Internally generated cash has been extensively explored in the literature on corporate investment, which emphasizes its role in navigating capital market imperfections that create a cost wedge between external and internal sources of funding (Fazzari et al. 1988). Since the cash margin is a pre-capital expenditure concept, the implication is that investment spending can be cut in response to revenue shocks, thus making it less likely that core activities, and by extension the workforce, need to be scaled back.

H2: *The impact of Black Swans on the number of employees decreases with cash margins.*

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

H3: *The impact of Black Swans on the number of employees decreases with the extent of equity financing.*

A general strategy for managing risk is flexibility in terms of making an exit from a

[1]Cash margin is defined as revenue over the sum of cost of goods sold and selling, general, and administrative costs. It is related to the operating margin except that it excludes items like depreciation, R&D, and extraordinary items. The purpose of cash margin is to get a clean measure of the firm's ability to generate a cash surplus from operations based on the level of sales in relation to core cost elements.

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

H4: *The impact of Black Swans on the number of employees decreases with operating flexibility.*

As highlighted above, risk capital can be conceptualized as any resource that allows a firm to navigate a worst-case scenario without having to make costly adjustments to its business models. Our working definition of risk capital is, for practical purposes, focused on the traditional elements that the corporate finance literature has identified: equity capital, liquidity, and operating flexibility. It is noted, however, that this literature also suggests that derivatives should be considered part of risk capital, at least in firms with major exposures to market risk. Here, the received view is that hedging is effectively a substitute for equity capital (Stulz 1996), meaning hedging can absorb losses just like equity does. In principle, derivatives can be designed to generate an inflow of resources when business conditions are at their most unfavourable, which is precisely what risk capital is intended to do. The challenges of identifying individual firm hedging policies, however, renders this potential source of risk capital outside the scope of our empirical framework.[2]

3. Sample, empirical design, and variables

3.1. Sample

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

3.2. Empirical design

The empirical model (Eq. 1) relates the log of the number of employees to Black Swans whilst controlling for a number of firm characteristics that are likely to be systematically related to the number of employees. The right-hand side includes the buffer-variables discussed in Section 2: the equity ratio, cash reserves, cash margins, and operating flexibility. To test the hypotheses, each buffer-variable is interacted with the Black Swan-dummy (Eq. 2). The model contains firm fixed effects, such that the impact of a Swan is measured relative to each firm's baseline level. The error terms are clustered at the firm level. An important consideration is whether the shocks, as captured by the Black Swan variable, are unexpected or not. Whereas a recession in the economy may be considered exogenous to any given firm, the same is not necessarily true of general

[2]Few firms directly report hedging positions in their financial statements making data availability problematic. Research strategies tend to focus either on small industry sub samples (Gilje and Taillard 2017), or integrate large scale textual analysis techniques using firm's annual reports (Hoberg and Moon 2017).

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

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

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

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

where *log(Employees)* is the natural logarithm of firm employees, *Q* is Tobin's Q, *Tangibility* is firm asset tangibility, and *Cash margin*, *Operating flexibility*, *Cash reserves*, and *Equity ratio*, are financial buffers (variables are explicitly defined and further discussed in next section). α_i and α_t are firm and time fixed effects, respectively. Under the null hypothesis that buffers of resources do not matter to employment numbers when a Black Swan occurs, these interaction terms would be jointly insignificant. An overall lack of significance in these interaction terms would suggest that any adjustment to the workforce is an orderly and economically justifiable response to changing circumstances.

A potential objection to the inferences that can be made from our empirical model is that the ability to fire employees may in itself be a form of risk mitigation, for example if the firm's workforce is largely made up of non-permanent workers. A large sensitivity of employment to revenue shocks could, in this view, be a sign of low risk due to a high fraction of temporary workers rather than a costly consequence of variability in performance. It should be noted, however, that we focus on a single country (US). While states do have their own labour laws, the US as a whole is widely regarded as having one of the most flexible laws in an international comparison (Bäurle et al. 2021). Any variation in the ability of temporary workers to buffer against revenue shocks should therefore largely be across industries, which we explicitly control for in the model[4].

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

3.3. Variable descriptions and definitions

Black Swan is a binary variable that takes the value one if the year-on-year drop in revenue is between 30-90% and zero otherwise. That is, it flags a one if a firm loses a third of its revenue or more, which is in most circumstances a very severe shortfall in revenue. We do not include decreases larger than 90% for two reasons. Firstly, there is a clear over-representation of observations in that part of the outcome distribution. The general pattern is that revenue shocks get progressively more infrequent the further out

[4]In the robustness section, we introduce industry-year fixed effects to account for time-varying differences in economic activity across industries.

in the tail one moves, however this changes once one reaches the 90th percentile. This suggests that there is a fair amount of noise contained in that part of the distribution, and that many of these outcomes are driven by irregularities, for example related to corporate restructurings rather than by demand shortfalls. Secondly, shortfalls in excess of 90% are too extreme: a near-total wipeout of business activity may not be a very interesting case to consider[5].

Log_Employees is the log of the number of employees (EMP)[6]. *Revenue*, *SGA* and *COGS* are defined as annual sales (REVT), selling, general, and administrative expenses (XSGA) and cost of goods sold (COGS), respectively. Size is the log of total assets (AT). *Tangibility* is the ratio of property, plant, and equipment (PPENT) to total assets (AT). Tobin's *Q* is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is the number of shares outstanding times share price (PRCC_F x CSHOC).

We define four variables related to risk capital that capture a firm's robustness to Black Swan events: *Equity ratio*, *Cash reserves*, *Cash margin*, and *Operating flexibility*. *Equity ratio* is defined as one minus total liabilities divided by total assets (1-LT/AT). This formulation is preferred because we want, for ease of exposition, a buffer-interpretation for all four moderating factors. By this, we mean a variable that has the following interpretation: the higher the value it takes, the more resilient the firm is presumed to be (according to the hypotheses presented in Section 2). The results reported throughout the paper are not sensitive to using alternative definitions such as leverage (short- and long-term debt over assets) and gearing (short and long term debt over book equity).

[5]Note that according to Taleb (2007), Black Swans have three characteristics: 1) they are highly improbable beforehand, 2) have massive consequences, and 3) we easily rationalize them after the fact. Given that more than a third of business volumes disappears in a single year, we believe it is justified to speak of massive consequences. Moreover, in the multivariate analysis we require that they come in the wake of two years of positive growth. Therefore, they should qualify as highly improbable as well. The third characteristic – ex post rationalization – is not obvious from the data, but is, according to Taleb, an ingrained feature of the human mind. It is therefore unlikely that boards of directors did not consider the event that produced the loss to make perfect sense with the benefit of hindsight.

[6]The log transformation is motivated by the observed distribution of the number of employees, which displays a marked tendency towards a fatter tail in the right-hand side of the distribution than the one implied by the Gaussian.

We define *Cash reserves* as cash and cash equivalents divided by total assets (CHE/AT). *Cash margin* is computed as Revenue/(SGA + COGS). *Cash margin* indicates the extent to which the firm is able to generate cash from the core elements of its operations. Both capital expenditure and R&D expenses are excluded from the measure, which means that investment is essentially considered a buffer with respect to number of employees. That is, faced with a sharp downturn in business activity (revenue), a firm can choose to defer its spending on new projects in order to preserve its current operations thus mitigating the impact on the number of employees. *Operating flexibility* is defined as COGS/SGA. Following Chen et al. (2019), we view COGS as a more flexible cost element than SGA. According to these authors, studies investigating firms' cost behaviour tend to find a substantial stickiness for SGA, meaning that it is slower to adjust downward compared to how it responds to increases in business activity. For COGS, however, there is little or no systematic evidence of stickiness. For our purposes, COGS over SGA is an imperfect proxy since COGS also contains a labour expense-item in addition to the purchase of raw materials and semi-finished goods (i.e. staff expenses directly related to the productions of goods). What really buffers the number of employees is the extent to which a firm's cost structure is dominated by aspects that are predominantly variable in nature such as the aforementioned purchases. However, Compustat does not present a sufficiently detailed breakdown to back out these labour expenses. All ratios are winsorized at the 1st and 99th percentiles to minimize the possible distorting effects of outliers.

3.4. Sample description

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

Table 1: Summary statistics

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

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

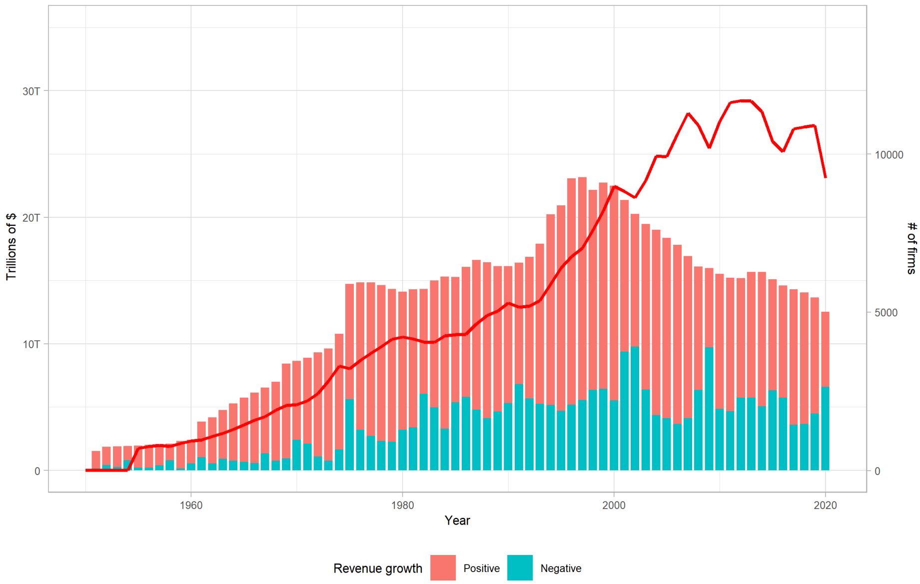
Table 2: Correlations

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

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

The development of aggregate revenue over time (the sum of revenue of all firms included in the sample) is illustrated in Figure 1, divided into positive and negative observations. Aggregate revenue is growing steadily over the sample period, except for a leveling out that began in the late 2000's. The total number of firms in the sample has been on a decreasing trend since the late 1990's, however, suggesting that more and more revenue is concentrated in the hands of larger firms. This is equivalent to the median size of firms increasing beginning around the year 2000, which we also verify.

Furthermore, an increasing number of firms report negative revenue growth overtime. In the first five years of the sample period (1970-1974) the ratio of negative to positive revenue growth is 20%, a stark contrast to the 62% seen in final five years of the sample (2016-2020).



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

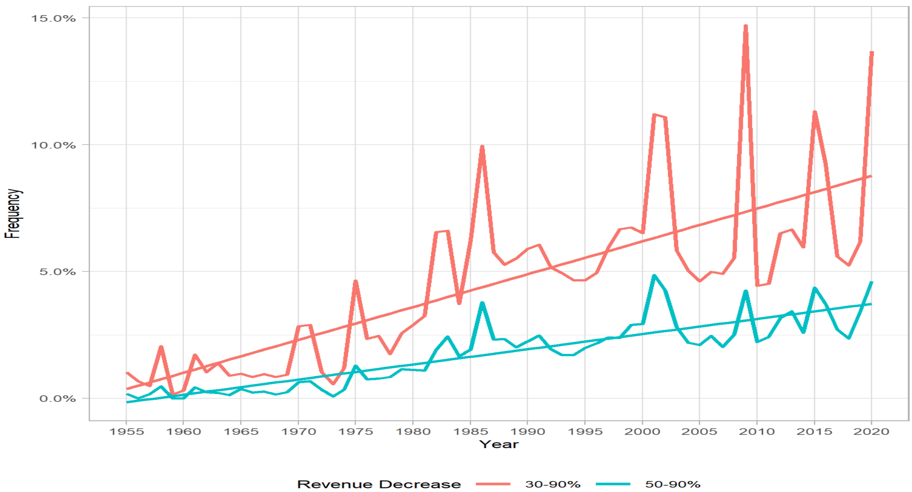
Figure 1: Historical revenue trends

4. Stylized facts about Black Swans

In this section, we provide stylized facts about Black Swans in regards to 1) their development over time, 2) relation to firm size, 3) industry patterns, and 4) the extent to which they are permanent or temporary in nature.

First, we investigate the popular belief that risk is on the rise. Proponents of this view often cite accelerating technological change, increased inter-connectedness, globalization, and the consequences of climate change as some of the main factors behind this development. Consulting firm PwC, for example, presents this as something close to an established fact: "*The world is getting riskier. Organizations are increasingly vulnerable as business becomes more complex, virtual and interdependent.*" To bring some evidence to bear on claims like these, Figure 2 depicts the development over time in the yearly mean value of revenue drops, which is to say the proportion of firms that experience a 30-90% fall in yearly revenue.[7] In addition to the definition with 30-90%, the graph shows the trend using a 50-90% as thresholds, representing an event even further out in the tail of the distribution (these firms lose over half of their revenue relative to the preceding year). Figure 2 is consistent with the popular notion that uncertainty is increasing over time. Both measures show a marked increase. The mean Black Swan rate between 1955 and 1975 is 1.2%, whereas the corresponding number in the 2000-2020 period is 6.1%. Sharp spikes in the rate of Black Swan seems to occur with greater frequency in the latter part of the sample. In fact, four out of the five years with the highest Swan rate are found in the 2000's.

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



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

Figure 2: Frequency of revenue drops over time

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

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

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

If size and sample composition do not drive the rising levels of revenue uncertainty, what does? To explain the observed trend in revenue uncertainty, one might point to several important secular trends. One is increasing competition from international companies as a result of globalisation. Relatedly, many business models may have become more vulnerable as a consequence of more complex and global supply chains. Another trend to keep in mind is the shorter life spans of products and of business models generally. That is, as customer tastes and preferences change at an accelerated pace, firms are at increased risk of finding that their key offerings have been rendered obsolete. Finally, the rising levels of private debt observed in the US may make consumers fickler. Given high levels of debt, changes in the economic outlook could prompt quick and substantial readjustments as potential customers prioritise debt servicing. This in turn is likely to create additional volatility in the demand for certain categories of products.

Second, we explore Black Swan rates across different size-cohorts to establish the relation between tail risk and firm size. What is clear from the data is, as expected, an over-representation among small firms in terms of the rates at which they experience Black Swans. Table 3 partitions the sample into terciles according to total assets. The smallest third accounts for over half of all Black Swans. Presumably, this reflects such firms' being more dependent on the success of a limited number of innovations and product lines. Large firms, in contrast, tend to have a more established and diversified market presence with some proven successes in the product mix at any given point.

Table 3: Black Swans across size terciles

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

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

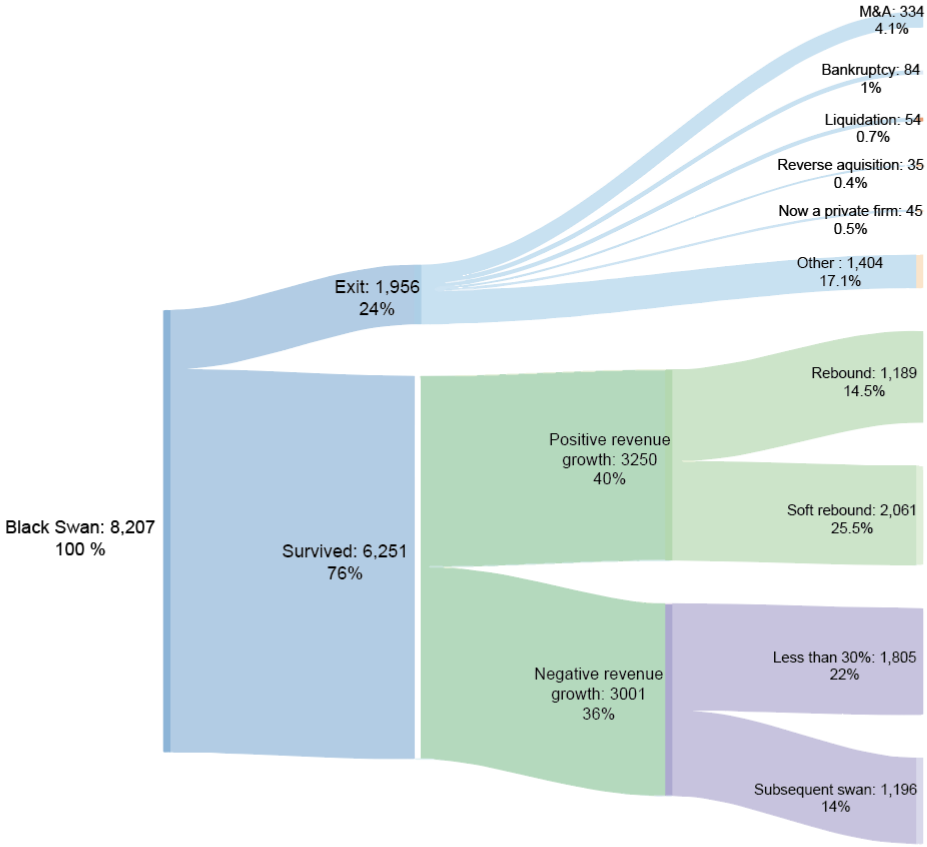
Third, we investigate the relationship between the rates of Black Swan and industry classification. Table 4 shows the Black Swan-rates per industry, and also juxtaposes them with the median values of each of the risk capital variables. The industries are arranged, in descending order, according to their respective Swan rate. The industry with the highest incidence of Swans is Oil, gas, and coal extraction. Interestingly, firms in this industry generally do not hold substantial cash reserves as a buffer against this tail risk. Instead, they have one of the highest cash margins, reflecting the fact that their main cost element is capital expenditure (many firms in this industry operate with low or negative EBIT-margins, see e.g. Andrén and Jankensgård 2015). This configuration suggests that the primary strategy for absorbing tail risk in this industry are reductions in capital expenditure. Relying on capex-cuts is consistent with the theory in Froot et al. (1993) because the value of investment opportunities in commodity-producing industries tend to co-vary with the product price that drives revenue. Furthermore, oil and gas producers are known to engage in extensive hedging using financial derivatives, which yield substantial cash payoffs in industry recessions (Jankensgård and Moursli 2020). The industry with the second-highest Swan-rate, Business Equipment, has less access to strategic hedging and may not see its investment opportunities co-move with revenue to the same extent. In keeping with these observations, this industry relies more on cash reserves as a means of absorbing tail risk outcomes.

Table 4: Industry swans and financial resources

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

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

Fourth and finally, we look at revenue performance in the year following a Black Swan. An important question is to what extent Swans are transient phenomena from firms that quickly rebound. From a risk capital-perspective, this makes a difference, because such buffers are primarily meant to protect against costly disruptions in the value-creation process that result from temporary shocks to performance. That is, the task of risk capital is not to indefinitely maintain a firm that has seen its business model fundamentally impaired. As a first step in mapping out this issue, Figure 4 details what happens in the year following a Swan. Firstly, we distinguish between firms that exit the sample and those that remain. Exit happens for a variety of reasons, such as bankruptcy, liquidation, and mergers. The majority, however, live to fight another day (76%). Secondly, we separate the surviving firms between those that revert to positive revenue growth (40%) and those that continue to experience a decline in revenue (36%). Of the firms returning to positive revenue growth, 36.3% (constituting 14.5% of the total number of Black Swans) bounce back to at least 75% of previous revenue levels ("Rebound"). Relatedly, we analyse the extent to which a Swan is followed by another similar drop. This is the question of whether Black Swans are serially correlated. According to Figure 4, such a consecutive Swan occurs in 14% of Swan-years. In unreported logit-regressions, we confirm that experiencing a Swan increases the likelihood of a Swan in the following year by about 5% (statistically significant at the 1%-level). We will come back to the issue of transient and cyclical Swans in Section 5 where we carry out drill-downs using the information in Figure 4.



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

Figure 4: What happens after a swan event?

5. Multivariate analysis

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

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

Table 5 reports the unconditional impact of a Black Swan on *Log_Employees* (Model 1) and the impact conditional on the Swan taking place in the 2000's (Model 2). The purpose of the latter model is to gauge whether fragility has increased over time, matching the increase in the frequency of Swans reported in section 4. On average, holding other factors affecting employment constant, years in which a Black Swan occurs are associated with 17% lower end-of-year employment compared to non-Swan years. Model 2 indicates that there is no statistically significant difference post-2000, suggesting firms' sensitivity to revenue shocks has not changed materially over time.

Table 5: Baseline Regressions

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

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

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

Next, we consider whether risk capital determines the employment-Swan sensitivity in line with the hypotheses presented in Section 2 (Table 6). We interact each of the four buffer-variables with the *Black Swan*-dummy, first separately (Models 2-5) and finally together (Model 6). The results strongly suggest that *Cash reserves* is the most important variable in lowering firm fragility to Black Swans. *Cash margins* is also significant in moderating Black Swans, with the expected positive sign, but neither *Equity ratio* nor *Op Flexibility* are significant at conventional levels. In unreported regressions, we test alternative definitions for both these variables, however the conclusions are unaffected. Further tests break down the sample into industries and sub-periods, yet the *Equity ratio* reaches statistical significance in none of them.[8]

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

Table 6: Regressions - Interaction terms

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

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

Note: Table reports regression results from Equation 2 with variables interacted with the dummy Black swan. Log(Employees) is the natural logarithm of employees (emp). Tobins Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price (PRCCF x CSHOC). Tangibility is asset tangibility defined as the proportion of firm physical assets (ppent) to total assets (at). Cash margin is defined as total revenue (revt) to the sum of cost of goods sold (cogs) and selling, general, and administration expense (xsga). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivalents(che) to total assets (at). Equity ratio is 1 minus the proportion of total liabilities (lt) to total assets. Black swan is a dummy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent with two years prior positive revenue growth, zero otherwise. Continuous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Sample includes all firms available in the Compustat files from the 1970-2020 period excluding financial and utility firms. Standard errors are clustered at firm level.

Before moving on to consider the robustness of our main results, we investigate the role of size in determining firm fragility. In Section 4, we found that the frequency of Swans is higher among small firms. But are they also more fragile? Nicholas Nassim Taleb in his book "Antifragility: Things that Gain from Disorder" (Taleb 2012) argues that size matters. In particular, he advances the idea that size is conducive to fragility, asserting that "size hurts you at times of stress. It is not a good idea to be large during difficult times" (p. 279) and that "fragility comes from size" (p. 282). To learn more about this conjecture, we split the sample into terciles according to total assets and re-estimate the baseline model for each subsample. The results are reported in Table 7. Among the smallest tercile, the difference in end-of-year employment is almost 22% between Swan-years versus non-Swan-years, whereas the corresponding difference in the largest cohort is 17%. This result indicates a somewhat higher sensitivity to shocks among smaller firms. However, Model 4, in which we instead include a binary variable representing the highest tercile (i.e. the largest firms), shows that the sensitivity to revenue shocks of larger peers is not statistically different from the other ones. The coefficient is negative (-0.042) but does not reach the statistical threshold. Therefore, Taleb's conjecture that larger firms are more fragile is not supported by our findings.

Table 7: Regressions on Size

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

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

Note: Table reports regression results on terciles of total assets (AT) calculated on a yearly basis. Models 1 through 3 report results on 1st through 3rd terciles of size, respectively . Model 4 includes an interaction term with TOP TERCILE, a dummy variable that takes on the value of 1 if a firm belongs to the highest tercile of size and 0 otherwise. Log(Employees) is the natural logarithm of employees (EMP). Tobins Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price (PRCCF x CSHOC). Tangibility is asset tangibility defined as the proportion of firm physical assets (PPENT) to total assets (AT). Cash margin is defined as total revenue (REVT) to the sum of cost of goods sold (COGS) and selling, general, and administration expense (XSGA). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivalents(CHE) to total assets (AT). Equity ratio is 1 minus the proportion of total liabilities (LT) to total assets. Black swan is a dummy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent with two years prior positive revenue growth, zero otherwise. Continuous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Sample includes all firms available in the Compustat files from the 1970-2020 period excluding financial and utility firms.

6. Extensions and robustness

In the following section, we provide robustness checks that further validate our findings. First, as tail risk has no strict and theoretically mandated definition, we show that our results are invariant to the choice of the threshold value used to identify Black Swans. Second, we show that the importance of cash reserves holds when we consider transient as well as cyclical Black Swans. Finally, we challenge our findings by introducing some changes in the sample selection as well as in the econometric specifications.

6.1. Alternative thresholds to identify a Black Swan

Table 8 examines whether results are sensitive to alternative definitions of a Black Swan. Our lower threshold of 30% is meant to capture a rare and very severe decline in revenue from one year to the next. We presume that most firms are likely to consider unexpectedly losing a third or more of their sales a drastic impact on their business. In Table 8, we raise and lower this threshold to consider both more and less extreme tail risk events (revenue drop between 20-90%, 40-90%, 50-90%). Moreover, we split our original 30-90% revenue decrease range into two sub-ranges to identify "mild" Black Swans (when a revenue shortfall is between 30-60%) and "severe" Black Swans (when a revenue shortfall is more extreme and between 60-90%). Again, recall that this comes on the back of two years of positive revenue growth and that firms carrying out large disposals of assets have been filtered out. Table 8 informs us that going further out the tail, or changing the definition of a Black Swan in general, does not change the conclusion: cash reserves are still the most important moderator of firm fragility. The effect is particularly relevant in the case of a "severe" Black Swan.

Table 8: Alternate swan definitions

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

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

Note: Table reports regression results from Equation 2 using various definitions of black swan, ranging from a 20-90 percent revenue decrease(Column 1) to 60-90 percent decrease (Column 5). Log(Employees) is the natural logarithm of employees (emp). Tobin's Q is defined as the logarithm of the market value of assets divided by total assets. The market value of assets is defined as total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price (PRCCF x CSHOC). Tangibility is asset tangibility defined as the proportion of firm physical assets (ppent) to total assets (at). Cash margin is defined as total revenue (revt) to the sum of cost of goods sold (cogs) and selling, general, and administration expense (xsga). OP flexibility is operating flexibility defined as cost of goods sold to SGA, while Cash is cash and cash equivalents(che) to total assets (at). Equity ratio is 1 minus the proportion of total liabilities (lt) to total assets. Black swan is a dummy variable that takes the value of 1 if revenue growth has fallen between 30 and 90 percent with two years prior positive revenue growth, zero otherwise. Continuous variables are lagged two periods and winsorized at the 1 and 99 percentiles. Sample includes all firms available in the Compustat files from the 1970-2020 period excluding financial and utility firms. Standard errors are clustered at firm level.

6.2. Transient and cyclical Black Swans

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

Table 9: Regressions - Rebound and top swan years

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

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

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

6.3. Other robustness checks

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

Table 10: Regressions - Robustness checks

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

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

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

7. Exogenous revenue shocks: the airline industry case

In the previous sections, we provide robust evidence of the ability of cash reserves to reduce firm fragility in the occurrence of Black Swans and mitigate the impact of such revenue shocks. However, firm policies are not developed in isolation and some underlying conditions could affect both revenues and employment, making the analysis suffer from potential endogeneity. Reverse causality does not likely plague our tests since we lag independent variables two years. Moreover, our evidence holds even when we analyse transient and cyclical Black Swans, which are less likely to be associated with changes in the firm's fundamentals. To further mitigate the issue of endogeneity, however, we develop a specific analysis on the airline industry in this section.

The airline industry has been threatened by global shocks throughout its history. Typically, these are segmented in three major areas (Brown and Kline 2020), namely (i) economic, (ii) health, and (iii) terrorism. While economic shocks, such as recessions, inflation, currency exchange, or commodity spikes, could be recognized in anticipation by firm managers to formulate decisions, global events related to health risks and terrorism can serve as notable exogenous and unexpected shocks to firms. By investigating the sensitivity of employment to Black Swans in the airline sector in the occurrence of such exogenous and unexpected events we can properly control for tail risks and revenue drops that are unrelated to any firm idiosyncratic characteristics. Therefore, the sequence of the shock impacting the top line (revenues) and in turn the bottom line (number of employees) is more straightforward. Another important benefit of using the airline industry is that the airline labour force often bears the brunt of any industry decline (Sobieralski 2020).

The U.S. airline industry falls under the overall Transportation by Air classification, which is covered by the Standard Industrial Classification (SIC) code 45. Accordingly, we select those firms belonging to the following SIC codes: 4512 (Air transportation scheduled), 4513 (Air Courier Services), 4522 (Air transportation, not scheduled), 4581 (Airports, Flying Fields, and Airport Terminal Services). In our sample, there are 184 unique firms belonging to these sectors.

Among health related shocks, none was quite as rapid and severe as the one posed by the spread of COVID-19. The virus was first reported in December 2019 in China's Wuhan Province and began spread almost immediately to other parts of the world. By late May 2020, over 4 million cases were reported globally and nearly every nation on the planet had closed its boarders to foreign visitors. For the airline industry this was a perfect storm scenario. Travel restrictions have reduced the mobility of individuals across the globe and air travel continued to shrink due to flight cancellations and capacity reductions. By April 2020 many major airlines were reporting that their traffic was down over 95 percent from the previous quarter (`www.bts.gov`). In line with this number, 54% of airline firms in our sample show a revenue drop higher than 30% in 2020.

To identify such an exogenous shock, we first create a dummy (Covid) that is equal to one when two conditions are met: the firm experiences a revenue drop higher than 30% and the drop occurs in 2020, the year of the global pandemic. However, the COVID-19 outbreak is not the only global pandemic that especially hit the airline industry. Therefore, we create a second dummy (Covid_ SARS) to also include those Black Swans taking place in the 2002-2003 outbreak of the Severe Acute Respiratory Syndrome (SARS)[9]. Finally, we further refine our Black Swan identification strategy to also consider exogenous events associated with terrorism and create a dummy (Covid_ SARS_ 9/11) equal to one when the Black Swan occurs in either one of the health shocks mentioned above (COVID or SARS) or after the 2001 terrorist attack (9/11).

Results are reported in Table 11. In the first column, we replicate our regressions on the sub-sample of airline industry firms conditional on the Black Swan taking place in 2020 during the COVID-19 pandemic. In the second column, we take into consideration airline industry Black Swans taking place after both the COVID-19 and the SARS outbreak. Finally, in the third column we add the exogenous Black Swans taking place in the airline industry after either a global pandemic or the 9/11 terrorist attack. The reported evidence is aligned with the findings from our baseline tests, notwithstanding the sample drop. The results indicate that, while each exogenous shock has per se a

[9]We acknowledge the 2009 Swine Influenza (H1N1) but do not include here as exogenous event since Black Swans taking place in this year could be contaminated by the contemporaneous 2008-2009 Great Recession.

negative impact on the employment numbers, the impact is mitigated when the firm is equipped with more cash reserves. Overall, our findings are in line with recent works (Fahlenbrach et al. 2021, Tawiah and O'Connor Keefe 2020, Zheng 2022) showing the primary role of cash holding in supporting corporate policies during exogenous shocks like the COVID-19 crisis.[10]

[10]In particular, Fahlenbrach et al. (2021) document significant heterogeneity in firms' resilience during the COVID-19-driven stock market collapse. They find that firms which are more financially flexible based on their cash holdings performed significantly better during the stock market collapse and the performance gap continues to persist during the subsequent rebound of the stock market, suggesting that the ability to fund cash shortfalls in times of crisis may have long-lasting value implications. Similarly, Tawiah and O'Connor Keefe (2020) and Zheng (2022) provide further evidence on the value of financial flexibility through cash holding in explaining corporate investment and performance during the revenue shortfall resulting from the Covid-19 shock.

Table 11: Regressions - Airline shocks

	Dep var = *log*(*employees*)		
	Model 1	Model 2	Model 3
Q_{t-2}	-0.026	-0.025	-0.015
	(-0.21)	(-0.20)	(-0.13)
Tangibility$_{t-2}$	0.535	0.537	0.549
	(1.35)	(1.35)	(1.39)
Cash margin$_{t-2}$	0.457**	0.454**	0.444**
	(2.03)	(2.02)	(1.99)
OP flexibility$_{t-2}$	3.44***	3.440***	3.417***
	(3.61)	(3.60)	(3.58)
Cash$_{t-2}$	-0.342	-0.340	-0.329
	(-0.69)	(-0.69)	(-0.66)
Equity ratio$_{t-2}$	0.545***	0.548***	0.548***
	(2.70)	(2.72)	(2.73)
Covid	-3.685**		
	(-2.34)		
Covid x Cash margin$_{t-2}$	-0.349		
	(-1.48)		
Covid x OP flexibility$_{t-2}$	4.398**		
	(2.40)		
Covid x Cash$_{t-2}$	2.130*		
	(1.70)		
Covid x Equity ratio$_{t-2}$	1.215		
	(1.23)		
Covid_SARS		-3.754**	
		(-2.37)	
Covid_SARS x Cash margin$_{t-2}$		-0.325	
		(-1.43)	
Covid_SARS x OP flexibility$_{t-2}$		4.433**	
		(2.37)	
Covid_SARS x Cash$_{t-2}$		2.328**	
		(1.99)	
Covid_SARS x Equity ratio$_{t-2}$		1.102	
		(1.16)	
Covid_SARS_9/11			-2.070**
			(-2.16)
Covid_SARS_9/11 x Cash margin$_{t-2}$			-0.408
			(-1.43)
Covid_SARS_9/11 x OP flexibility$_{t-2}$			2.479**
			(2.32)
Covid_SARS_9/11 x Cash$_{t-2}$			2.149*
			(1.75)
Covid_SARS_9/11 x Equity ratio$_{t-2}$			1.535*
			(1.76)
Constant	-3.664***	-3.663***	-3.645***
	(-3.53)	(-3.53)	(-3.51)
Observations	1,123	1,123	1,123
Adjusted R-squared	0.502	0.502	0.503
Firm FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes

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

Note: Model 1 reports results from Equation 2 including the dummy *Covid* equal to one when the Black Swans take place in the 2020 outbreak of COVID-19. Model 2 introduces the dummy *Covid SARS* equal to one when Black Swans take place in the 2020 outbreak of COVID-19 or in the 2002–2003 outbreak of the Severe Acute Respiratory Syndrome (SARS). Model 3 adds the dummy *Covid_SARS_9/11* equal to one when the Black Swan occurs in either one of the health shocks mentioned above (COVID-19 or SARS) or after the 2001 terrorist attack (9/11). Market value of assets is total assets (AT) minus common equity (CEQ) plus market value of equity, where market value of equity is number of shares outstanding times price (PRCCF × CSHOC). *Tangibility* is defined as the ratio of physical assets (PPENT) to total assets (AT). *Cash margin* is total revenue (REVT) divided by the sum of cost of goods sold (COGS) and selling, general, and administrative expense (XSGA). *OP flexibility* is operating flexibility defined as (COGS/XSGA), while *Cash* is cash and cash equivalents (CHE) divided by total assets (AT). *Equity ratio* is 1 minus the proportion of total liabilities (LT) to total assets. Continuous variables are lagged two periods and winsorized at the 1st and 99th percentiles. Standard errors are clustered at the firm level.

8. Conclusions

The Black Swan-problem that motivates this paper is that committing resources to risk capital in order to deal with tail risk reduces return on equity in the vast number of scenarios in which such risks do not materialize. This makes it pertinent to understand which sources of risk capital are effective in absorbing tail risk, construed in this paper as large, negative, and unexpected revenue shocks ("Black Swans"). Risk capital is here broadly conceptualized as any buffer that helps absorb and mitigate the impact of such revenue shocks, thereby allowing firms to avoid negative consequences to its strategy execution. Our proxy for strategy execution in this paper is the number of employees, on the premise that differences in the employment-Black Swan sensitivity is an indicator of the extent to which firm must make deep and costly adjustments to its strategy.

Our empirical analysis incorporates over 160,000 firm-year observations in the time span 1970-2020. Out of the elements of risk capital investigated in this study, cash reserves stand out in terms of their ability to buffer against Black Swans. Cash reserves are associated with a statistically and economically significant reduction in firm fragility, measured in terms of a decrease in the employment-Black Swan sensitivity. Cash margins are also associated with a lower fragility, albeit not as robustly so as cash reserves. Overall, liquidity-based sources of risk capital fare best when it comes to absorbing tail risk.

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

Avenues for future research could investigate whether firms with low equity capital to a higher degree use changes in capital expenditure as a means to absorb tail risk (as opposed to workforce adjustments). This kind of research could help shed light on the puzzling absence of significance for equity capital in our analysis. Another interesting line of research would be to explore whether firms with excessive risk capital contribute to the creation of corporate zombies, which is to say firms that go on existing with low profitability for years on end. We identified a meaningful sub sample of firms whose revenue did not rebound following the initial shock. It would be meaningful to analyse whether overcapitalised firms are more prone to become “zombie-like” following such revenue tail risk events.

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Paper IV

Labour adjustment costs and investment to cash flow sensitivities

Nick Christie

1. Introduction

A core area in corporate finance research deals with the interaction between capital market frictions and corporate investment. By now it is well-understood that financing frictions such as taxes, equity issuance costs, agency costs, and information asymmetry problems increase the cost of external financing and impact manager's incentives in taking on new investment.

A particular corollary of these financing frictions, which has seen considerable attention in the literature, is the sensitivity of investment to a firm's internally generated cash flow. Empirical research has historically identified a positive association between investment and profits,[1]with a preference for firms to prioritize cash for investment needs (Myers, 1984). This suggests that firms generally invest more when cash flow is high because internally generated funds are cheaper compared to their external alternatives of debt or equity financing. Importantly, the literature has shown the link between high cash flows and increased investment holds in the Q-theory framework, where controlling for investment opportunity with Tobin's Q predicts no such relationship exists. The traditional explanation of this phenomenon originates with the findings of Fazzari et al. (1988), who attribute the investment to cash flow sensitivities (ICFS) identified in their experiments to that of financial constraints - where firms facing greater frictions in obtaining external finance rely more heavily on their internally generated funds to support their planned investment needs.

[1]Tinbergen (1938), to give one such early example, finds that changes in investment are better explained by firm profits than changes in firm output, the later being a predictor of the accelerator theory of investment

This financial constraints explanation has fuelled much debate and criticism over the years. A large body of empirical studies challenges the claim that ICFS are solely attributable to, or a measure of, financial constraints (see for example: Kaplan and Zingales, 1997; Alti, 2001; Chen and Chen, 2012; Bodnaruk et al., 2015; Farre-Mensa and Ljungqvist, 2015; Moshirian et al., 2017; Andrén and Jankensgård, 2019). While recent studies have critiqued the efficacy of financial-constraint proxies and pointed out potential measurement error in Tobin's Q, relatively sparse attention has been paid to other factors that may influence the investment–cash flow relationship. What actually drives ICFS remains an unsettled puzzle in the corporate finance literature.

This investigation proposes that labour adjustment costs (LAC) may help explain observed differences in ICFS. LAC represent the costs firms incur due to a changing demand of labour in response to changes in investment, encompassing such costs as recruitment fees, training, severance packages, and other such costs associated with managing productivity. LAC's have been shown to have implications across a wide spectrum of corporate phenomenon from asset pricing in financial markets (Belo et al., 2017), to increased cash holdings (Ghaly et al., 2017), to greater asymmetric cost behaviour (Golden et al., 2020), to expanded risk management policies (Qiu, 2019), and to slow investment and sales growth (Bai et al., 2020). Despite the extensive literature, to my knowledge no study has yet examined how labour-specific adjustment costs might explain differences in observable ICFS. This paper aims to fill that gap.

Just how LAC may account for differences in ICFS is largely an empirical question. As is the direction this potential relationship may take. On one hand, LAC may have a negative association with ICFS. Costly adjustments to labour inputs may dip into cash flow earmarked for investment purposes, creating a type of "crowding out" effect where LAC are prioritized over investment. This idea has seen some support in the literature with the findings of Liao et al. (2020), who report an inverse relationship between ICFS and capital adjustment costs. These capital adjustment costs, the authors describe, are attributable primarily to adoption of new technology. Costs strictly related to that of labour, the purview of this investigation, may indeed follow a similar trend. On the other hand, recent findings suggest LAC are associated with greater information asymmetry (Marshall et al., 2021), a key component of the "financial constraints" theory of

ICFS. The effect of information asymmetry on ICFS, which has been documented in the literature (Ascioglu et al., 2008), suggests a positive LAC-ICFS relationship. Moreover, the plausibility of both these theoretical perspectives suggests these mechanisms may even contradict each other, creating a cancelling out effect where a significant LAC-ICFS relationship may not be observed. It is in the pursuit of disentangling this ambiguity which motivates the need for deeper empirical investigation.

To identify if LAC are indeed associated if ICFS, I first examine the relationship using a sample of U.S. manufacturing firms between 2002 to 2019. I construct a LAC proxy, the Labour Skills Index (LSI), to test the effect of LAC on ICFS. Here, the greater salaries, training cost, recruitment fees, and general scarcity of specialized labour which is associated with highly skilled professions is assumed a reasonable proxy for LAC. After estimating baseline panel regressions of the standard *Q*-model with a measure of cash flow and asset tangibility, I augment the model with the LAC proxy and its interaction term with cash flow to test LAC's influence on ICFS. The results show that compared to firms with high LSI values (2.7), low LSI firms (1.4) firms demonstrate more than two-times greater ICFS (0.08 vs 0.03). As we shall see, the data support the hypothesis that greater LAC attenuate ICFS.

Endogeniety concerns are an important aspect of all empirical studies, and this investigation is no exception. A potential concern with the preliminary tests is the possibility that the LSI proxy is either prone to measurement error or is inefficient in its ability to capture LAC. To strengthen casual inference, and provide robustness to my conclusions, I further estimate a difference-in-difference model which exploits the staggered adoption of state-level US employment protection laws across a thirty-year period. Historically, laws related to the protection of worker's rights in the U.S. have not been regulated by the central government, instead the responsibility has fallen on the shoulders of individual states to adopt employment protection legislation. The result of this delegated responsibility creates a unique opportunity for this investigation, with different states adopting various worker protection laws at different time periods - establishing a quasi-natural experiment setting for hypothesis testing. Legislation which restricts a firm's ability to downsize in the presence of reduced investment opportunities has clear implications for increased labour adjustment costs. Limiting a firm's ability to dismiss labour in times of productivity downturns has consequences such as higher severance packages, increased recruitment fees and hiring costs, and greater worker training costs. I report a negative and significant relationship between ICFS and the adoption of each of the three worker protection laws examined in this investigation, which is consistent with the results of the LSI tests and reinforces the conclusion of a negative association between ICFS and LAC.

Finally, to address the role of financial constraints in the LAC-ICFS relationship, I examine the hypothesis that financial constraints increase the effect of LAC on ICFS, regardless of direction. Here, the argument is essentially that of an augmented financial constraints hypothesis, where greater LAC amplify financing frictions related to securing external capital. Leveraging three popular financial constraints proxies found in the literature, I sort firms into constrained and unconstrained groups and estimate interaction models with the LSI index in each sub-sample. The idea, as I expand on below, is that firms which face both greater LAC and increased financing frictions should be even more reliant on cash flow for investment needs. Contrary to expectations, the data show no support for this hypothesis. The LAC-ICFS effect is absent in financially constrained firms and only observed with unconstrained firms. The findings suggest a potential offset effect of financial constraints and LAC, where the magnitude of ICFS are increasing in financial constraints as well as decreasing in costs associated with labour. These results are similar to those of Liao et al. (2020), who, focusing strictly on capital adjustment costs, report similar findings when examining ICFS and costs associated with the adjustment of capital.

This paper's contribution to the corporate finance literature is materialized in several ways. First, I expand on the literature on ICFS by introducing LAC as a determinant of ICFS. Using a proxy for LAC and exploiting a natural experiment, I show that differences in ICFS may be explained in part by firms' labour adjustment costs. These findings add to the growing evidence that ICFS are unlikely to be due to a single factor, namely financial constraints, but instead suggests they may be driven by a complex interaction of a number of factors. Costs relating to the adjustment of labour dip into available internal funds attenuating investment spending. Lastly, it challenges the traditional financial constraints explanation of ICFS. Counter to my hypothesis, I report that the LAC-ICFS effect is largely absent in financially constrained firms. The results suggest the presence of an offset effect where LAC's influence on ICFS is offset in the presence of financial constraints. While these findings highlight an empirical avenue for future researchers to pursue, caution is warranted in the strict interpretation of this study's findings as support for the financial constraint interpretation of ICFS.

This paper is most similar to that of Liao et al. (2020) who investigate the effect capital adjustment costs arising from advances in technology in explaining ICFS. In contrast to their study, which emphasises capital adjustment costs via technological change, this paper's focus is particularly on that of labour adjustment costs. As LAC are likely the largest contributor to adjustment costs associated with capital (Anderson et al., 2003), I allow for sharper and more intuitive testing using a direct proxy of labour adjustment costs as well as a quasi-natural experiment.

The rest of the paper is outlined as follows. Section 2 reviews the literature related to ICFS and LAC and develops testable hypotheses. In section 3, I introduce the various data sources, present the empirical design, and describe sample characteristics. Section 4 presents estimation results of the various models and the conclusion is found in Section 5.

2. Relevant literature and hypothesis development

Investment to cash flow sensitivities should be understood within the context of the Q-theory of investment. Tobin (1969) theorized that individual firm investment ought to be explained by marginal Q, representing the ratio of the market value of an additional asset relative to its replacement cost. When the market values assets more than the cost replacement, firms are incentivized to add to their capital stock and do so in their best interest. Dependent on an efficient market, firms should continue to invest as long as investors value assets in place more than the replacement costs of said assets, until the point where the marginal cost of replacement equals that of the market value of assets. An important implication is that Q-theory implies investment is solely determined by Q, and that internal capital, or any other measure of liquidity for that matter, plays no part in the process after controlling for Q.

In an influential paper, (Fazzari et al., 1988) augment a traditional Q model with a measure of internally generated cash flow, reporting a significant relationship between cash flow and investment while holding Q constant. According to the authors, these observed investment to cash flow sensitivities (ICFS) should be interpreted as that of financial constraints, where firms which facing relatively greater costs in securing external financing rely more heavily on internal funds and thus demonstrate greater ICFS. Importantly, this hypothesis draws an crucial link between investment decisions, internal capital, and the financial resources of a firm. Firms which have difficulty raising external financing, Fazzari et al. (1988) reason, should have investment which is more sensitive to fluctuations in their cash flow compared to firms which have relative ease in acquiring external funds. An implication of this conclusion is that ICFS are to be a considered a reasonable measure of financial constraints.

The substantial uproar ensuing Fazzari et al. (1988) has challenged the authors' findings and resulted in what Brown and Petersen (2009) state as "one of the largest empirical literatures in corporate finance". Empirically, researchers have consistently documented a significant and positive relationship between investment and cash flow after controlling for Tobin's Q, with the majority of studies centred around identifying financially constrained firms (Kaplan and Zingales, 1997; Lamont et al., 2001; Whited and Wu, 2006; Hadlock and Pierce, 2010; Hoberg and Maksimovic, 2015; Bodnaruk et al., 2015), or investigating potential bias in measuring Tobin's Q (Erickson and Whited, 2002; Bond et al., 2004; Cummins et al., 2006; Erickson et al., 2014). While these studies have contributed greatly to our understanding of investment, and ICFS in particular, sparse attention has been paid to factors or determinants outside the traditional Q-investment framework. Recent studies suggest that ICFS cannot be explained entirely by measurement error in Q (Ağca and Mozumdar, 2017), nor should they be interpreted as a measure of financial constraints (Chen and Chen, 2012; Farre-Mensa and Ljungqvist, 2015; Bodnaruk et al., 2015). If a greater understanding of the investment-cash flow relationship is to be realized, we must expand the horizon beyond that of an explanation that rest primarily on financial constraints.

What actually explains ICFS, beyond that of financial constraints, remains somewhat of a puzzle in the literature. The question has led researchers to investigate alternative views of the determinants of ICFS. Moshirian et al. (2017) examines ICFS in an international setting suggesting that asset composition is a contributing factor in explaining ICFS. Christie (2018) provides empirical evidence in asset tangibility's effect on ICFS, documenting that time series patterns across industries can be explained by asset tangibility. Andrén and Jankensgård (2019) report similar findings, showing that capital intensity plays a part in determining ICFS. In a recent study, Liao et al. (2020) suggest that capital adjustment costs, measured by the technological advancement, may divert available cash flow away from investment, creating negative pressure on ICFS. Considering that labour costs associated with production can be extensive, and that such costs are often substantial when shifting from one investment opportunity to another (Anderson et al., 2003), it is quite likely adjustment costs due to labour exert similar, or even greater, pressure on ICFS.

The theoretical relationship between LAC and ICFS suggested by the extant literature is ambiguous and potentially contradictory. LAC arise as firms vary their investment commitments during the course of business operations, incurring a range of costs corresponding with the change in labour demand. With an increase in demand, labour costs materialize in the form of hiring costs (e.g advertising and recruitment costs and costs associated with interviews and proficiency testing), as well as retraining costs (e.g. company training programs and mentorships). Similarly, decreases in labour demand incur cost such as firing costs (e.g. severance packages and legal fees due wrongful dismissal), and retentions costs (e.g. productivity losses and labour allocation costs). The theoretical mechanisms in which LAC may affect ICFS could go in two directions.

On one hand, LAC may induce a positive effect on ICFS. This could materialize via two potential channels. First, studies suggest greater LAC are associated with increased information asymmetry (Chen and Chen, 2013; Marshall et al., 2021). The theory here is that as information asymmetry increases, so does the wedge between the cost of internal vs. external finance. This mechanism is one of the keystones on the theory of financial constraints and ICFS brought forth by Fazzari et al. (1988), where firms facing greater costs in securing external finance rely more heavily on their internal funds, translating into a greater dependency on cash flows for investment needs, and hence greater ICFS. Similarly, LAC may increase the cost of external financing in that greater hiring costs, employee training, and costly layoffs may reduce the operating flexibility of firms and increase equity costs (Chen et al., 2011). Greater information asymmetry and reduced operating flexibility should increase the wedge between internal and external financing costs, rendering firm investment more dependent on internally generated cash flow.

On the other hand, high adjustment costs may absorb firm cash flow earmarked for corporate investment, creating a "crowding out" effect where cash is diverted away from capital expenditures. As firms invest, they increase capital stock, measured as capital expenditure, but also incur a set of adjustment costs, arising as the firm transitions between investment opportunities, or takes on new ones. Liao et al. (2020) report an inverse relationship between ICFS and capital adjustment costs, arguing that adjustment costs due to advances in technology eat into precious cash marked for investment and drive down ICFS. A significant proportion of these adjustment costs has been attributable to that of labour, where costs relating to hiring, training, and dismissal of a firm's workforce are incurred as investment varies (Anderson et al., 2003). Here, a "crowding out" effect may indeed be present in the face of high LAC, where firms facing greater LAC must divert cash flow earmarked for investment towards labour-force management.

The above considerations, highlighting the theoretical support for either a positive or negative relationship between LAC and ICFS, leads to the development of the following hypotheses which are intentionally left open to avoid a priori assumptions between ICFS and LAC. Considering a potential bi-directional effect between LAC and ICFS is therefore more inline with the literature.

H1a: *Investment to cash flow sensitivities are lower in firms faced with greater Labour adjustment costs due to the crowding out effect*

H1b: *Investment to cash flow sensitivities are greater in firms faced with greater Labour adjustment costs due to increased informational asymmetry*

Considering each of the above hypotheses, the presence of financial constraints in either of the theoretical situations should exacerbate the effect of LAC on ICFS. A central tenant in the theory of financial constraints is that the scarcity of external funding increases the dependency of internal cash flow for investment needs, in turn driving greater ICFS. Greater financial constraints should then compound the effect of LAC on ICFS in either situation. In the case of hypothesis **H1a**, financially constrained firms facing high borrowing costs would rely even more on cash flow to fund labour adjustment costs when investing, resulting even smaller ICFS due to more precious cash flow being diverted away from investment and into labour costs. If, on the other hand, LAC increases information asymmetry, as in **H1b**, and magnifies financial constraints, we would expect financially constrained firms with high LAC to become more constrained and demonstrate much greater ICFS. This discussion then leads to the last hypothesis:

H2: *The effect of LAC on ICFS is more pronounced in financially constrained firms*

3. Data, variable definitions, and empirical framework

3.1. Data sources and variable definitions

This paper utilizes two empirical methods to proxy and test the effect of labour adjustment costs on ICFS, where data availability and their composition guiding sample construction. Data used in this study is derived from 4 primary sources. To construct the Labour Skills index, which I describe in detail below, employment and skills data are taken from the Occupational Employment Statistics database of the Bureau of Labour Statistics and the U.S. Department of Labour's O*NET program.[2] The timing and passage of worker protection laws is taken from Schwab et al. (2006), who document the precise month and year of each law is adopted by the respective U.S. states. Lastly, firm financial data is extracted from the Compustat database to estimate the variables in the study. Secondary data sources for inflation estimates and descriptions of NAICS industry classifications are sourced from the OECD and the U.S. Census Bureau, respectively.

The data collection process results in two distinct samples: the "WPL sample" and the "LSI sample". The "LSI sample" includes all manufacturing in the Compustat database beginning with the first year of reliable data needed to construct the LSI index

[2] Raw data are available at https://www.bls.gov/oes/data.html and https://www.onetcenter.org/database.html.

in 2003 and continuing to the last year of available data in 2019. The LSI sample is comprised of 22,640 firm-year observations. The Worker protection laws (WPL) sample includes all manufacturing firms in the Compustat database from period 1969 to 2003. Following Bai et al. (2020), the WPL sample period begins 5 years before the first good faith exception is adopted by New Hampshire in 1974 and ends 5 years after the last adoption of the good faith exception by the state of Louisiana in 1998, resulting in a sample size of 50,665 firm-years. The next section defines the LAC proxy used in the analysis and describes the empirical setting of the natural experiment.

3.1.1. Labour skills index

Following the work of Belo et al. (2017), Ghaly et al. (2017), and Golden et al. (2020), I develop a skills-based index to gauge the extent that firms rely on skilled labour in their day-to-day operations. Using data from the Bureau of labour Statistics (BLS) Occupational Employment Statistics (OES) program, I match survey data from the U.S. Department of labour's O*NET program to develop an industry-level index that weights the distribution of job types found in a particular industry by their associated occupational skill level. This labour Skills index (LSI) measures the ratio of high-skilled workers to total workers in a given industry, based on the distribution of occupations and their required skill levels. The LSI is defined as follows:

$$LSI_i = \sum_{j=1}^{O} \left(\frac{E_{ji}}{E_i} \times Z_j\right)$$

where E_{ji} is the number of employees in industry i working in occupation j, E_i is the total number of employees in industry i, O is the total number of occupations in industry i, and Z_j is the $O * NET$ program classification score - the Job Zone score which captures the skill level of occupation j.

The O*NET program is the primary source of occupational information found in the United States, a comprehensive database of worker attributes and job characteristics updated regularly with survey data over a wide range of industries. The program constructs and reports a skill-based classification system which sorts occupations into one of five "Job Zones", where each Job Zone contains a group of occupations that are similar in level of education, needed experience, and required on-the-job training. Job zone 1 consists of occupations that need little or no preparation to perform, while Job Zone 5 groups the occupations where extensive preparation is needed to carry out occupational duties.

To determine the proportions of low and high skilled workers in a particular industry, I use data compiled from the BLS OES program, which conducts a semi-annual survey across the United States and collects data on wage and salary workers across over 800 occupations and produces occupational employment and wage estimates for over 450 industry classifications at the national level. This wealth of data allows for the identification of industry occupational proportions down to the industry sub-level. Utilizing the industry-level occupation proportions at the NAICS 4-digit level and the Job Zones scores from the O*NET program, I weight each occupation's Job Zone score by the proportion of the total workforce. Table 1 illustrates the LSI compiling process while Table 2 gives examples of the industries at the top and bottom of the LSI distribution.

Table 1: Constructing the Labor Skill Index

NAICS	Industry	OCC code	OCC title	Pct of total workforce	Job zone	Weighted LSI
113300	Logging	11-1021	General and Operations Managers	1.3%	4	0.052
113300	Logging	19-1032	Foresters	2.3%	4	0.093
113300	Logging	33-9032	Security Guards	0.1%	2	0.002
113300	Logging	37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	0.1%	2	0.002
113300	Logging	43-1011	First-Line Supervisors of Office and Administrative Support Workers	0.4%	3	0.013
113300	Logging	43-3031	Bookkeeping, Accounting, and Auditing Clerks	1.6%	3	0.047
113300	Logging	43-3051	Payroll and Timekeeping Clerks	0.2%	2	0.003
113300	Logging	43-6014	Secretaries and Administrative Assistants, Except Legal and Medical	1.9%	2	0.038
113300	Logging	43-9061	Office Clerks, General	3.5%	2	0.067
113300	Logging	45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	4.2%	3	0.127

Note: Table illustrates the construction of the Labour Skill Index (LSI) for the Logging industry. *NAICS* is the North American Industry Classification System number. *OCC Code* is the BLS occupation code for a particular occupation, while *OCC Title* is official title of said occupation. *Job Zone* refers to the $O * NET$ program classification score associated with a OCC Code, taking on a value from 1 (no preparation to perform) to 5 (extensive preparation to perform). The weighted LSI is computed using job zone skill levels and workforce distribution.

Table 2: Skilled Labor Index Across Industries

NAICS	Industry	Skilled labor index (LSI)
More reliant on skilled labor		
3254	Pharmaceutical and Medicine Manufacturing	2.784
3364	Aerospace Product and Parts Manufacturing	2.615
3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	2.573
3344	Semiconductor and Other Electronic Component Manufacturing	2.505
4862	Pipeline Transportation of Natural Gas	2.502
2111	Oil and Gas Extraction	2.486
Less reliant on skilled labor		
3116	Animal Slaughtering and Processing	1.794
3162	Footwear Manufacturing	1.766
3365	Railroad Rolling Stock Manufacturing	1.745
3117	Seafood Product Preparation and Packaging	1.654
3169	Other Leather and Allied Product Manufacturing	1.652
1133	Logging	1.467

Note: Table illustrates the skilled labour index (LSI) for various industries based on NAICS classifications at the top and bottom of the LSI distribution.

3.1.2. Employee protection laws

Employee protection in the United States has a relatively short history compared to other industrialized nations. Until the late 20th century, the US legal system defended the right that workers could be dismissed *at will* by their employer, for no cause, reason, or fault in expectations. Beginning it the 1970's, U.S. courts at the state level began implementing what have become to be known as wrongful-discharge, or worker-protection laws (WPL), which legislated employee protection from early and unreasonable termination. The specific aim of these adopted laws falls into one of three categories: the implied contract, public policy, and good faith exceptions. Each of these laws has strong implications for increasing LAC for those firms located under the jurisdiction of the states where they were adopted.

The good faith exception requires employees to be treated in a "fair manner", requiring a just cause for termination. Protecting employees from whimsical dismissal, this law necessitates employers to present just motivation for termination. Similarly, the implied contract exception suggests employees not belonging to some sort of collective agreement or union are implicitly included into an agreement which prevents termination without good cause. The public policy exception protects employees from termination if they refuse to engage in illegal activities or act in a way that violates established public policy.

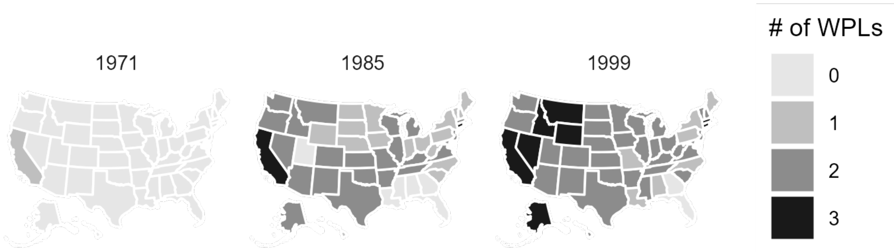
While the extent in which LAC are increased with the passing of a particular WPL may vary in magnitude, the mechanism, and effect, should be the same: each of these worker protection laws increases labour adjustment costs by limiting firms' ability to quickly downsize or restructure in response to changing investment opportunities. Higher severance costs, legal risks, and recruitment challenges can make firms more cautious in their hiring and investment decisions[3].

As the decision to pass these wrongful-discharge laws is taken at the state level, rather than federally, the variation across state lines and the staggered timing of adoption provides an opportune setting for a natural experiment. Figure 1 illustrates the number of adopted WPLs across the United States at three representative time points in the sam-

[3]For detailed definitions and further background on these worker discharge laws, see Schwab et al. (2006) for a comprehensive review.

ple: 1971, 1985, and 1999. In contrast to the early years of the sample period, where only the single state of California had adopted a WPL, the later years illustrate the extent and cross-sectional variation of adoption worker protection laws across the nation, allowing me to test the impact of these laws on ICFS using a difference-in-differences approach.

Figure 1: Adoption of worker protection laws



Note: Figure demonstrates proportion of US states which have adopted one or more worker protection laws at three time periods: 1971, 1985, 1999. Worker protection laws are defined as the adoption of the implied contract, good faith, or public policy exceptions to the traditional "at will" employment rule.

3.2. Empirical design

The standard framework for analysing ICFS is based on the Q-theory of investment, which states that a firm's investment decisions should be driven solely by Tobin's Q, a measure of the ratio between the market value and replacement cost of a firm's assets. Any additional factors are theorized to have no effect in explaining observed capital expenditure.

In order to test the hypotheses developed in the previous section, I estimate the traditional model from Fazzari et al. (1988) augmented with asset tangibility:

$$\frac{I_{i,t}}{TA_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 \frac{CF_{i,t}}{TA_{i,t-1}} + \beta_2 AT_{i,t-1} + \beta_3 Q_{i,t-1} + \epsilon_{i,t} \tag{1}$$

where $I_{i,t}$ is capital expenditures (CAPEX)[4] and $CF_{i,t}$ is firm cash flow, calculated by adding depreciation expense to income before extraordinary items (IB + DP), for firm i and time t. Both variables are standardized by beginning-of-period total assets, $TA_{i,t-1}$ (TA). $Q_{i,t-1}$ is defined as the beginning-of-period market value of assets divided by total assets and is a proxy for investment opportunity. The market value of assets is defined as total assets minus book value of equity (SEQ) plus market value of equity, where market value of equity is number of shares outstanding times share price ($PRCC_F * CSHOC$). $AT_{i,t-1}$ is beginning-of-period asset tangibility measured as the proportion of property, plant, and equipment (PPENT) to total assets. I include asset tangibility because previous evidence that ICFS are in partly driven by differences in firm's physical asset base (Moshirian et al., 2017; Christie, 2018; Andrén and Jankensgård, 2019).

The coefficient β_1 is the investment to cash flow sensitivity, measuring the sensitivity of investment to internally generated cash flow. β_2 captures the sensitivity of investment to asset tangibility, while β_3 represents the investment to Q sensitivity. I include firm-fixed effects, α_i, in order to control for time-invariant firm characteristics, and time-fixed effects, α_t, to account for firm-invariant macro shocks across the sample period. Standard errors are clustered at the firm level across all models.

To test whether LAC influence ICFS, and that dependence on skilled labour is associated with lesser ICFS, I augment Equation 1 with *LSI* and its cross-product term with cash flow to estimate the effect of the LSI on ICFS:

$$\begin{aligned} \frac{I_{i,t}}{TA_{i,t-1}} = {} & \alpha_i + \alpha_t + \beta_1 \frac{CF_{i,t}}{TA_{i,t-1}} + \beta_2 AT_{i,t-1} + \beta_3 Q_{i,t-1} \\ & + \beta_4 LSI_{i,t} + \beta_5 \left(\frac{CF_{i,t}}{TA_{i,t-1}} \times LSI_{i,t} \right) + \epsilon_{i,t} \end{aligned} \tag{2}$$

here the interaction term $\left(\frac{CF_{i,t}}{TA_{i,t-1}} \times LSI_{i,t} \right)$ captures whether LAC moderates ICFS. If labour costs "crowd out" investment, β_5 should be positive, suggesting that firms with higher LSI show weaker ICFS.

[4] Compustat items in parentheses

To strengthen inference, I next test whether the staggered passage of worker protection laws have influenced the relationship between investment and cash flow. As the laws were adopted at different times across the states, the variation in labour adjustment cost should be exogenous to firm-level investment decisions. The following difference-in-difference model is then estimated:

$$\begin{aligned}\frac{I_{i,t}}{TA_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 \frac{CF_{i,t}}{TA_{i,t-1}} + \beta_2 AT_{i,t-1} + \beta_3 Q_{i,t-1} \\ + \beta_4 WPL_{i,t} + \beta_5 \left(\frac{CF_{i,t}}{TA_{i,t-1}} \times WPL_{i,t} \right) + \epsilon_{i,t}\end{aligned} \tag{3}$$

where $WPL_{i,t}$ is a dummy variable equal to 1 if a firm has its headquarters in a state that has passed the respective worker protection law at time t, and 0 otherwise. β_4 measures the effect of the passage of the worker protection law when cash flow is equal to zero. A negative sign on $\beta 5$ would give evidence to support the hypothesis that ICFS are lower in firms that face stronger worker protection laws.

Finally, to test Hypothesis 2, whether financial constraints amplify the relationship between LAC and ICFS, I split firms into constrained and unconstrained groups using three established financial constraint measures: the KZ-index, the WW-index, and the SA-index. I then run tests on these sub-samples to identify the LAC-ICFS on constrained status. I first estimate Eq.(1) separately for constrained and unconstrained firms for baseline comparisons, then augment Eq.(2) to including debt, equity, and cash variables to control for alternative sources of finance in the following model:

$$\begin{aligned}\frac{I_{i,t}}{TA_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 \frac{CF_{i,t}}{TA_{i,t-1}} + \beta_2 AT_{i,t-1} + \beta_3 Q_{i,t-1} \\ + \beta_4 \frac{\Delta Debt_{i,t}}{TA_{i,t-1}} + \beta_5 \frac{\Delta Equity_{i,t}}{TA_{i,t-1}} + \beta_6 \frac{\Delta Cash_{i,t}}{TA_{i,t-1}} + \beta_7 LSI_{i,t} \\ + \beta_8 \left(\frac{CF_{i,t}}{TA_{i,t-1}} \times LSI_{i,t} \right) + \epsilon_{i,t}\end{aligned} \tag{4}$$

where, as defined in Eq.(2), $I_{i,t}$ is capital expenditures, $CF_{i,t}$ is cash flow, $Q_{i,t-1}$ is Tobin's Q, $AT_{i,t-1}$ is beginning-of-period asset tangibility for firm i at time t. $\Delta Debt$, is the period-on-period change of the sum of total debt and current liabilities (DLC + DLTT). $\Delta Cash$ is the period-on-period change of cash and cash equivalents (CHE), while $\Delta Equity$ is the change of book equity (SEQ) minus the change in retained earnings (RE). Variables are deflated by beginning-of-period total assets, TA_{t-1} (TA). Other variables are the same as .

To be consistent with previous studies, a number of restrictions are made upon the data to account for the potential distortionary effects of mergers and acquisitions (Chen and Chen, 2012; Andrén and Jankensgård, 2016; Moshirian et al., 2017). Total assets, total sales, and market capitalization are required to be $1 million inflation-adjusted dollars Lagged values of total assets and PP& E are required to be present and firm-year observations with sales growth or asset growth above 100% are removed from the sample. Lastly, continuous variables are windsorized at the 1st and 99th percentiles to minimize the effect of outliers.

3.3. Sample description

Table 3 reports the descriptive statistics for the variables motivated in the previous section, categorized into the LSI sample in Panel A and the WPL sample in Panel B.

Differences between variables can be observed between the samples. Greater mean values of Investment (0.071 vs. 0.042), Cash flow (0.080 vs 0.035), and Tangibility (0.302 vs 0.217) are found in the earlier WPL sample. In contrast, a lower mean value of Q is seen in the earlier sample (1.582 vs 1.998).

Table 3: Summary Statistics

	n	Mean	SD	Min	Median	Max
Panel A: LSI Sample						
Investment	22640	0.042	0.040	0.000	0.030	0.260
Cash flow	22640	0.035	0.189	-1.149	0.079	0.428
Tangibility	22640	0.217	0.161	0.006	0.174	0.767
Q	22640	1.998	1.443	0.423	1.540	10.894
LSI	22640	2.351	0.310	0.881	2.343	3.065
Panel B: WPL Sample						
Investment	50665	0.071	0.060	0.001	0.055	0.410
Cash flow	50665	0.080	0.128	-0.897	0.098	0.397
Tangibility	50665	0.302	0.155	0.028	0.280	0.794
Q	50665	1.582	1.180	0.417	1.200	11.168
Implied contract	50665	1.545	0.498	1.000	2.000	2.000
Public policy	50665	1.581	0.493	1.000	2.000	2.000
Good faith	50665	1.180	0.384	1.000	1.000	2.000

Note: Panel A reports statistics corresponding to the LSI sample, consisting of manufacturing firms in the Compustat universe from the period 2003 to 2019. Panel B reports statistics on the WPL sample, including all manufacturing firms in the Compustat database from the period 1969 to 2003. Variable definitions are described in detail in Section 3.2.

Correlations of the variables in the study are presented in Table 4. While some patterns can be seen among the variables, the greatest correlation is between Investment and Tangibility estimated at 0.506, suggesting multicollinearity concerns are not an issue.

Table 4: Correlations

Panel A: LSI Sample

	Investment	*Cash flow*	*Tangibility*	Q_{t-1}	*LS Index*
Investment	1				
Cash flow	0.184	1			
Tangibility	0.506	0.114	1		
Q_{t-1}	0.071	-0.179	-0.165	1	
LS Index	-0.113	-0.194	-0.203	0.172	1

Panel B: WPL Sample

	Investment	*Cash flow*	*Tangibility*	Q_{t-1}	*Implied contract*	*Public policy*	*Good faith*
Investment	1						
Cash flow	0.279	1					
Tangibility	0.440	0.095	1				
Q_{t-1}	0.117	-0.085	-0.094	1			
Implied contract	-0.042	-0.106	-0.096	0.132	1		
Public policy	-0.016	-0.089	-0.041	0.117	0.512	1	
Good faith	0.005	-0.113	-0.132	0.143	0.245	0.371	1

Note: Panel A reports correlations of variables in the LSI sample, consisting of manufacturing firms in the Compustat universe from the period 2003 to 2019. Panel B reports correlations of variables on the WPL sample, including all manufacturing firms in the Compustat database from the period 1969 to 2003. Variable definitions are described in detail in Section 3.2.

4. Multivariate analysis

This section reports results from the multivariate analysis using fixed effect regressions to test whether labour adjustment costs may explain differences in investment to cash flow sensitivities. Two approaches are taken to examine this relationship. First, I utilize the constructed labour skills index, developed earlier, as a proxy for LAC at the firm level and integrate the variable into the traditional ICFS framework to examine the effect of LAC on investment and cash flow. Second, I then then exploit the state-level staggered adoption of employment protection laws over 30 years in the US in a quasi-natural experiment to examine how the change in employee protection can affect ICFS.

4.1. Labour skills and ICFS

Table 5 shows results from models examining the effect skilled labour has on investment to cash flow sensitivities. The table shows coefficients, associated t-statistics, and significance levels for each explanatory variable in the model, along with goodness of fit measures. Model 1 shows estimates from the baseline model and uses the traditional *Q*-theory investment model augmented with a measure of cash flow following (Fazzari et al., 1988), and controlling for asset tangibility. The inclusion of asset tangibility is motivated by recent findings that highlight the importance of a firm's physical asset base when estimating ICFS which is motivated in Section 2. All coefficients are significant at the 1% level while the magnitude of the *Cash flow* coefficient is 0.04, much in line with results from recent studies (Chen and Chen (2012) report very low sensitivities around 0.02, similarly, Andrén and Jankensgård (2016), Lewellen and Lewellen (2016), and Larkin et al. (2018) report levels around 0.05).

Model 2 introduces the labour skills index, while Model 3 adds the cross-product term of cash flow and the labour skills index, *Cash flow x LSI*, which serves to test Hypothesis (1). This main variable of interest, capturing the effect of the labour skills dependence on ICFS, is both negative and statistically significant the 1% level, suggesting that firms with a higher dependency on a skilled labour demonstrate significantly weaker investment to cash flow sensitivities. This means that when firms face greater labour adjustment costs, valuable cash at hand is utilized to compensate for these cost, attenuating cash flow's effect on investment. As the multiplicative term in Model 3 consists of two continuous variables, assessing the magnitude of this interaction term, or directly interpreting the stand-alone coefficients, becomes less intuitive compared to interaction terms utilizing discrete variables (see Jaccard et al. (1990) for more clarification). To better illustrate the conditional relationship of cash flow's affect on investment at alternate levels of LSI from Model 3, Figure 2 plots various values of Cash flow at different values of LSI found in the sample, along with 95% confidence intervals highlighting the inverse relationship between the two coefficients, illustrating ICFS are decreasing in the LSI. The negative slope shows that as the level of the LSI moves from one to three, ICFS are slashed by more than half.

Overall, the results indicate that firms with a higher dependence on skilled labour demonstrate lower ICFS. While the theoretical framework allows for both positive and negative LAC-ICFS relationships, the findings support the negative "crowding-out" effect. A possible explanation is that while higher LAC may contribute to information asymmetry, it is not strong enough to override the effect due to labour adjustment costs. However, the findings provide empirical support for the role of labour adjustment cost moderating cash flow's effect on investment.

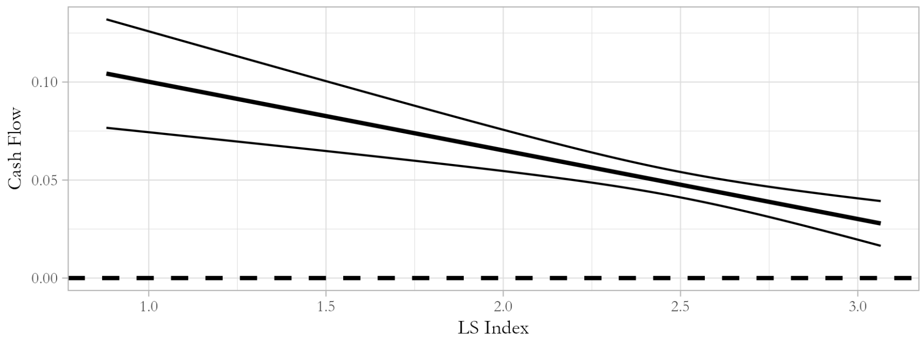
Table 5: Regressions - Labor Skills Index

	Model 1	Model 2	Model 3
Cash flow	0.042^{***}	0.042^{***}	0.148^{***}
	(0.003)	(0.003)	(0.024)
Tangibility	0.140^{***}	0.140^{***}	0.140^{***}
	(0.008)	(0.008)	(0.008)
Q_{t-1}	0.004^{***}	0.004^{***}	0.004^{***}
	(0.000)	(0.000)	(0.000)
LSI		-0.008^{**}	-0.005
		(0.003)	(0.003)
Cash flow x LSI			-0.044^{***}
			(0.009)
Firm effects	Yes	Yes	Yes
Time effects	Yes	Yes	Yes
Num. obs.	22640	22640	22640
R^2 (within)	0.111	0.111	0.115

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Note: Table reports coefficients estimated from Eq.(2) - the regression of physical investment on cash flow, asset tangibility, Tobin's Q, LSI, and the interaction term Cash flow × LSI. LSI index is the Labour Skills Index compiled from BLS survey data, where the process is detailed in Section 2. All variables are winsorized at the 1st and 99th percentiles to reduce possible distortionary effects of outliers.

Figure 2: Marginal effects plot - labour skills



Note: Figure plots estimates of the *Cash flow* coefficient at various levels of the Labour Skills Index. Results are from Eq.(2)

4.2. Employment protection

Next, I test whether the adoption of the implied contract, good faith, or public policy exceptions affect the relationship between investment and cash flow. If stronger employment protections increase labour adjustment costs, then firms operating in states with stricter employment laws should demonstrate lower ICFS according to Hypothesis 1. Table 6 reports the results from Eq. (3). Models 1 through 3 report results from regressing investment on firm cash flow, asset tangibility, Tobin's Q, adding an indicator variable for whether of not a firm's headquarters is situated in a state that recognizes the implied contract, good faith, or public policy exceptions, respectively.

Table 6: Regressions - Worker Discharge Laws

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Cash flow	0.141^{***}	0.141^{***}	0.141^{***}	0.205^{***}	0.157^{***}	0.204^{***}
	(0.005)	(0.005)	(0.005)	(0.008)	(0.006)	(0.009)
Tangibility	0.209^{***}	0.209^{***}	0.209^{***}	0.209^{***}	0.208^{***}	0.209^{***}
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
Q	0.007^{***}	0.007^{***}	0.007^{***}	0.007^{***}	0.007^{***}	0.007^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Implied contract	0.001			0.009^{***}		
	(0.001)			(0.001)		
Good faith		-0.003^{*}			0.001	
		(0.002)			(0.002)	
Public policy			-0.001			0.008^{***}
			(0.001)			(0.002)
Cash flow x Implied contract				-0.089^{***}		
				(0.009)		
Cash flow x Good faith					-0.049^{***}	
					(0.009)	
Cash flow x Public policy						-0.087^{***}
						(0.010)
Firm effects	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	50665	50665	50665	50665	50665	50665
R^2 (within)	0.152	0.152	0.152	0.158	0.154	0.157

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Note: Table reports coefficients estimated from Eq.(3). Variable definitions are presented in Section 3.2. Data is taken from the Compustat universe, including firms with valid observations from Eq.(3). *Implied contract*, *Public policy*, and *Good faith* are dummy variables taking on the value of 1 if a firm is located in a state with the respective WPL passed, 0 otherwise. Firms with extreme sales or asset growth (>100%) are excluded to limit M&A effects. Firms with negative cash flow are removed. Sales and total assets are adjusted for inflation, requiring $1 million thresholds. Standard errors are clustered at the firm level.

The results show a negative relation between investment and the passing of the good faith exception at the 5% level of significance (Model 2). Recognition of the implied contract and public policy exceptions are not associated with any change in capital expenditures. This is similar to the findings of (Bai et al., 2020) who report a negative and significant relation only with the acceptance of the good faith exception in a similar framework. Models 4 through 6 incorporate interaction terms with cash flow and each of the three employee protection exceptions. The results show a negative and statistically significant relationship between firm cash flow and each one of the exceptions in regard to investment. The estimates imply much lower ICFS estimates for those firm head quartered in states which have passed the implied contract (0.116 vs 0.205), good faith (0.108 vs 0.157) and the public policy exceptions (0.117 vs 0.204).

To strengthen these findings, Table 7 consolidates the WPL variables into a single measure following Golden et al. (2020), defining *HighWorkerProtection* as equal to one when a state has passed at least two of the policy exceptions and zero if not. The interaction term of cash flow and *HighWorkerProtection* remains both negative and significant at the 1% level, reinforcing the conclusion that higher LAC, from stronger employment protection, attenuate ICFS.

Table 7: Regressions - Worker Discharge Laws Combined

	Model 1	Model 2
Cash flow	0.141^{***}	0.192^{***}
	(0.005)	(0.008)
Tangibility	0.209^{***}	0.209^{***}
	(0.006)	(0.005)
Q	0.007^{***}	0.007^{***}
	(0.000)	(0.000)
High Worker Protection	-0.000	0.007^{***}
	(0.001)	(0.001)
Cash flow x High Worker Protection		-0.078^{***}
		(0.009)
Firm effects	Yes	Yes
Time effects	Yes	Yes
Num. obs.	50665	50665
R^2 (within)	0.152	0.157

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Note: Table reports coefficients estimated from Eq.(3). Variable definitions are presented in Section 3.2. Data is taken from the Compustat universe, including firms with valid observations from Eq.(3). *High Worker Protection* is a dummy variable taking on the value of 1 if a firm is located in a state with 2 or more WPL in place, 0 otherwise. Firms with extreme sales or asset growth (>100%) are excluded to limit M&A effects. Firms with negative cash flow are removed. Sales and total assets are adjusted for inflation, requiring $1 million thresholds. Standard errors are clustered at the firm level.

4.3. Financial constraints

The results from this investigation so far suggest an inverse relationship between LAC and ICFS. I next address the hypothesis that financial constraints should magnify the effect of LAC on ICFS. Identifying financially constrained firms has proven problematic in the literature mainly because they are not directly observable to the researcher. Studies have empirically relied on estimating financial constrained firms by sorting companies according to a particular metric, or financial constraints index based on firm characteristics, and comparing regression results based on samples taken from the top and bottom terciles. In this manner, firms located in the top (bottom) tercile are theorized to be more (less) financially constrained. Fazzari et al. (1988) sort firms by their dividend policy to identify financially constrained firms, while Lamont et al. (2001) sort firms based on the variables identified by Kaplan and Zingales (1997) to construct the $KZ-index$, which the most widely utilized measure in estimating financial constraint status. According to their model, financially constrained firms are more leveraged, have less cash holdings, pay out less dividends, and have lower operating income. Similarly, Whited and Wu (2006) construct the $WW-index$, which relies on six components in its construction: leverage, cash flow, paying dividends, total assets, firm sales growth, and industry sales growth. Hadlock and Pierce (2010) argue for the use of a simpler, more intuitive index which is estimated solely on firm size and firm age in their $SA-index$[5].

I follow this same methodological approach, utilizing the WW, SA, and the KZ indexes in assessing the relationship between LAC and ICFS in the presence of financial constraints. First, results from baseline tests using Eq.(1) are presented in Table 8, where unconstrained (constrained) firms refer firms located in the bottom (top) tercile of the sample sorted on the respective financial constraints measure. The initial results offer inconclusive evidence towards the theory that financially constrained firms should demonstrate greater ICFS. While all cash flow coefficients are significant with p-values less than 0.001 across the models, the results do not provide a conclusive pattern. Greater, not lessor, ICFS are observed in the unconstrained group vs the constrained group using both the WW-index (0.040 vs 0.023) and the SA-index (0.072 vs 0.024). Utilizing the KZ-index, the opposite pattern is observed, with the unconstrained group demonstrating lessor ICFS compared to the constrained group (0.018 vs 0.040). While these

[5]Following convention (using Compustat identifiers), The KZ index is calculated as: $-1.002(IB+DP)/PPENT_{t-1} + 0.283(AT + PRCC\_FxCSHO - CEQ - TXBL)/PPENT) + 3.139(DLTT + DLC)/(DLTT + DLC + SEQ) - 39.368(DVC + DVP)/PPENT_{t-1}$, the WW index is calculated as $-0.091xCF - 0.062xDividendDummy + 0.021xTLTD - 0.044xLNTA + 0.102xISG - 0.035xSG$, and the SA index as $0.737xlog(TA) + 0.043xlog(TA)^2 - 0.040xFirm\_Age$.

initial results may suggest contradictory findings, caution is warranted in interpreting this as evidence towards the efficacy of one financial constraint measure over another, a consideration left for future research.

Table 8: Regressions - Financial constraints

	WW index		*SA index*		*KZ index*	
	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained	Constrained
Cash flow	0.040***	0.023***	0.072***	0.024***	0.018***	0.040***
	(0.007)	(0.005)	(0.008)	(0.005)	(0.004)	(0.007)
Tangibility	0.183***	0.112***	0.135***	0.151***	0.241***	0.101***
	(0.015)	(0.011)	(0.012)	(0.016)	(0.018)	(0.012)
Q	0.003***	0.004***	0.004***	0.003***	0.002***	0.006***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Firm effects	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	7178	7170	7330	7052	7178	7170
R^2 (within)	0.124	0.083	0.147	0.085	0.193	0.065

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Note: Table reports coefficients estimated from Eq.(1) - the regression of physical investment on cash flow, asset tangibility, and Tobin's Q. Variable definitions are presented in Section 3.2. Data is taken from the Compustat universe, including firms with valid observations from Eq.(1). Firms identified as constrained (unconstrained) belong to the top(bottom) tercile of firms sorted by the respective financial constraints index. Firms with extreme sales or asset growth (>100%) are excluded to limit M&A effects. Firms with negative cash flow are removed. Sales and total assets are adjusted for inflation, requiring $1 million thresholds. Standard errors are clustered at the firm level.

Table 9 presents results after adding the LAC proxy and a set of control variables to Eq. 2, where $\Delta Debt$ is the period-on-period change of total debt, $\Delta Equity$ is the period-on-period change of equity, and $\Delta Cash$ is the period-on-period change of cash and cash equivalents.[6] These variables are deflated by begging-of-period total assets. By using these control variables, I am able to account for other financing sources beyond that of cash flow which may provide further insight into specifically how financial constraints may affect the LAC-ICFS relationship.

The results in Table 9 offer no support towards the hypothesis that the LAC-ICFS relationship is magnified in the presence of financial constraints, which predicts a magnified and significant coefficient on the Cash flow - LSI interaction term for financially constrained firms. With different constraint measures providing conflicting results, the results are inconclusive.

[6]All models in this paper have been tested with and without this set of control variables with only marginal differences to note and main findings remaining analogous.

Given the known biases in financial constraint proxies Bodnaruk et al. (2015), the results highlight the challenge of accurately identifying financially constrained firms and suggest caution in relying on traditional financial constraints proxies.

Table 9: Regressions - Financial constraints, controls, and LSI

	WW index		*SA index*		*KZ index*	
	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained	Constrained
Cash flow	0.281^{***}	0.046	0.279^{***}	0.100^{***}	0.083^{*}	0.089^{**}
	(0.048)	(0.026)	(0.043)	(0.024)	(0.034)	(0.033)
Tangibility	0.192^{***}	0.117^{***}	0.139^{***}	0.164^{***}	0.248^{***}	0.117^{***}
	(0.014)	(0.011)	(0.012)	(0.015)	(0.018)	(0.011)
Q	0.002^{***}	0.003^{***}	0.003^{***}	0.002^{***}	0.002^{***}	0.004^{***}
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
Δ*Debt*	0.057^{***}	0.064^{***}	0.048^{***}	0.072^{***}	0.023^{***}	0.086^{***}
	(0.005)	(0.007)	(0.005)	(0.007)	(0.003)	(0.006)
Δ*Equity*	0.048^{***}	0.041^{***}	0.027^{***}	0.047^{***}	0.022^{***}	0.065^{***}
	(0.005)	(0.005)	(0.005)	(0.004)	(0.002)	(0.007)
Δ*Cash*	-0.020^{***}	-0.021^{***}	-0.019^{***}	-0.013^{**}	0.000	-0.022^{*}
	(0.004)	(0.004)	(0.004)	(0.005)	(0.002)	(0.009)
LSI	-0.006	-0.005	0.008^{*}	-0.007	0.005	-0.000
	(0.005)	(0.004)	(0.003)	(0.006)	(0.003)	(0.005)
Cash flow x LSI	-0.089^{***}	-0.000	-0.084^{***}	-0.021^{*}	-0.022	-0.009
	(0.018)	(0.010)	(0.018)	(0.009)	(0.014)	(0.014)
Firm effects	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	7178	7170	7330	7052	7178	7170
R^2 (within)	0.205	0.144	0.202	0.168	0.227	0.175

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Note: Table reports coefficients estimated from the regression of physical investment on cash flow, asset tangibility, Tobin's Q, Δ Debt, Δ Equity, Cash, LSI, and the interaction term Cash flow $\times$ LSI. Data is taken from the Compustat universe, including firms with valid observations from Eq.(4). Firms with extreme sales or asset growth (>100%) are excluded to limit M&A effects. Firms with negative cash flow are removed. Sales and total assets are adjusted for inflation, requiring $1 million thresholds. Standard errors are clustered at the firm level.

5. Conclusion

The determinants of investment to cash flow sensitivities remain a largely unexplained phenomenon in the corporate finance canon. The majority of extant studies dealing with these sensitivities frame their existence in terms of financial constraints, an association which appears precarious at best in light of recent findings. This paper looks beyond the traditional explanations of ICFS, investigating how labour adjustment costs can explain variation in ICFS sensitivities, providing new empirical evidence that firms facing higher LAC demonstrate lower ICFS. The findings challenge the notion that ICFS can be solely interpreted as a measure of financial constraints and suggest that firms' dependence on skilled labour plays a significant role in shaping investment financing behaviour.

The results demonstrate that firms with higher labour adjustment costs, proxied by the Labour Skills Index (LSI), show significantly weaker ICFS. Constructing a Labour skills index built on survey data from Bureau of Labour Statistics and the U.S. Department of Labour, I augment the traditional model of Fazzari et al. (1988) with a measure of LAC and report a negative and significant relationship between ICFS and LAC. This relationship is consistent with the hypothesis that greater LAC create a "crowding-out" effect, where internal funds are allocated to managing labour costs rather than financing new investments.

I provide further evidence towards this relationship with difference-in-difference tests which leverage the staggered adoption of worker protection laws at the US state-level across a 30-year period. Firms headquartered in states with greater worker protection laws demonstrate significantly lower ICFS. This finding indicates that stronger employment protections increase LAC, restricting firms' ability to adjust labour costs in response to changing investment opportunities, thereby weakening the link between cash flow and investment. Taken together, the results offer convincing evidence towards LAC being a determinant of ICFS.

Contrary to prediction, financial constraints do not magnify this effect. Utilizing three popular financial constraint measures found in the literature, I test the LAC-ICFS relationship on constrained and unconstrained firms, reporting no significant effects for the financially constrained groups. Surprisingly, the negative relationship is seen only for firms which a least likely to be financially constrained. A possible explanation for this finding, similar to the reasoning of (Liao et al., 2020), is the presence of a cancelling out effect, where ICFS are increasing in financial constraints, yet decreasing in LAC. However, as my baseline tests offer limited support for financially constrained firms demonstrating greater ICFS, caution is warranted in support for this conjecture. While the noted bias in financial constraint measures and methodology may potentially account for the differences in findings, further research is needed to fully understand these relationships.

This study contributes to the growing literature which aims to better understand ICFS and their determinants. The conclusions should give pause to researchers utilizing ICFS as a proxy for investment efficiency, as to those attributing theses sensitivities solely to that of financial constraints. While this paper provides empirical support for LAC as a determinant of ICFS, it does not entirely dismiss the role of financial constraints. It instead suggests that ICFS arise from a combination of multiple firm-specific factors. Understanding these complex interactions remains an important avenue for future researchers.

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